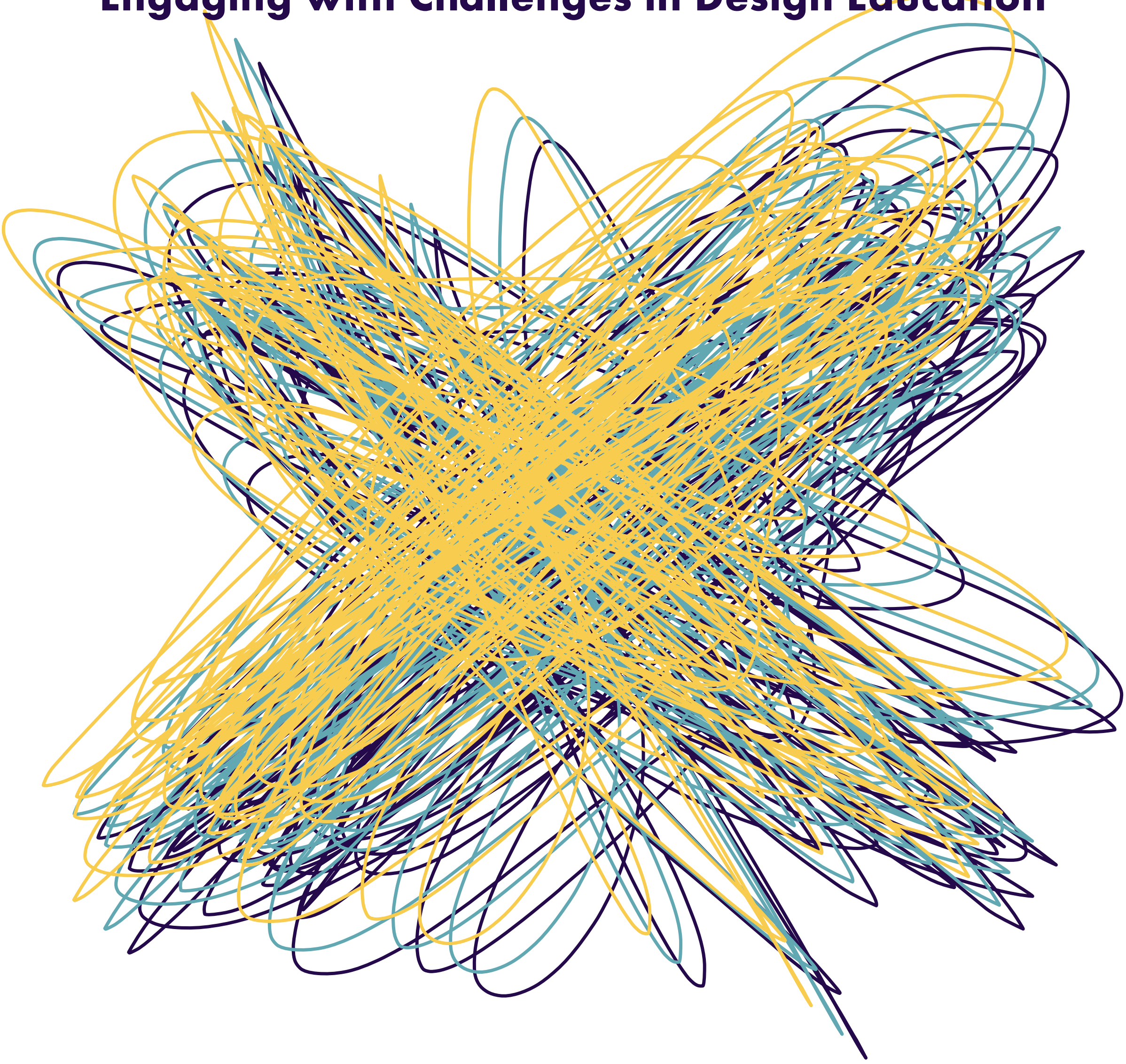
Rethinking Experiential Learning in Design Education

VOLUME 3

PROCEEDINGS

DRS LEARNxDESIGN 2021

Engaging with Challenges in Design Education



6th International Conference for Design Education Researchers

24–26 September 2021
Jinan | China

Editors
Erik Bohemia
Liv Merete Nielsen
Lusheng Pan
Naz A.G.Z. Börekçi
Yang Zhang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Happy
Jody Nyboer
朱迪•妮波尔
Brad Hokanson
布拉德•霍坎森
Good Luck
in the Year
of the Ox
牛年大吉
Year
of the
Ox
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Proceedings of the DRS LEARN X DESIGN 2021

6th International Conference for Design Education Researchers
Engaging with Challenges in Design Education

10th Anniversary of the International Conference for Design Education Researchers
国际设计教育学者大会10周年

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Erik Bohemia
Liv Merete Nielsen
Lusheng Pan
Naz A.G.Z. Börekçi
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Section 09

LEARN X DESIGN 2021
Engaging with Challenges in Design Education
6th International Conference for Design Education Researchers
Shandong University of Art & Design | Jinan, China

10th Anniversary of the International Conference for Design Education Researchers

DRS LEARNxDESIGN 2021
国际设计教育学者大会**10**周年

Lusheng Pan
https://doi.org/10.21606/drs_lxd2021.329

As the DRS LEARN**x**DESIGN General Chair, it is my hope, that in the next decade, the future conference organising committee members will look at back this 10th Anniversary of the International Conference for Design Education Researchers volume of conference proceedings with an affection. The volume reflects the dedicated work of close to 500 individuals who in various ways contributed to production of these proceedings as authors, peer reviewers, planners, volunteers, editors, managers, technicians, or designers. The 10th Anniversary of the International Conference for Design Education Researchers reflects incredible determination of those who came before us who initiated and establish conference as the key platform for the Design Research Society's Education SIG to disseminate research related to Design Education.

I would like to thank to the Design Research Society to entrust Shandong University of Art & Design to host this key International Conference for Design Education Researchers. This has been a first time a Chinese University has hosted a key International Design Education conference of this size. I would especially thank to the International Academic Organizing Committee members Erik, Liv, Yang and Naz, who contributed their enthusiasm and expertise to make the event a wonderful success. Great gratitude is to be given to staff from OsloMet, UDD, and METU who have generously set up the specific Zoom links for the parallel sessions and thus made it possible to translate these sessions.

By embarking on hosting the 10th Anniversary of the International Conference for Design Education Researchers, Shandong University of Art & Design's aim was to make a significant contribution to national and international research on design education. To achieve this aim Shandong University of Art & Design has made a number of important commitments. One of these was to initiate a new **Design Education Research Centre**. The university has made a substantial planning to inaugurate the centre shortly after the conference.

To bridge the persistent Global South and North divide as the host, Shandong University of Art & Design, has widen the International Scientific Programme Committee memberships.

To enable recent graduates to provide a significant input into what should be covered at the conference which focuses on how they should be educated we have made call for the emerging scholars.

Our focus is to deliver a high-quality academic conference. Thus, the focus was on the quality rather than the quantity. We have supported a rigorous peer review process to include the high selected quality academic papers in the conference proceedings

Drawing is a fundamental language for designers. It supports to analyse, organise, communicate, reflect, negotiate, persuade, explain, discuss, and present design concepts, products, experiences, and services. It is used throughout New Product Development process, from strategic initiation to its implementation. Thus, I was supportive of the International Academic Organising Committee proposal to introduce a Track which will challenge authors to use visualisation methods to communicate their papers in a visual form.

In 2016 the Chinese Ministry of Education has included the Design discipline to the "Special Catalogue of General Colleges and Universities" with aim to scale up the design education. Since 2016, more than **2000 of institutions** have been delivering design programmes. Every year more than **540 000** students enrolled into Design programmes. The number of **students studying design and related majors** in the school now **exceeds 2 million**. The design discipline has become the most prominent one in more than 140 first-level disciplines

and more than 90 undergraduate majors in China.
I would like to thank to the local committee in Shandong University of Art & Design. Thanks to the design group who was responsible for designing the beautiful gifts and certificates of the top submissions. Also, I want to say thank you to the cultural event group. They provided the delegates with cultural feasts. I really appreciate support from the assistants who recording the sessions. Great gratitude should be given to our interpreters, who help us to enjoy the conference with their efforts.

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Professor Dr. Lusheng PAN, Vice-Chair of China Federation of Literary and Art Circles, Chair of China Folk Literature and Art Association, President of Shandong University of Art & Design, founder of Oriental Folk Art Museum, senior expert and leading talent in national philosophy and social sciences, enjoying special government allowance of the State Council. He also serves as the main leader of the Teaching Steering Committee of design specialty in Colleges & universities of Ministry of Education. His research focuses on design education and folk art. He has presided more than 30 national research programs, undertaken over 20 major national & provincial social service projects, published more than 30 books and over 200 academic papers.

LEARN X DESIGN 2021 Engaging with Challenges in Design Education
6th International Conference for Design Education Researchers
Shandong University of Art & Design | Jinan, China

Jinan 2021: Engaging with Challenges in Design Education

6th International Conference for Design Education Researchers: DRS Learn X Design 2021

Erik Bohemia, Liv Merete Nielsen, Naz A.G.Z. Börekçi and Yang Zhang
https://doi.org/10.21606/drs_lxd2021.330

10th Anniversary of the DRS Learn X Design Conference Series

The year 2021 has been particularly special for the DRS Learn X Design (LxD 2021)[1] organising teams. The conference series marked the 10th anniversary since the first event was held in Paris in 2011 (Bohemia et al., 2011)[2], see the reflection on page 50. Since then, the conferences have been organised biannually. The DRS/CUMULUS 2nd International Conference for Design Education Researchers was held in Oslo in 2013, on the theme of *Design Learning for Tomorrow – Design Education from Kindergarten to PhD* (Lloyd & Bohemia, 2013; Nielsen et al., 2015; Reitan et al., 2013)[3], see the reflection on page 45. The DRS/CUMULUS/Design-Ed Learn X Design 3rd International Conference for Design Education Researchers was held in Chicago in 2015, on the theme of *Education and Design to Enlighten a Citizenry* (VandeZande et al., 2015)[4], see the reflection on page 38. The DRS Learn X Design 4th International Conference for Design Education Researchers was held in London in 2017, on the theme of *The Allure of the Digital and Beyond* (Pritchard & Lambert, 2017)[5], see the reflection 35. The DRS Learn X Design 5th International Conference for Design Education Researchers was held in Ankara in 2019, on the theme of *Insider Knowledge* (Börekçi et al., 2019)[6], see the reflection on page 30. The theme for the 6th International Conference for Design Education Researchers hosted by the Shandon University of Art & Design was *Engaging with Challenges in Design Education* (Bohemia et al., 2021). The general 2021 conference theme reflected the unprecedented changes which took place in design education around the world since the first event was held in Paris a decade ago. For example, in China since 2016, more than 2000 of institutions have been delivering design programmes. Every year, also in China alone, more than **540 000** students enrol into Design programmes. And the number of **students studying design and related majors** in the Chinese schools now **exceeds 2 million**. The design discipline has become the most prominent one in more than 140 first-level disciplines and more than 90 undergraduate majors in China. China's growth of design programmes and design student graduates at universities is shifting the very foundation of how design is taught (Pan, 2021). In additional, the Design is being taken up increasing by other disciplines (Bravo & Bohemia, 2021) and being incorporated into general education (Lutnæs, 2019) which requires us to reconceptualise the design education and its purposes (Bravo & Bohemia, 2020; Lloyd, 2011). This echoes advocation by scholars such as Anita Cross (1984), Buchanan (2000), and Nielsen and Brænne (2013) for design to become part of the general education.

At the time when the general conference theme was proposed, Covid-19 which forced the most rapid and radical changes on design education, was not yet on horizon (see Figure 1). However, as the education has been rapidly transformed due to the Covid-19 pandemic that has affected the entire world, the general theme

[1] https://dl.designresearchsociety.org/drs2021-learnxdesign/

[2] https://dl.designresearchsociety.org/drs2011-learnxdesign/

[3] https://dl.designresearchsociety.org/drs2013-learnxdesign/

[4] https://dl.designresearchsociety.org/drs2015-learnxdesign/

[5] https://dl.designresearchsociety.org/drs2017-learnxdesign/

[6] https://dl.designresearchsociety.org/drs2019-learnxdesign/

of the conference indivertibly became a fitting theme.

Figure 1. SUAD proposed to host the 2021 DRS Learn X Design conference in 2019. On the right, students practicing a performance routine at one of the SUAD theatres. The plan was to introduce conference participants to different cultural activities.
Note: The conference visual identity evolved over the time

The DRS Learn X Design 2021, 6th International Conference for Design Education Researchers took place online between 24–26 September 2021. It was hosted by Shandong University of Art & Design (SUAD) in Jinan, China. During this online international conference, the participants reflected on the ongoing challenges which have affected their practices. The process of sharing different perspectives with the international design education community members facilitated collective learning. The challenges that design educators experienced were reflected in the conference tracks, such as managing design education in times of crisis; and those related to ethics and our personal, societal and educational circumstances.

Submissions

Altogether 338 authors from 39 counties contributed 168 submissions as full research papers, case studies, visual papers or workshop proposals. The case studies and visual papers submission categories were introduced for the first time in this conference. The idea for the visual papers' category came from the Engineering and Product Design Education (E&PDE) conference which introduced this submission category at its 2018 event (Childs et al., 2018). The idea for the case studies was take from the 2019 Academy for Design Innovation international conference (Bohemia et al., 2019).
After a round of double-blind peer review process, which was supported by 219 members of the International Scientific Panel[7], 50 (30%) submissions were accepted, 56 (34%) submissions were provisionally accepted[8] pending satisfactory further peer reviews managed by the track chairs, and 58 (35%) submissions were rejected. This was followed by the subsequent peer review process involving the track chairs and co-chairs. The outcome of this final process was the inclusion of 91 submissions, which were scheduled in the conference programme and included for publication in the proceedings. The overall acceptance/rejection rate across the four categories was 46% (see Table 1), which is on par with the general DRS biennial international conferences (Boess et al., 2020).

[7] Please see the full list on page ii.

[8] If both peer reviewers indicated that a submission required a major revision then the submission was rejected outright.

Table 1. Submissions received for the 6th International Conference for Design Education Researchers: DRS Learn X Design 2021

	Received	Accepted	Rejected
Aggregate	**168**	**91 (54%)**	**46%**
Research Papers	103	53 (51%)	49%
Case Studies	39	24 (61%)	39%
Workshop	19	11 (7%)	58%
Visual Papers	7	3 (4%)	43%

Laying Out the Track Themes

With the aim of living up to the expectations of the 10th anniversary conference, one of the major concerns of the organisers was to articulate its relevance and appeal to attract diverse international design research community. The tracks facilitated achieving this goal. The tracks, by defining the conference scope by defining the subject matter and the extent to which the topics are explored, are the backbone of a conference. The tracks overview the existing pathways, determine new ones for research in an area, and set up the community for the conference. With its tracks, a conference can draw attention to the significance of a discipline and address the members of its community.

One of the particularities for the organization of this conference was the openness that the organisers strived to achieve, with voice given to a wide group of international scholars. The conference track themes were constructed altogether with a motivated group of international scholars and colleagues leading the process as track chairs and co-chairs. The track chairs from diverse backgrounds were invited to propose the themes guided by their specific research. Thus, the LxD 2021 tracks' scope diverted from traditional design education conferences which focus is explicitly on educational topics such as assessment or student group work. Instead, the LxD 2021 tracks themes were guided by specific tracks' chairs research areas, like how problems framing limits the potential solutions, and then related this area to education.

As the International Academic Organising Committee, we were very excited to be working together in this process. With the aim of making this process beneficial beyond experienced researchers, it was decided to give an opportunity to early career researchers in chairing a track for this conference. A call was made in August 2020, titled *Fishing for the Big Idea.* This is how the track *Futures of Design Education* was incorporated into the conference, with four early career researchers leading the process (see Figure 2, and Volume 4, on page 854).

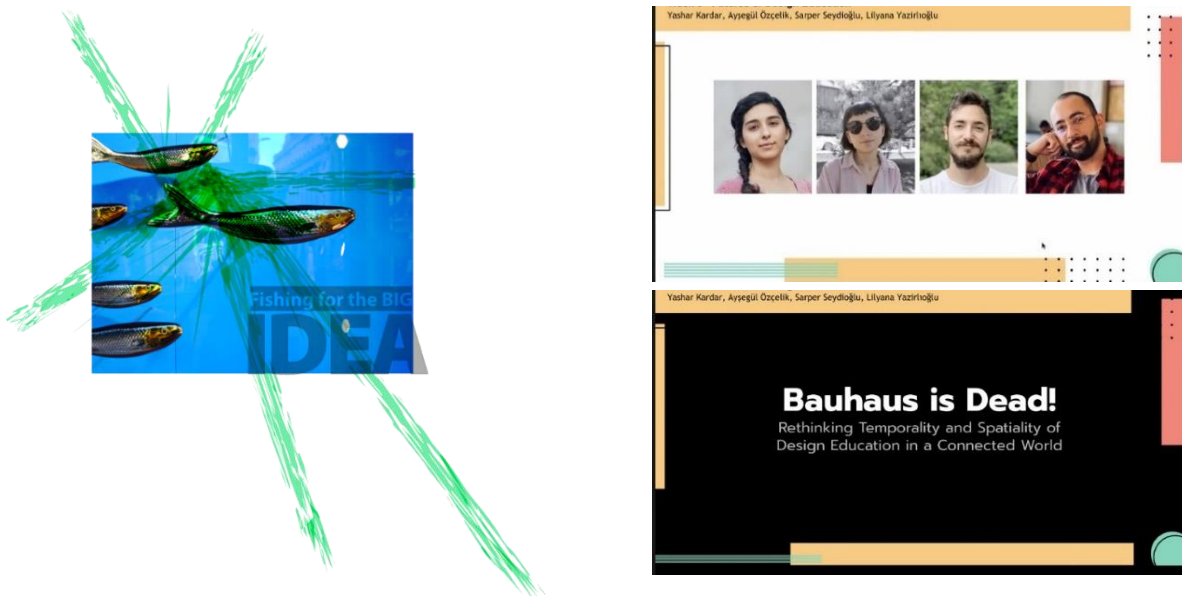

Figure 2. Fishing for THE BIG IDEA™; The team of the early career researchers, the School of Small Fish, who initially proposed the theme: Bauhaus is Dead!

A total of 44 track chairs and co-chairs[9] from 14 countries (Australia, Baltimore County, Brazil, Canada, Chile, China, Colombia, Denmark, Finland, Germany, India, Netherlands, Norway, Sweden, Turkey, UK, USA) worked together and in parallel, in bringing their own approaches and points of view, with topics that supported and complemented one another, and allow the germination of new discussions in the area. The wide geographical distribution required synchronisation among all which was facilitated by regular meetings distributed into an extending timetable, and long collaborative working hours. Many meetings were held online, with the altruism of the track chairs who were in different parts of the world (see Figure 7). Despite the challenges, these meetings also brought the benefits of including diverse perspectives which led to new ideas.

Figure 3. Regular meeting of track chairs and co-chairs provided opportunity to shape the conference scope

Figure 4. Share your Passion opening session for the Articulation of Alternate Futures symposium, which was held in September 2020, provided the track chairs with opportunity to know each other's interests

[9] Track chairs and co-chairs are listed under the heading *International Scientific Panel* on page i.

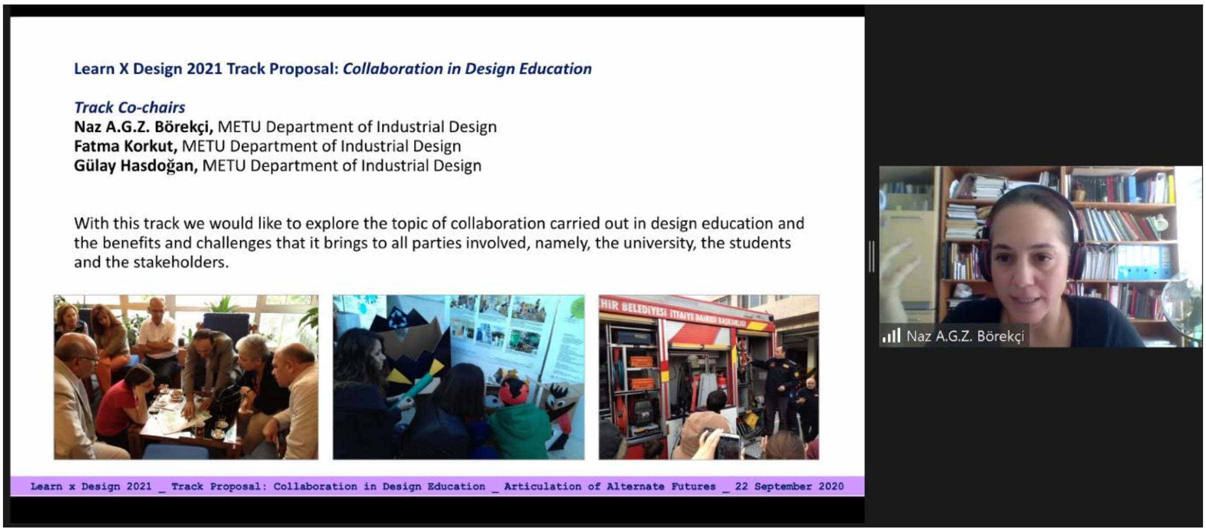

Figure 5. Naz A.G.Z. Börekçi outlining a track proposal titled 'Collaboration in Design Education' at during the 'Articulation of Alternate Futures' symposium which was held in September 2020.

Figure 6. On the left, Liv Merete Nielsen introduced Úrsula Bravo who proposed the track titled 'Design Thinking to Improve Creative Problem-solving' and on the right, Katja Thoring outlined proposal for the track titled 'Design Learning Spaces' during the 'Articulation of Alternate Futures' symposium which was held in September 2020.

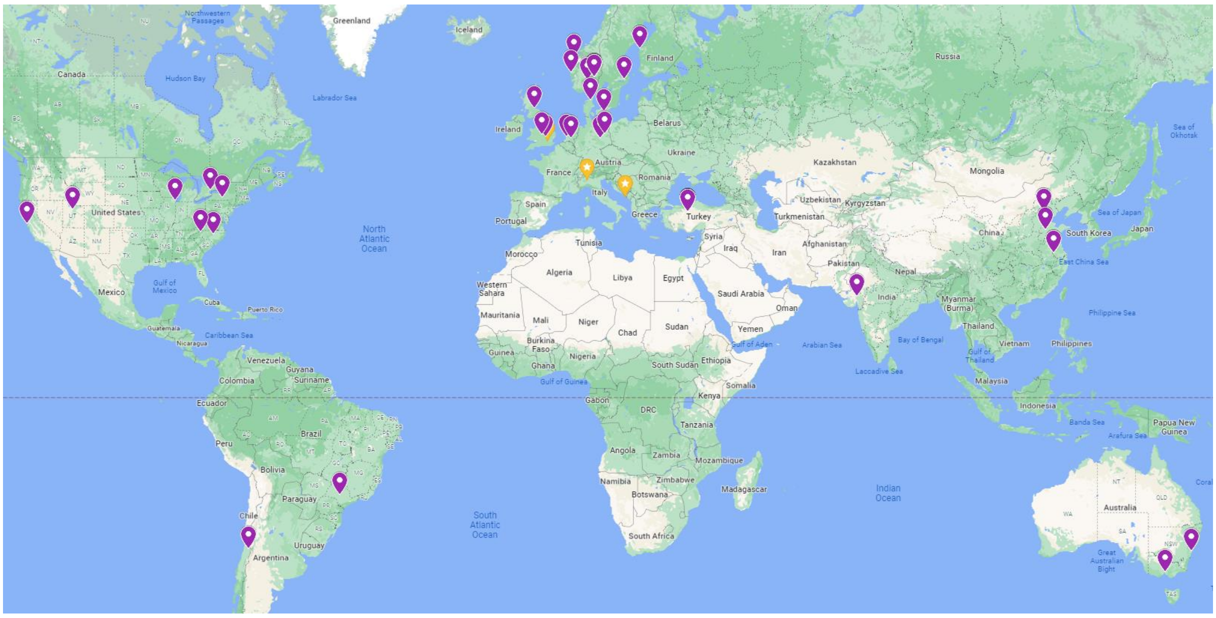

Figure 7. The geographical location of the LxD 2021 Track chairs and co-chairs

The 10-year anniversary conference programme and the four-volume conference proceedings have been organised within the 10 track themes managed by the track chairs with support from their co-chairs (see Table 2).

Table 2. List of Tracks and Submission Categories

Track №	Track Title	Submission Types: Full Research Papers	Case Studies	Workshops	Visual-Papers
Track 01	Design Thinking to Improve Creative Problem-solving	o	o	o	
Track 02	Empowering Critical Design Literacy	o	o	o	
Track 03	Alternative Problem Framing in Design Education	o	o	o	o
Track 04	Collaboration in Design Education	o	o	o	
Track 05	Co-creation of Interdisciplinary Design Educations	o	o		
Track 06	Learning Through Materiality and Making	o	o		o
Track 07	Sketching & Drawing Education and Knowledge	o	o	o	o
Track 08	Design Learning Environments	o	o	o	o
Track 09	Futures of Design Education	o	o	o	o
Track 10	Design Educators as Change Agents	o	o	o	

The track titled **Design Thinking to Improve Creative Problem-solving** chaired by Úrsula Bravo and co-chaired by Catalina Cortés, Jeannette LaFors, Andrés Téllez and Natalia Allende asked scholars to consider the challenges of taking design-based approached those who do not intent to be trained as designers such as children, youth, teachers, and leaders in schools, universities, and other educational contexts (Bravo et al., 2021), see the track's introduction on page 59.
The **Empowering Critical Design Literacy** track chaired by Eva Lutnæs and cochaired by Karen Brænne, Siri Homlong, Hanna Hofverberg, Ingvill Gjerdrum Maus, Laila Belinda Fauske and Janne Beate Reitan aimed to explore the current educational practices, academic discourses and implications of design education empowering for critical design literacy (Lutnæs et al., 2021), see the track's introduction on page 222.
The next track titled **Alternative Problem Framing in Design Education**; chaired by Lesley-Ann Noel, and co-chaired by Renata Marques Leitão, Hannah Korsmeyer, Sucharita Beniwal, and Woodrow W. Winchester III, was asking scholars to consider how we might move design education away from problems, pain and othering (Holliday et al., 2010) towards positive models of framing challenges such as joy, desires, utopia and other positive or alternative re-frames (Noel et al., 2021), see the track's introduction on page 277.
The following track **Collaboration in Design Education** chaired by Naz A.G.Z. Börekçi and co-chaired by Fatma Korkut and Gülay Hasdoğan intention was to explore the benefits and challenges of collaboration in design education. For example, the submissions tackled issues related managing collaborations and strategies which facilitate maintenance and commitments of the parties to support design education (Börekçi, Korkut, & Hasdoğan, 2021), see the track's introduction on page 322.
The **Co-creation of Interdisciplinary Design Educations** track which was chaired by Arild Berg and co-chaired by Camilla Groth, Fausto Medola and Kate Sellen, focus was on the challenges related to co-creation practices when disciplinary world views 'crash' and what the implications of these are for design education (Berg et al., 2021), see the track's introduction on page 476.
The **Learning Through Materiality and Making** track which was chaired by Juha Hartvik and co-chaired by Mia Porko-Hudd and Ingvild Digranes was informed by the Scandinavian educational practices which aimed to provide children and young people an opportunity to process materials in order to gain experience, knowledge and learning that can be useful at different stages of life, in study, professional and leisure activities (Hartvik et al., 2021), see the track's introduction on page 604.
The **Sketching and Drawing Education and Knowledge** track which inspired the new submissions Visual Papers category was chaired by Bryan F. Howell and co-chaired by Jan Willem Hoftijzer, Mauricio Novoa Muñoz, Mark Sypesteyn, and Rik de Reuver focused was on research that reveals insights into how and why sketching and visual knowledge is reflected in education (Howell et al., 2021), see the track's introduction on page 626.
The **Design Learning Environments: Exploring the Role of Physical, Virtual, and Hybrid Spaces for Design Education** chaired by Katja Thoring and co-chaired by Nicole Lotz and Linda Keane provided a rich forum for the scholars explore how the physical and digital spatial environments of educational institutions can be designed in order to better facilitate learning (Thoring et al., 2021), see the track's introduction on page 687.
The track titled **Futures of Design Education: Beyond Time & Space** which was chaired by Yashar Kardar and

co-chaired by Lilyana Yazirlıoğlu, Ayşegül Özçelik, and Sarper Seydioglu was based on recent graduates' experiences. The track asked the scholars to venture beyond the 'studio' to explore possibilities of new design education models conscious of members' social dynamics, identities, communities, and their role in enabling new education models which are more inclusive, personalised, and sustainable (Kardar et al., 2021), see the track's introduction on page 856.

The final track titled **Design Educators as Change Agents** which was chaired by Yang Zhang and co-chaired by Xiang Xia and Ziyuan Wang. The track's broad theme focused on design educators as change agents of design education (Xia et al., 2021), see the track's introduction on page 920.

The four submission category types

In addition to the ten tracks, the prospective authors were able to select one of these four submission categories:

- Research Papers
- Case Studies
- Visual Papers
- Workshop Proposals

The full **research papers** submissions were between 3500 and 6000 words in length. The **case studies** provided a platform for sharing a reflective account of a project(s). The case studies submissions were between 1500 and 3000 words in length. The **workshop proposals** provided an opportunity for scholars to explore new and emerging practices and research topics, facilitate debates, gather data, and test on-going research. They enabled practitioners to showcase their work in collaboration with design researchers. The workshop proposal submission were no more than 1500 words. The **visual papers** allowed scholars to used sketched images to communicate the primary information while text plays a supporting role. The visual papers needed to contribute new knowledge.

Preparatory Events

Two international events supported the main conference and marked certain milestones in the preparations. The first event was titled *Articulations for Alternate Futures.* It was an open symposium that took place one year prior to the conference, on 22–23 September 2020. The *Articulations for Alternate Futures* symposium invited prospective conference track chairs to introduce their main themes. The purpose was to articulate potential track themes and then further develop them in relation to each other, thus making sure that the themes complemented one another rather than compete. How the calls could be made or improved were also discussed to make sure the call for submissions would be open and addressing a wide range of academic, practical and research interests. The symposium was open to the participation of an extended audience, who were interested in the conference topic and would consider contributing. Altogether, over 110 participants have joined the two-day online symposium. Based on the discussions, the tracks were reorganised, merged, shuffled and reformed until the call for submissions was made in February 2021.

Figure 8. Naz A.G.Z. Börekçi is outlining programme for the Articulation of Alternate Futures symposium, which was held in September 2020.

The second supporting event was the *Explorations of Alternate Futures* symposium, held on 10–11 May 2021, where track chairs and organisers came together to rehearse the programme and the setting for a more inclusive and fulfilling online conference experience. This two-day symposium was attended by around 90 participants.

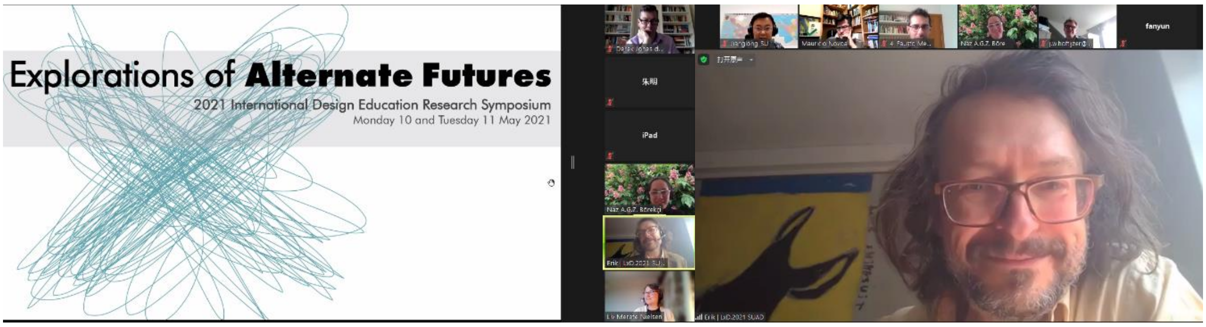

Figure 9. Exploration of Alternate Futures symposium which was used to prototype the online conference delivery

The online symposium held a year ahead of the conference helped the organisers to prototype the September 2021 conference and to identify which elements should be kept and which needed to be discarded. For example, the online parallel sessions were envisaged to take place in the breakup rooms, thus simplifying how delegates might enter the conference as they needed only one online meeting link. However, the online Zoom platform allowed only one interpretation channel to and from Chinese across all the breakup rooms. Thus, subsequent parallel sessions had dedicated meeting links. The timing and overall rhythm of the session delivery, social events and regular breaks were also tested. On the other hand, demonstration of the traditional Baduanjin stretching exercise by Master Ms. Feng Yujuan during the breaks was one of the highlights of this event. The event participants were introduced to eight Baduanjin basic steps. Fatma Korkut, 2019 LxD co-chair, stated that:

> *In general, I think the mood was perfect; people felt engaged and motivated. Geographical and institutional diversity was high. Thematic diversity was not that high, in my opinion. Perhaps some tracks intersect heavily around design thinking and design literacy. I felt excited about mini-exhibitions concerning visual design thinking (Bryan), and data-driven design (Roland). The presentation by young researchers was terrific; I listened to it with tongue in cheek :)) We should have more student presence in this conference series. Plus, we need to encourage more visual events.*

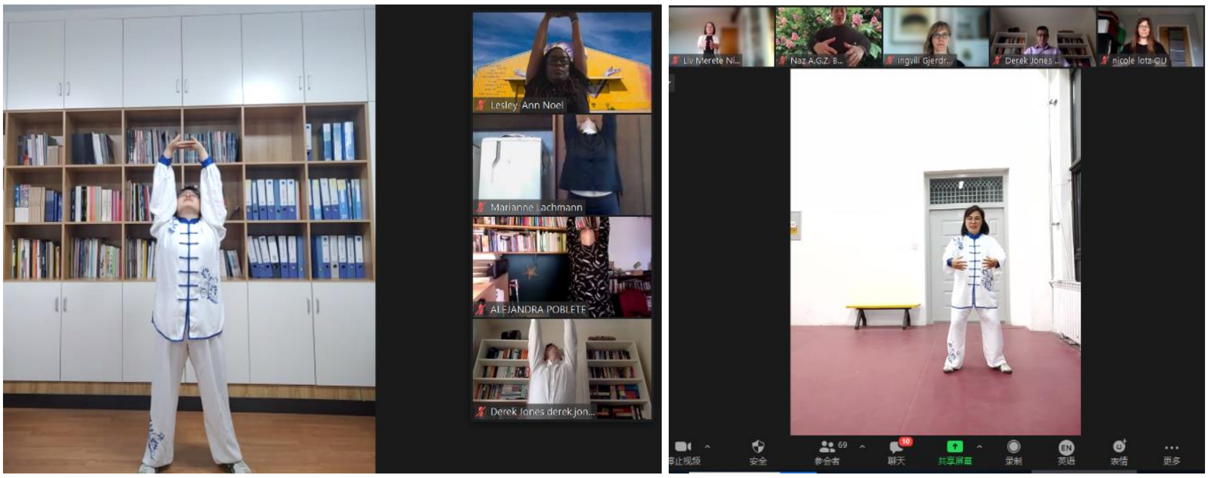

Figure 10. Master Ms. Feng Yujuan demonstrated the traditional stretching exercise: Baduanjin

Derek Jones, the DRS Design Education SIG convener, described the LxD 2021 planning process as

> *…inverting the normal conference procedure. Instead of a closed, small committee (that gets larger), it will be a wider, more open and inclusive community of organising contributors from the start. Instead of waiting to see what papers might be received and how to organise their review, it will make the*

contribution process an integral part of the conference process, again, from the very start. It is this change in process that is particularly exciting and one that is potentially a better template for academic quality.

Derek perceived that the adopted conference planning and organising provided the following benefits:

Firstly, it avoids 'track isolation', where track chairs are responsible for everything as individuals - almost as mini conferences in their own right. Whilst this can work well in some subjects, the LxD 2021 proposal was to avoid such separation and isolation. This has already begun with this first symposium, where negotiation and discussion of subjects and themes between track chairs was in evidence, exploring domain overlaps and synergies. This will continue through the online platform.
Secondly, it shares knowledge between track chairs and subject domains which assists with the work and effort involved in being a track chair. Already, the sharing that took place in the first symposium indicates that contributors are keen to assist with this and with the best of intentions - to make each track as academically competent as possible.
Thirdly, it builds community. This was enabled right from the introduction through the setting, the tone and the intention of conference and process. Introducing track chairs to one another has already established a number of new connections that were evidenced in the discussion during the second day. Many follow-ups have taken place (not least for me!) and this will only continue, developing both the social and academic community of design educators.
Fourthly, it will improve the academic quality of the work. By making gate process more visible it becomes more easily open to questioning and scrutiny (something also encouraged directly by Erik and the team). This, in turn, helps co-develop a community understanding of quality as well as the boundaries of this quality. It also supports and fosters new academics, helping them to see what a peer review process is (and is not!), as well as inviting them to contribute to its shaping.
Finally, however it has been achieved, there was no sense of anyone acting as if they knew more than anyone else - no grandstanding; no arrogance; no 'appeals to authority'. This felt like a community willing to listen to and evaluate each others' experience of knowledge and quality in design education research. This is the best traditions of a Community of Practice - something familiar to designers and design educators alike.
And, of course, it's critical not to forget the importance of facilitation and organisation. All too often the work behind the scenes is invisible and the event itself can seem easy, simple and effortless. That the team made it look like easy was obviously due to significant effort and professionalism. The event was superbly hosted (accommodating, personable, relaxed, inclusive) and felt clearly supported academically and professionally.

The Derek's account has captured the spirit the organisers aimed to foster a more inclusive and open collaboration to break away from the dominant hierarchical conference planning and organisation. The idea was to bring on board voices which are generally excluded from these events which meant to preconfigure (Raekstad & Saio Gradin, 2019) and distribute the decision making and responsibility to a wider cohort of participants.
Following the Exploration of Alternate Futures symposium, the contributing authors were notified of their submission status. Thirty percent of the submissions were accepted, and 35% were provisionally accepted, requiring a second round of revisions which were managed by the specific track chairs. The camera-ready papers[10] were finally received on the 8th of June 2021. This meant the organisers were ready to work on the conference proceedings and prepare the conference programme.

Decision Time

Around this time, May 2021, a difficult decision had to be made, of carrying out this conference online rather than face to face in China, under the generous hospitality of SUAD. The main reasons for this were the ongoing Covid-19 pandemic, and the difficulties due to traveling restrictions and different travel administrations across the world. It would have been wonderful to have the conference face to face in China, and meeting with the DRS LxD 2021 community there, but unfortunately this has not been possible.
Regardless of the change of setting, the conference preparations continued for hosting a memorable

[10] These would form these conference proceedings.

conference and accommodating the community in the best ways possible. Many long working hours, working out of details and resolving technical issues have taken place in the background, from a group of dedicated people. Special thanks are owed to Jianglong Yu, the Conference General Secretary, and the Local SUAD Team, in the coordination of all this.

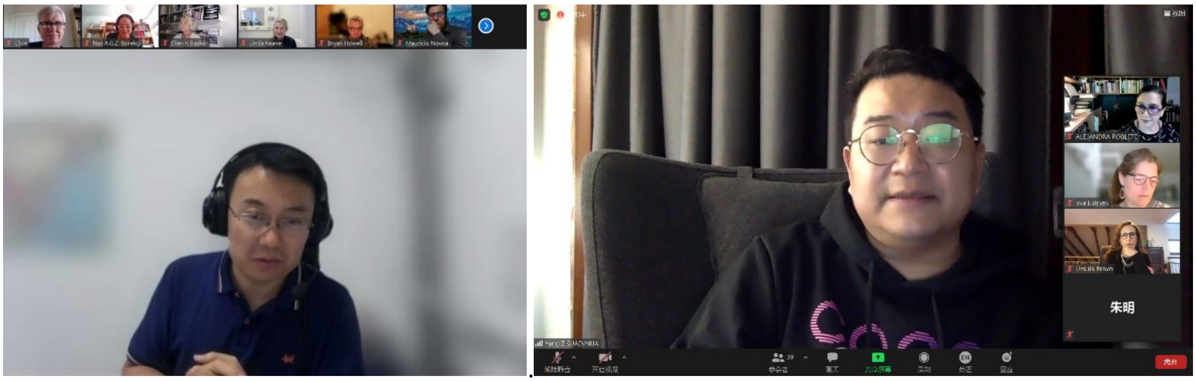

Figure 11. On the left, Jianglong Yu, the Conference General Secretary who worked closely with Yang Zhang, the International Academic Organising Committee co-chair.

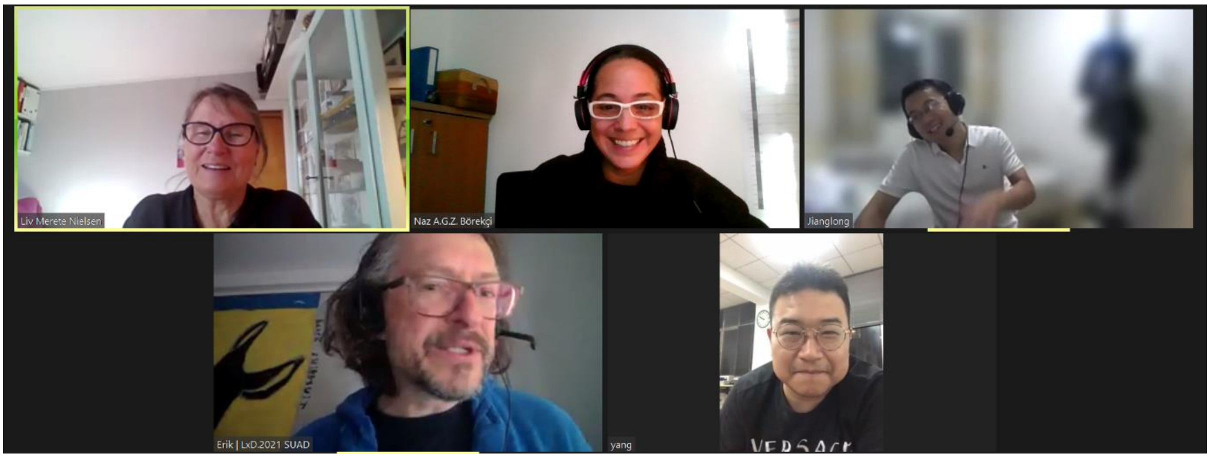

Figure 12. One of the many regular planning meetings of the International Academic Organising Committee members

Figure 13. The local conference organising team was led by SUAD President Professor Pan Lusheng

Conference Visual Identity

A sense of community can be conveyed and strengthened with the branding and visual identity for a conference. Many thanks to Katja Thoring for her efforts in developing the visual identity for the DRS LxD 2021 conference. She has produced countless propositions for the logo and its adaptation into graphic assets to be used on the conference website, proceedings cover, submission templates, social media announcements and email banners.

Figure 14. 'Call for Submissions' website banner (author: Katja Thoring)

Figure 15. 'Call for Submissions' DRS banner (author: Katja Thoring)

With the hopeful expectation of the conference to take place face to face in China, she also has developed propositions for prints of fabric masks to be distributed to participants (Figure 17, left). The DRS LxD 2021 logo is based on the "X" of the conference's name. The initial ideas were developed in SUAD, with the green splash centred in order to form the "X", indicating the "mark" that the conference leaves behind. Katja developed this idea into a fuzzy but focal "X", representing the intersection of dense and repeated movements, indicating the crossing of paths and leaving multi-coloured marks as a community.

The conference visual identity was strengthened with the fascinating graphics developed exclusively for the DRS LxD 2021 conference, by students from Chinese universities, co-ordinated by their professors, and by the Local SUAD Team. More than 100 separate images were produced, representing the ox, which is the zodiac sign of the year 2021 (Figure 17, Right). In Chinese culture, the ox symbolises wealth, prosperity, diligence, and perseverance. This Chinese zodiac sign marks the year 2021 as one of heavy responsibilities and endurance, to which it is surely easy to relate.

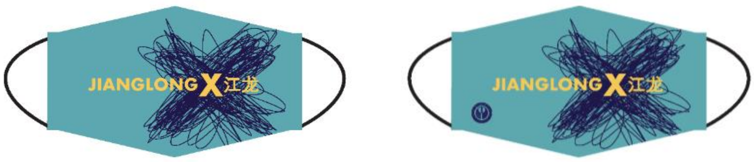

Figure 16. Mask design by Katja Thoring which protected the conference participants as well as identify them, thus reducing the need to produce name badges.

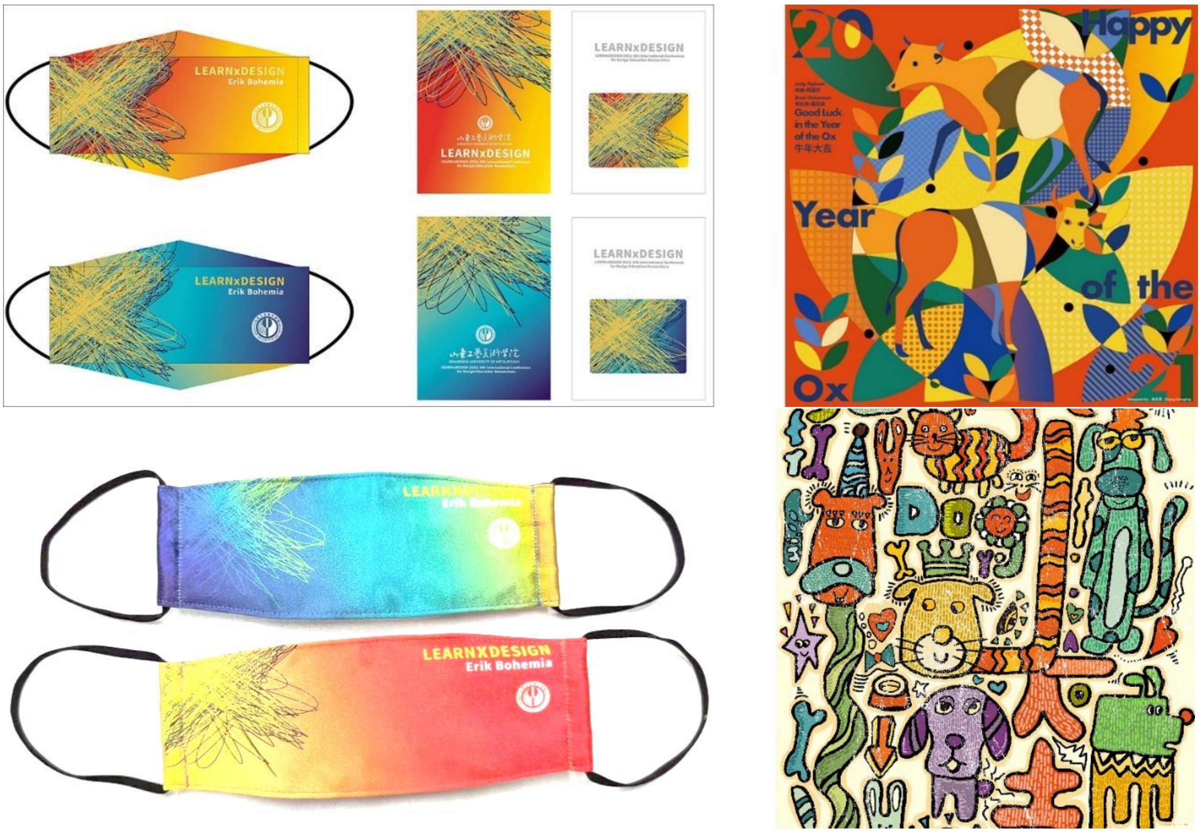

Figure 17. Left: Early visual identity explorations for conference participants' masks and proceedings cover, by Prof. Zhang Yan. Right: An example of the graphic images produced by SUAD for the "year of the ox" of the "year of the dog".

Conference Programme

The DRS Learn X Design 2021, 6th International Conference for Design Education Researchers has accommodated ten tracks responding to the main conference theme *Engaging with Challenges in Design Education*. The proceedings have been organised into 10 sections each corresponding to one of the ten tracks. The tracks' chairs and the co-chairs introduced by the specific (Berg et al., 2021; Börekçi, Korkut, & Hasdoğan, 2021; Bravo et al., 2021; Hartvik et al., 2021; Howell et al., 2021; Kardar et al., 2021; Lutnæs et al., 2021; Noel et al., 2021; Thoring et al., 2021; Xia et al., 2021). We would like to thank the track chairs and co-chairs for their involvement in the chairing of the tracks, and the selfless work they have placed into the quality of the track contributions (Table 2, page 5).

To enable the participation of delegates from all over the world within reasonable day times, the International Academic Organising Committee decided to schedule compact daily programmes lasting around 5 to 6 hours, including frequent social breaks. The compacted schedule resulted in having up to 8 parallel sessions to accommodate the accepted presentations and workshop deliveries. Taking the Central European Time as the basis, the programme hours indicated an early morning for the participants located in the Western Hemisphere, afternoon time for those located around the Greenwich Time Zone, and the evening times for the participants located in the Eastern Hemisphere.

Scientific Programme

In total, the scientific programme of the conference included 28 presentation sessions for the delivery of 80 research papers, case studies and visual papers, and 12 workshop sessions for the delivery of 11 workshops. The three-day programme for the conference accommodated plenary sessions to begin each day.

Day One

On the first day, 24 September 2021 Friday, following the conference opening by Erik Bohemia, the welcome speeches were given by Professor Pan Lusheng, the President of SUAD (see Figure 20), the general conference chair; and Professor Liv Merete Nielsen (see Figure 30), the chair of the International Scientific Programme Committee. The plenary session of the first day included keynote addresses by the five track chairs: Linda Keane, Úrsula Bravo (see Figure 19), Eva Lutnæs (see Figure 18), Naz A.G.Z. Börekçi and Bryan Howell. Two parallel sessions were carried out, one for paper presentations and one for the workshops.

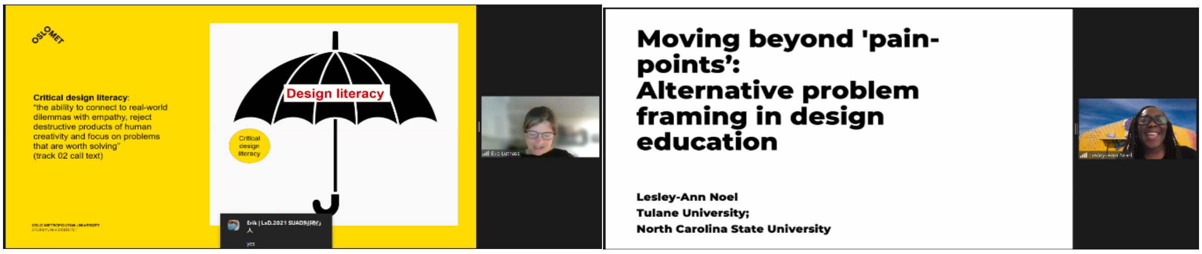

Figure 18. On the left Eva Lutnæs introducing the track Empowering Critical Design Literacy and on the right Lesley-Ann who chaired the track Moving Beyond Pain-Points: Alternative Problem Framing in Design Education.

Figure 19. Úrsula Bravo introduces the track Design Thinking to Improve Creative Problem-solving.

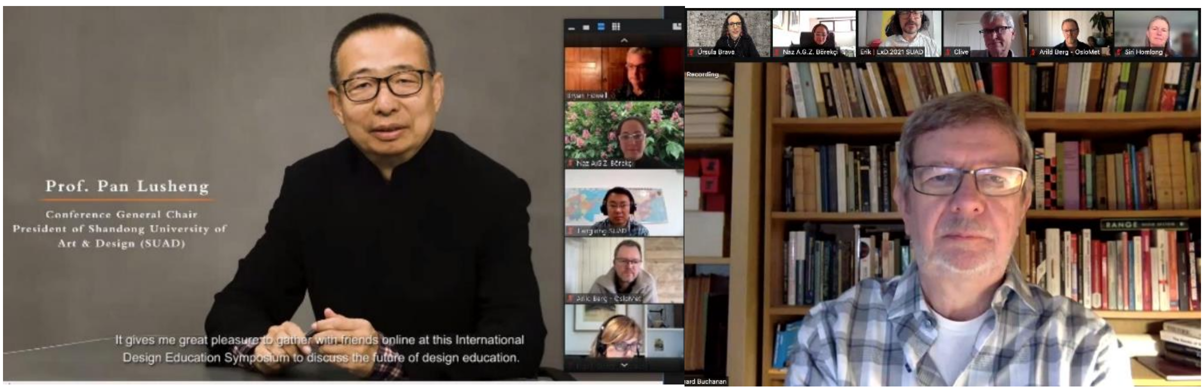

Figure 20. Left: Professor Pan Lusheng, President of SUAD, giving his welcome speech, 24 September 2021. Right: Professor Richard Buchanan, giving his keynote address, 25 September 2021.

Day Two

On the second day, 25 September 2021 Saturday, the plenary session included keynote addresses by the three track chairs: Lesley-Ann Noel (see Figure 18), Arild Berg, and Xiang Xia.

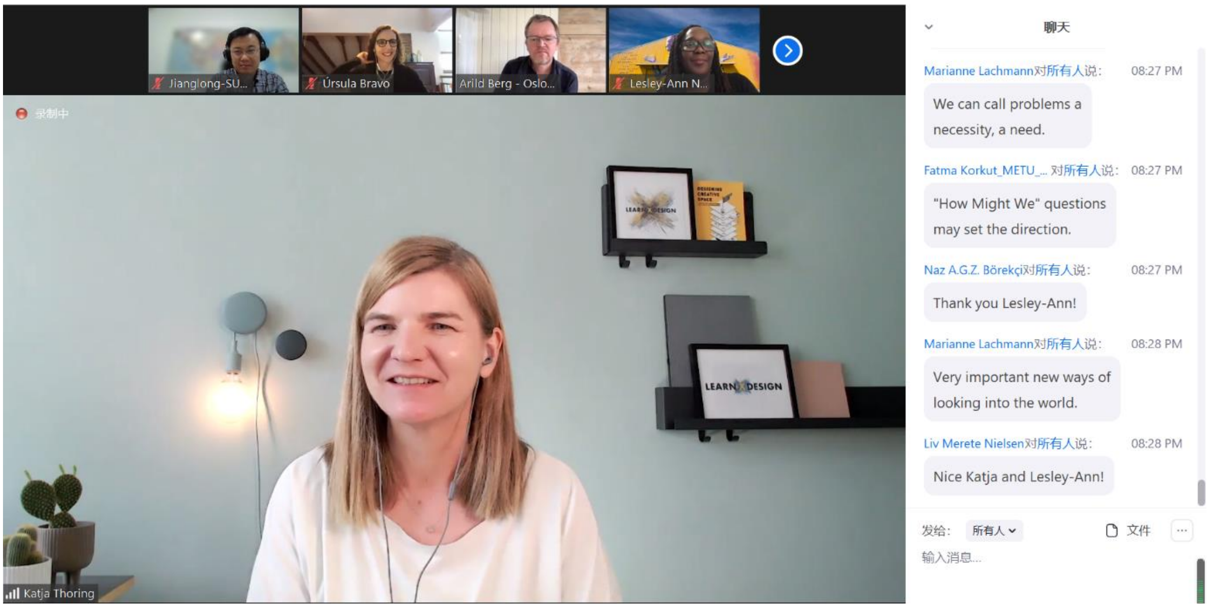

Figure 21. Katja Thoring, who chaired the track Design Learning Environments, is addressing questions from participants.

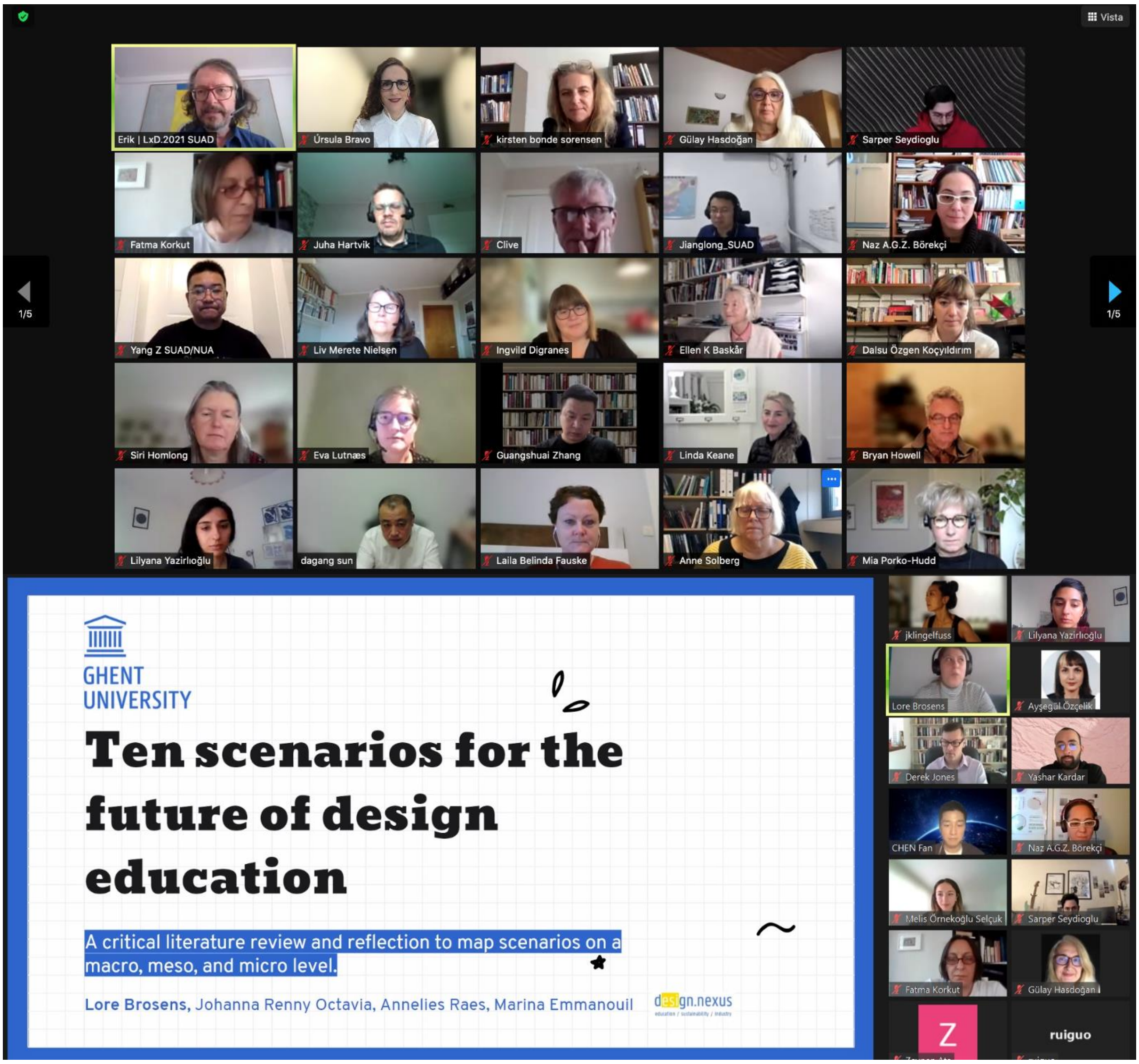

Figure 22. Presentation by Lore Brosens

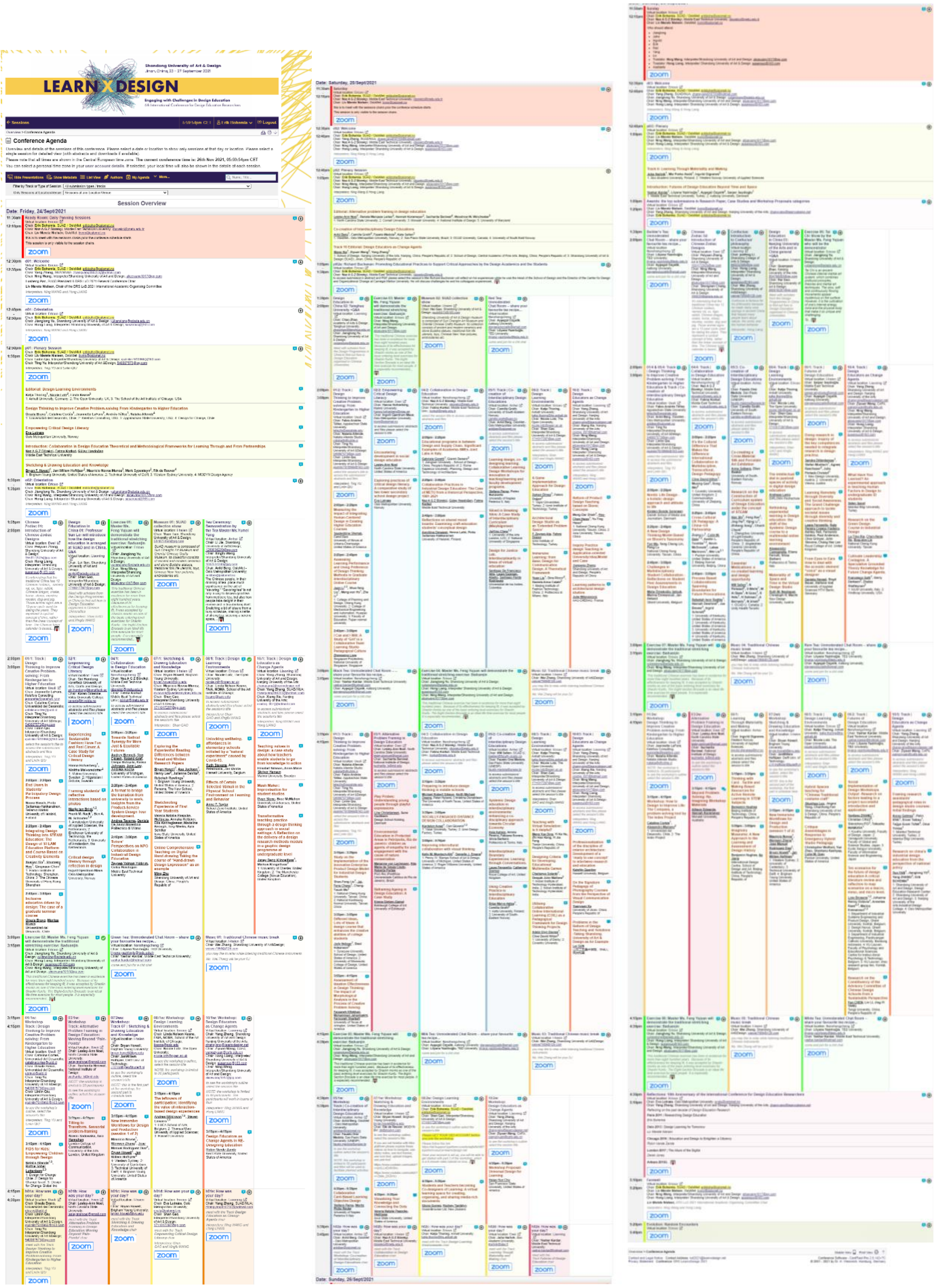

Figure 23. The three-day conference programme pattern of session distribution. Each column represents one of days, from left day 1, middle day 2 and on the right is the day 3.

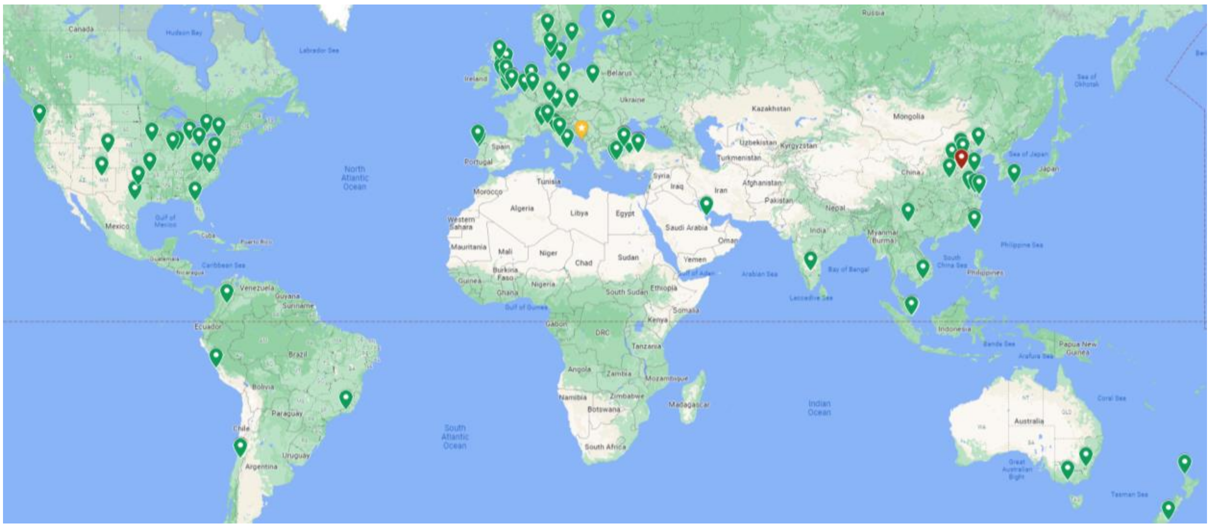

Figure 24. The distribution of authors of the accepted submissions.

This was followed by the keynote address by Professor Richard Buchanan, titled *Promoting Educational Practices to Support Critical Approaches by the Design Academics and the Students*. Richard Buchanan is Professor of Design & Innovation at Weatherhead School of Management, Case Western Reserve University and Chair Professor of Design Theory, Practice, and Entrepreneurship, College of Design & Innovation, Tongji University. He is one of the editors of the *Design Issues*: A Journal of design history, theory, criticism published by MIT Press. Buchanan reflected on his experiences while he was the Head of the School of Design and the Director of the Center for Design and Organizational Change at Carnegie Mellon University (Buchanan, 2004). He discussed the challenges he and his colleagues experienced while trying to develop educational practices which will support critical approaches by the design academics and the students. Although most of the design schools, faculties, departments are aiming to develop more critical practices, implementing and embedding the critical pedagogical practices are extremely challenging as it requires the cultural transformation of the practices of how the design academics are trained (educated), see Figure 20.

Three parallel sessions were conducted on this day, dedicated mostly to paper presentations and for workshops.

Day Three

On the third day, 26 September 2021 Sunday, the plenary session included keynote addresses by the two track chairs: Juha Hartvik and Yashar Kardar.

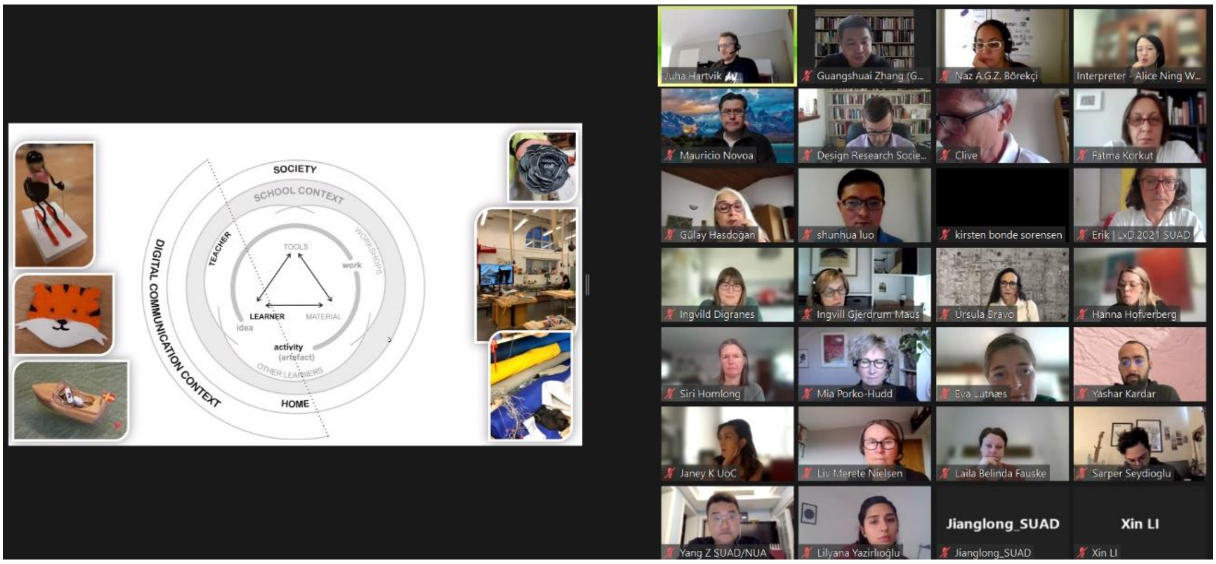

Figure 25. Juha Hartvik introducing the track Learning Through Materiality and Making.

This was followed by the announcement of the awards, *Top Submissions in Research Paper, Case Studies and*

Workshop Proposals Categories, carried out by Liv Merete Nielsen and Yang Zhang. Two parallel sessions were conducted on this day for paper presentations and workshops.

Top Awards

Three categories for top awards were selected based on the double-blind evaluation from the peer review members of the *International Scientific Review Panel.* The three categories were: Research Paper, Case Studies and Workshop Proposals. They are listed alphabetically following the first author's name.

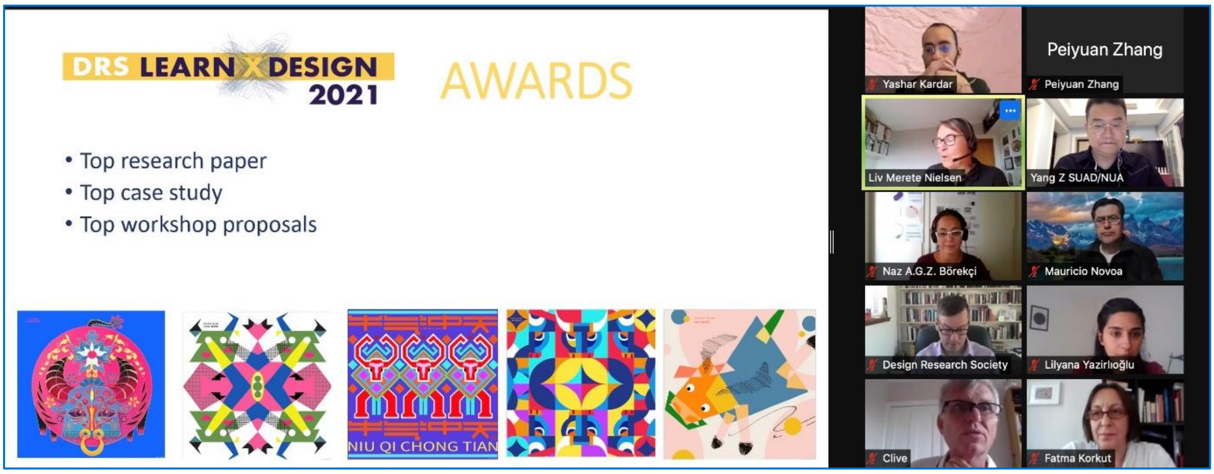

Figure 26. Liv Merete Nielsen and Yang Zhang chaired the Awards Ceremony for the research and visual papers, workshop proposals and case studies.

Top *Research Papers*

The following nine research papers were awarded.

- Systemic Design Education in Interdisciplinary Environments: Enhancing A Co-Disciplinary Approach Towards Circular Economy
  Track 05, A. Aulisio; A.Pereno; F. Rovera; S. Barbero
- Ten Scenarios for the Future of Design Education: A Critical Literature Review and Reflection to Map Scenarios on a Macro, Meso, and Micro Level
  Track 10, L. Brosens; J. R. Octavia; A. Raes; M. Emmanouil
- Collaboration Practices in Industrial Design Education: The Case of METU from a Historical Perspective, 1981-2021
  Track 04, N. A. G. Z. Börekçi; G. Hasdoğan; F. Korkut
- Exploring the Experiential Reading Differences Between Visual and Written Research Papers
  Track 07, B. Howell; A. Jackson; H. Lee; J. DeVita; R. Rawlings
- I Can and I Will: A Study of 'Grit' in a Collaborative Team Learning Studio Pedagogical Culture
  Track 01, Z. Liow
- Study on the Implementation of the Innovative Enterprise Product Design Model for Industrial Design Students
  Track 01, S.-F. Liu; J.-F. Chang; C.-T. Wu
- Different Ideas, Lots of Ideas: A Design Course that Enhances the Creative Abilities of College Students
  Track 01, J. Nyboer; B. Hokanson
- Measuring the Impact of Integrating Human-Centered Design in Existing Higher Education Courses
  Track 01, S. Shehab; C. Guo
- Reform of Product Design Teaching Based on Bionic Concepts
  Track 11, M.-D. Shieh; H.-C. Hsiao; Y.-T. Hsiao

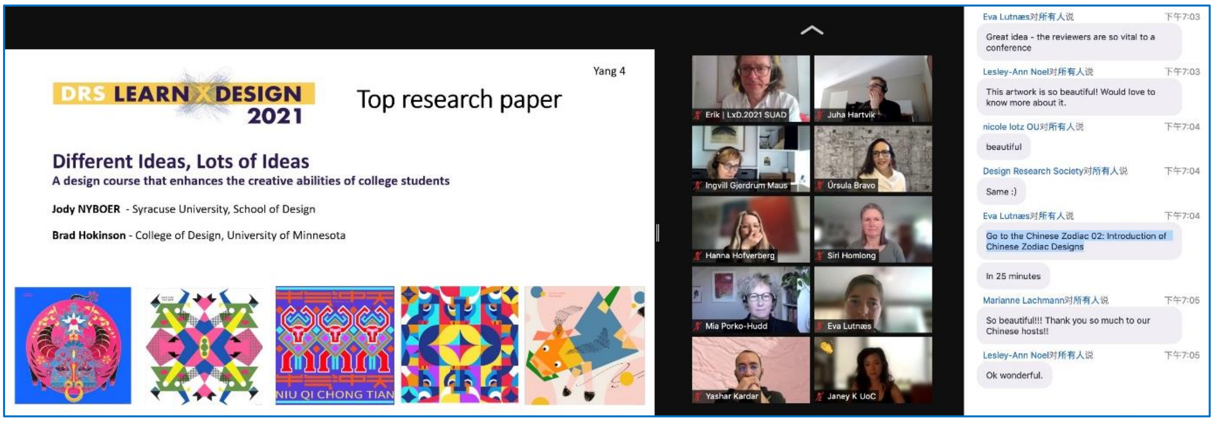

Figure 27. Presentation of Awards in the Research Papers category

Top *Case Studies*

- Preparing to Introduce Design Thinking in Middle Schools
  Track 04, M. R. Gibson; K. M. Owens; P. Hyland; C. Donaldson
- Essential Siloed in Breaking Silos: A case of Interdisciplinary Curriculum (Mis)Alignment
  Track 05, JiaYing Chew
- Mash Maker: Improvisation for Student Studios
  Track 11, R. Slone; B. McMahon

Top *Workshop Proposals*

- Workshop: How to Design to Improve Life: The Compass, A Problem-Solving Tool by The Index Project
  Track 01, C. Cortes; M. Alesandro
- Tilting to Transform: Sensorial Problem-Framing
  Track 03, N. Sadowska; T. Hanrahan

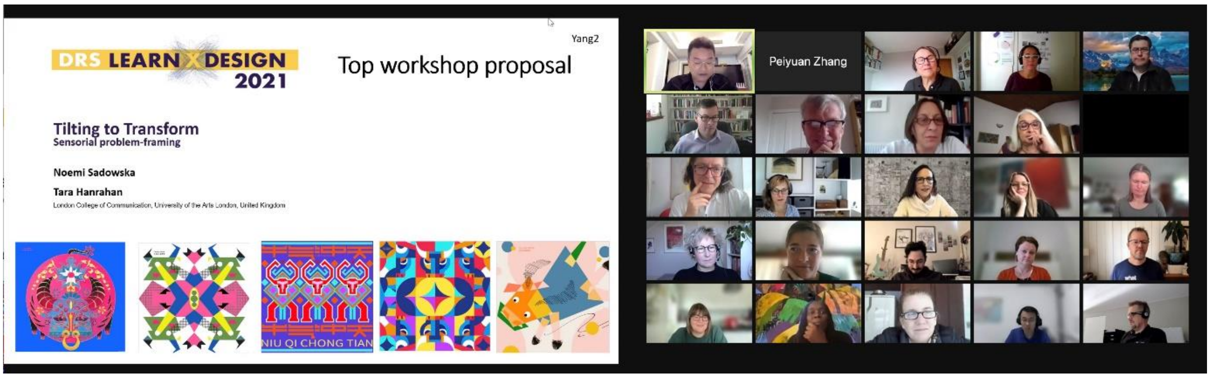

Figure 28. Presentation of Workshop Proposals Awards.

The final plenary session celebrated the 10th anniversary of the Learn X Design conference series. This session brought together the organisers and chairs of the past Learn X Design conferences: Erik Bohemia, Paris 2011 (Bohemia, 2021); Liv Merete Nielsen, Oslo 2013 (Nielsen, 2021); Robin Vande Zande, Chicago 2015 (Vande Zande, 2021), Derek Jones, London 2017 (Jones, 2021) and Fatma Korkut, Ankara 2019 (Börekçi, Korkut, & Koçyıldırım, 2021) were invited to present their reflections on "the ways in which the conferences have contributed to the development of design education research." Their reflections also are included in this conference proceedings.
During this session, the early career researchers who have organised the Futures of Design Education track shared their insights with the conference delegates. Lilyana Yazirlıoğlu, one of the members, said that:

> *…with the conference, I had a chance to discover what is going on in the backstage of preparing an international conference from selection of themes to reviewing papers and preparing the online*

conference setting which I found quite informative for a recent graduate student and an early career researcher like me. Especially, having discussions with other track chairs to enhance the themes in the early stages of the conference creation process was inspiring since it offered our team a sense of belonging to a bigger and supportive design community.

Lilyana's team member Yashar Kardar said that for him:

> *…this was a great experience! Being part of the conference enabled me to meet and learn from researchers from almost all over the world, and work closely and learn from experienced, passionate, and encouraging people such as Erik Bohemia, Derek Jones, and Naz Börekçi. This created an exceptional chance get an insight into the general state of design education research and the global dynamics influencing its development. It also personally has given me the courage to want to contribute to the design research community at a much larger scale. I think activities that would include young researchers such as myself, and members of my team build an incredible opportunity to empower young researchers from all over the world.*
> *We think that the mixing of scholarly discussions at a high level and social interaction is at the core for making these conferences attractive and important.*

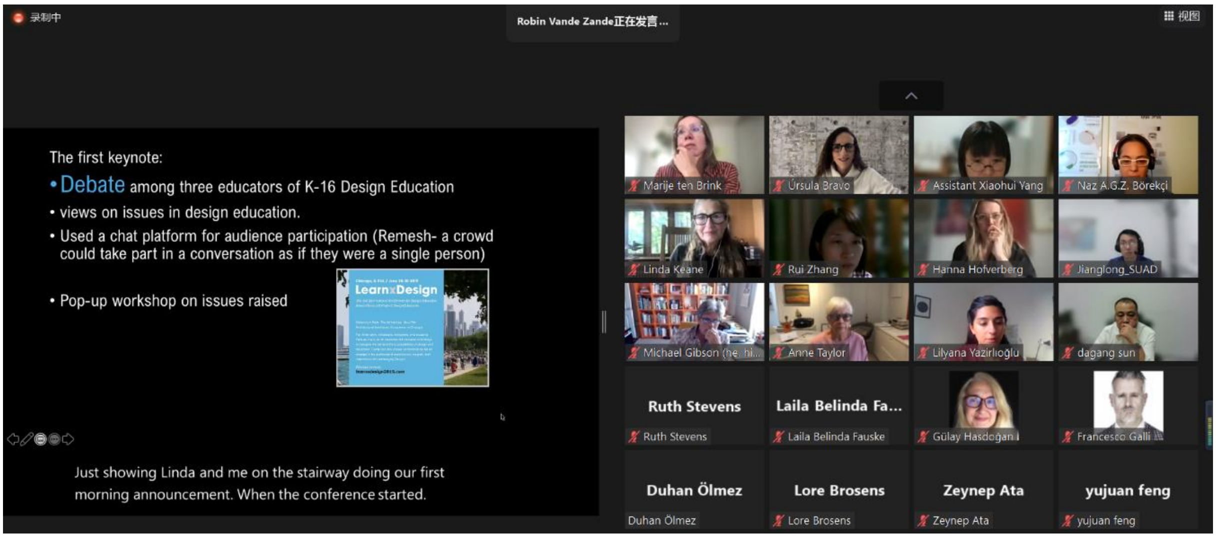

Figure 29. Robin Vande Zande reflected on the 2015 LxD conference which was hosted in Chicago.

The farewell speech for the conference was given by Professor Xin Li (see Figure 30), Vice President of SUAD, after which, the conference was closed by Professor Liv Merete Nielsen (see Figure 31).

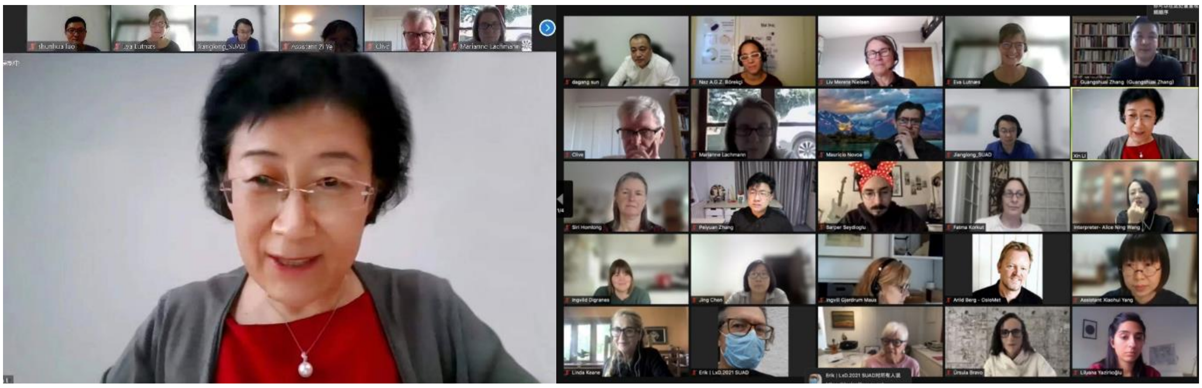

Figure 30. Professor Xin Li, Vice President of SUAD who closed the conference with her farewell speech

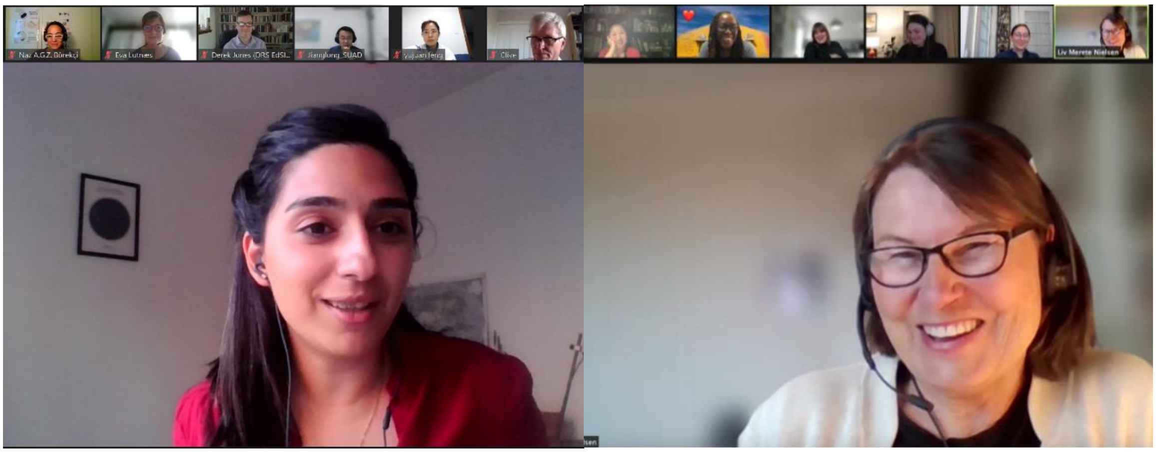

Figure 31. On the left, Lilyana Yazirlıoğlu reflecting her and her team members' experience of organising a conference track, and on the right, Liv Merete Nielsen is summarising the event.

Social Programme: Conveying the Significance of Chinese Culture

It was believed that the conference programme would be enriched with social events, both for the conveying of the significance and richness of Chinese culture, and for providing an attractive and embracing medium for the delegates to come together. Various social gatherings were planned for the 15-minute and 30-minute breaks between the sessions, throughout the three conference days. These gatherings included relaxing exercise sessions, where Master Ms. Feng Yujuan demonstrated traditional stretching exercise, the Baduanjin; the audition of traditional Chinese music, and unmoderated chat rooms designated for tea breaks.

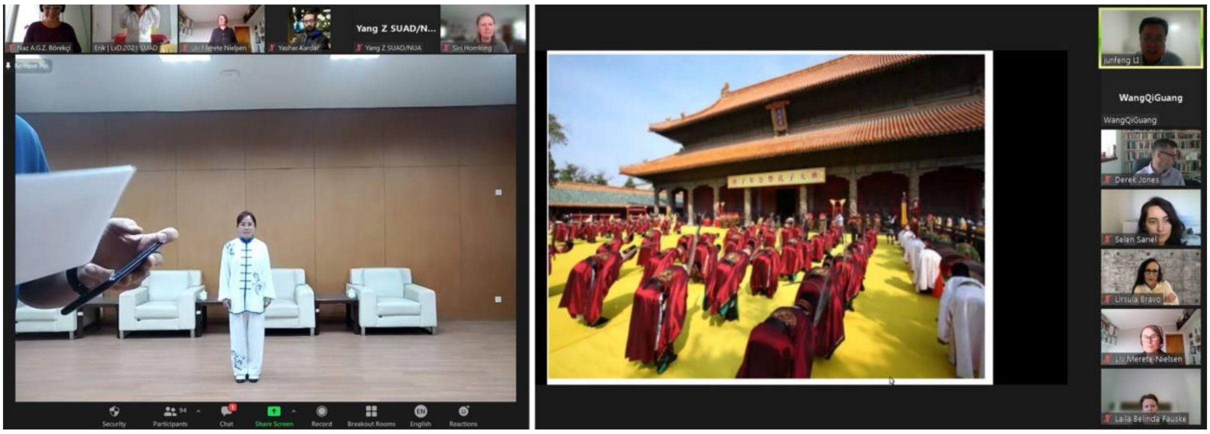

Figure 32. Left: Master Ms. Feng Yujuan beginning her exercise session, 26 September 2021. Right: Professor Junfeng Li presenting on Confucius, 26 September 2021.

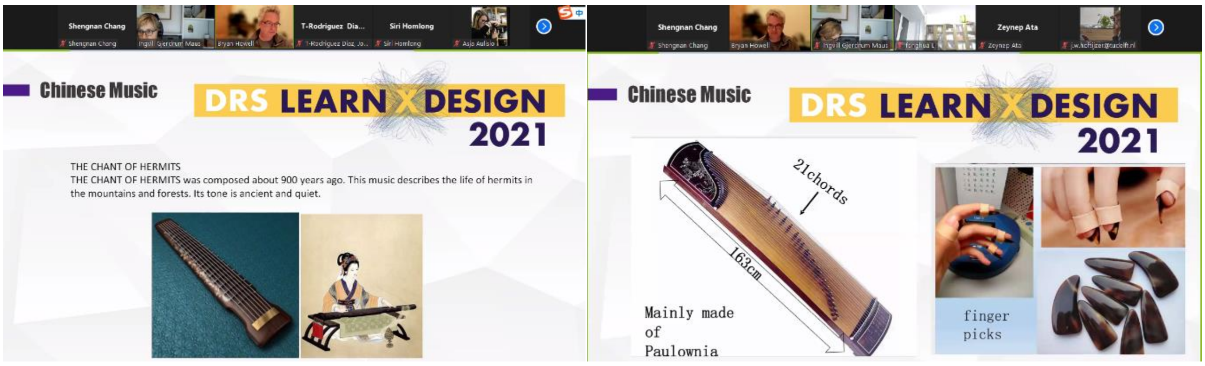

Figure 33. The conference delegates were able to relax during the breaks listening to examples of Chinese music.

A tea ceremony demonstration took place by Tea Master Ms. Yumei Yang. The Chinese people, in their drinking of tea, place much significance on the act of "savouring". "Savouring tea" is not only a way to discern good tea from mediocre tea, but also how people take delight in their reverie and in tea-drinking itself. Snatching a bit of leisure from a busy schedule, making a kettle of strong tea, securing a serene space, and serving and drinking tea by yourself can help banish fatigue and frustration, improve your thinking ability, and inspire you with enthusiasm. You may also imbibe it slowly in small sips to appreciate the subtle allure of tea-drinking, until your spirits soar up and up into a sublime aesthetic realm. Buildings, gardens, ornaments and tea sets are the elements that form the ambience for savouring tea. A tranquil, refreshing, comfortable and neat locale is certainly desirable for drinking tea. Chinese gardens are well known in the world and beautiful Chinese landscapes are too numerous to count.

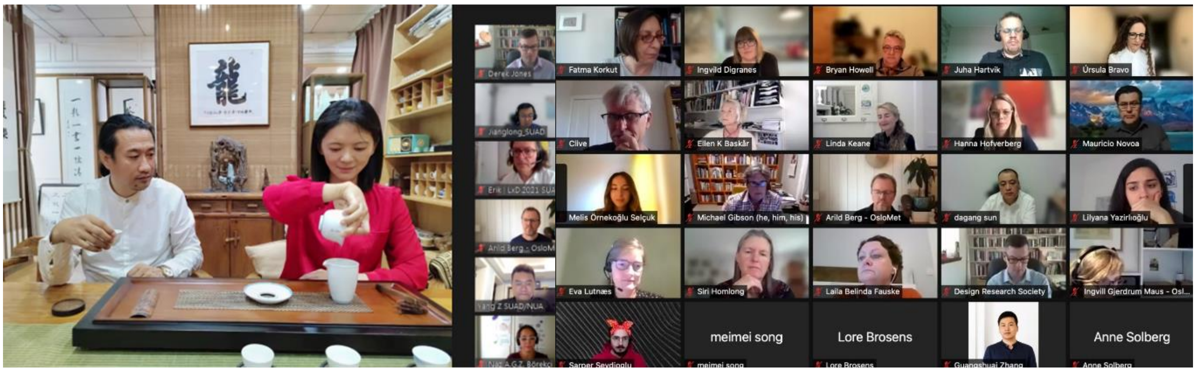

Figure 34. Tea Ceremony by Tea Master Ms. Yumei Yang.

The Chinese zodiac signs, and the designs that were prepared by Chinese students for the conference were presented in two break sessions. As in the Western cultures, traditional China has 12 Chinese zodiacs. However, these traditional Chinese zodiac signs are arranged in a 12-year cycle used for dating the years. They represent a cyclical concept of time, rather than the linear concept of time. The Chinese lunar calendar is based on the cycles of the moon and is constructed in a different fashion than the solar calendar. Every year is assigned an animal sign according to a repeating cycle from Rat to Pig. These traditional Chinese zodiacs are: the rat, ox, tiger, rabbit, Chinese dragon, snake, horse, sheep, monkey, rooster, dog and pig (see Figure 34).

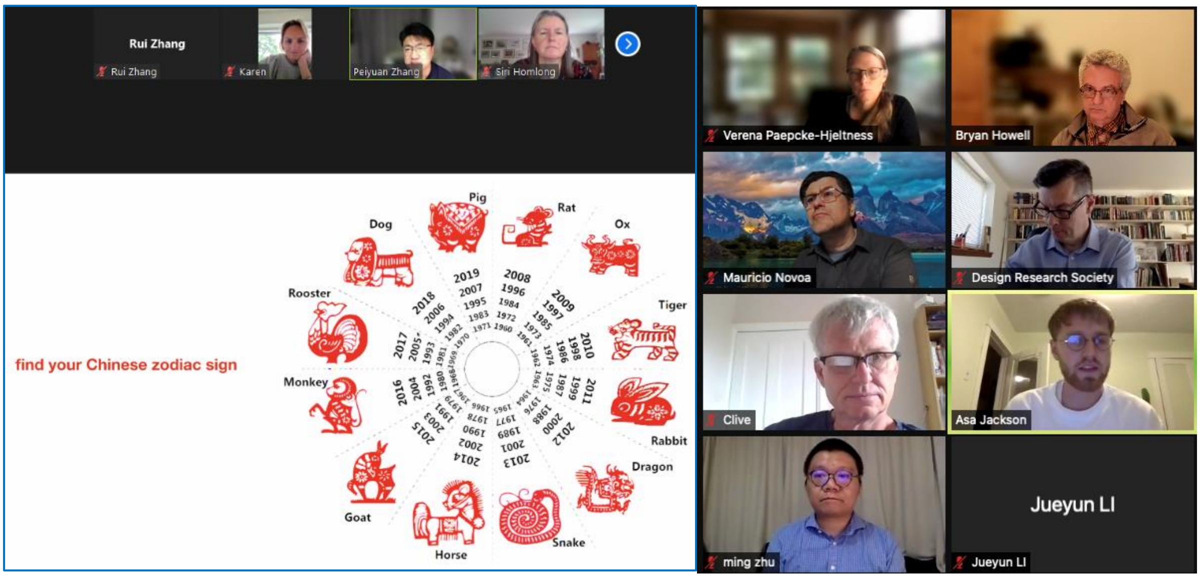

Figure 35. Chinese Zodiac session.

Design education in China was introduced in three break sessions, by Professors: Sun Lei from SUAD; Zhao Chao from Academy of Arts & Design, Tsinghua University; and Zhao Quanquan from Nanjing University of the Arts; describing to the audience how design education is organised at these three top ranking Chinese universities. This was also an opportunity for the conference delegates to meet with scholars from the design

programmes in China.
The SUAD museum, composed of Sun Changlin Art Museum and Oriental Chinese Crafts Museum was presented to the audience in two break sessions. The museum's collection consists of ancient and modern ceramics and stone Buddha statues, traditional folk life utensils, toys, Chinese New Year pictures, embroideries and many more artefacts.

Figure 36. Entrance to the Museum of Folk Arts.

Figure 37. The Museum of Folk Arts.

Figure 38. Introduction to Confucius' Philosophy presented by Professor Junfeng Li.

On the final day of the conference, a presentation was given in the main break session by Professor Junfeng Li titled *Introduction to Confucius' Philosophy*. Confucius is famous for his philosophy because he made many wise sayings in ancient China that helped many people learn about nature, the world, and human behaviour.

All presentations were simultaneously interpreted for the international audience.

The Proceedings

The Learn X Design 2021 conference proceedings have been assembled into 4 volumes. Altogether, there are over 1000 pages of material.

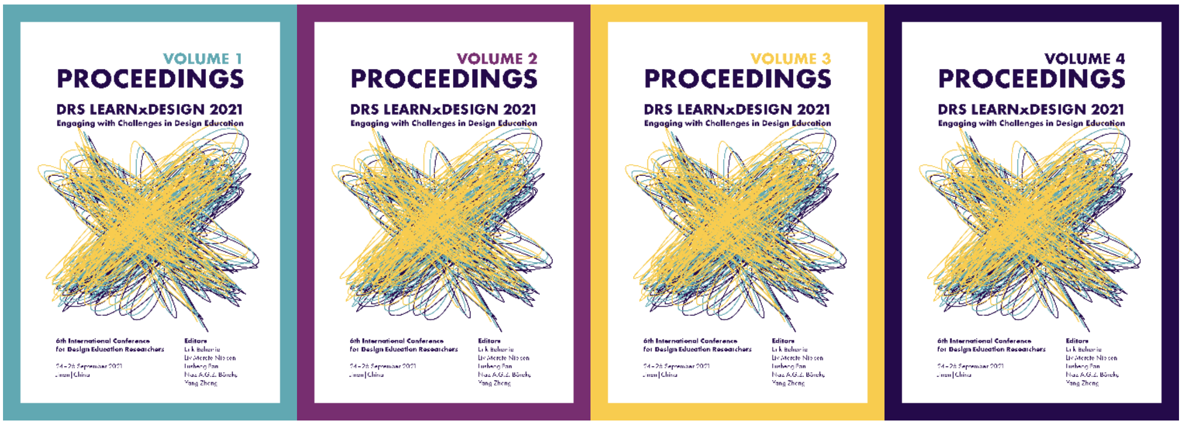

Figure 39. Each of the four volumes' cover pages was allocated one of the conference colours.

The proceedings from each conference reflect how topics have been given priority. Some years the conferences have been further developed and published in special issues of scientific journals. Also, after this conference such special issues will be conducted.

DRS Learn X Design 2021 Community

The conference registration never went on sale as it was fully subscribed, if only the authors and their co-authors of accepted submissions would attend the event. The participation was strictly by invitation only. The invited participants were the authors and their co-authors, the international and the local organising committee members, the track chairs, and co-chairs, 10 bursary holders, and selected scholars based in China.

Figure 40. Call for Bursary submissions (source: Katja Thoring)

Participants from 28 countries have registered. Over 500 people have actively contributed to a variety of roles such as expert peer reviewers (see the list on page ii), authors (see the Index of Authors on page 1077 in the Volume 4), track chairs and co-chairs (see the list on page i), the local planning and organising committees and assistants (see the list on page iv).

Acknowledgment and Special Thanks

As we conclude this editorial, we would like to thank the Shandong University of Art & Design for generously hosting the DRS Learn X Design 2021: 6th International Conference for Design Education Researchers. We would like to thank you to the SUAD Council's for taking the steps to enable diverse scholars from all around of the world to contribute advancing the field Design Education Research by lowering the barriers and to enable participation of scholars from marginalised communities by kindly offering to cover the registration cost for the Track Chairs/co-chairs and Authors/co-authors of accepted submissions, keynotes and those awarded SUAD President's bursaries to attend the conference.

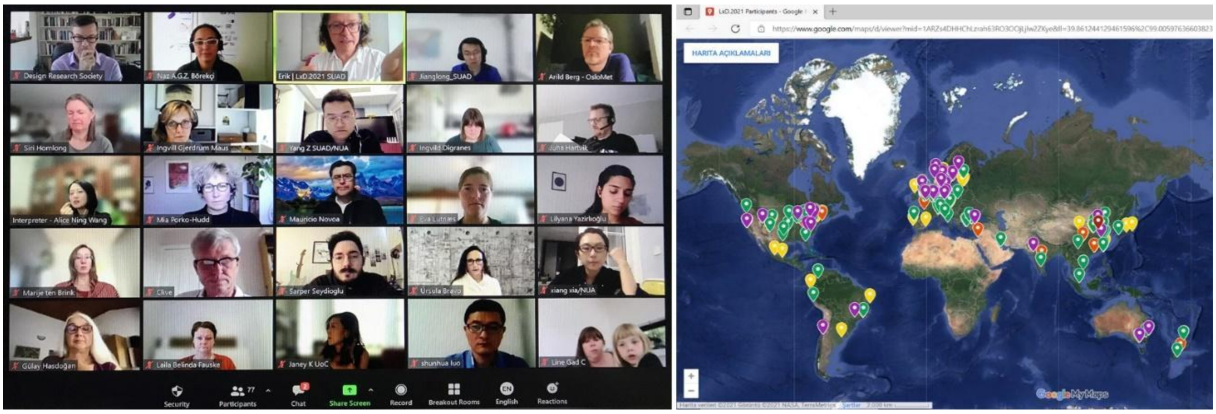

Figure 41. Left: A moment in the conference on Zoom, 26 September 2021. Right: Distribution of the LXD 2021 community across the world, Google My Maps. https://www.google.com/maps/d/u/0/edit?mid=1ARZs4DHHChLzrah63RO3OOjLjlw2ZKye&usp=sharing

We also thank the Design Research Society Special Interest Group in Design Education, DRS EdSIG, for giving us the opportunity and trust to organise it. We would like to thank the General Conference International Planning Committee, International Academic Organising Committee, Patrons of the Conference, International Scientific Programme Committee, and International Scientific Panel for their contribution. We would also like to thank the following institutions that have provided their kind support in the realization of the conference: Design Literacy International Network, Hochschule Anhalt, Hochschule für Wirtschaft und Recht Berlin, Middle East Technical University, Oslo Metropolitan University, The Open University (UK), Tulane University, Universidad del Desarrollo and Åbo Akademi University.

We felt the power of the community with this conference, however online, and found it to be a good opportunity for the community to expand itself in numbers, as well as in knowledge and mindsets. We hope that it has been a fulfilling conference experience for its participants also. We thank the DRS Learn X Design 2021 community for contributing to the conference and taking an active part in its realisation. It is not yet decided who will host the 7th DRS Learn X Design conference in 2023. In line with the previous conferences, we will be very happy to support those who will contribute to the continuity of design education research. Endings for events are never easy, especially when there is a lot of time and commitment involved. Nevertheless, we consider endings to be new beginnings. We will now begin a new decade for the DRS Learn X Design conference series and look forward to meeting with the design education researchers community in 2023.

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Section 06

Learning Through Materiality and Making

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Engaging with Challenges in Design Education
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Track 06: Learning Though Materiality and Making

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When the theme for this track was planned, we were already living in the shadow of the covid-19 pandemic. However, no one could fully fathom its extent and length of time. The pandemic era including emergency remote teaching (Hodges et al., 2020), and research carried out based on the realities that apply from March 2020, have shown that the topics discussed in this track are important.

Track Papers

This track consists of two papers. The two papers show that approaches can become more digital and thus develop the activities. The concrete materials are used as aids for learning.

In the first paper Thinking with Card: Tactile and Making-Based Resources for Active Remote Learning in STEM Subjects, Hughes describes a project corresponding to the need for stimulating active learning through making, suitable for home and remote learning. The aim of the constructed models was to help students understand complex concepts which are difficult to grasp from textbooks or even demonstrations. The physical nature of these resources can be helpful in situations where visual thinking and mechanical skills can enhance learning.

In the second paper Imaginary Museums: A New Approach to the Learning and Assessment of Design History, Jiang and Hughes outline an approach taken to re-establish the status, significance, and implementation of the design history component of a practice-based undergraduate design course. A project was undertaken to revise the teaching material and mode of assessment to be more appropriate for remote learning. The traditional lectures were developed into an online course using widely available video and texts, as well as seminar discussions and support of students' own research. Essay submissions were replaced by a piece of design work through which the research was presented.

Learning With Materials

Nordic craft science stresses the value of learning within material activities and the process of making tangible artifacts in different materials and with the use of a variety of tools (Carlsen et al., 2018; Hasselskog, et al., 2018; Illum & Johansson, 2012). Craft science highlights the importance of activities that aim to develop the student´s ability to handle holistic processes including idea creation and development of idea, planning, and preparation for making, as well as the concrete making of the artifact (Pöllänen, 2009; Porko-Hudd, Pöllänen, & Lindfors, 2018). During all stages of this iterative process self-evaluation and evaluation together with other students are included. In the making of artifacts the student and the tools become a whole as material is transformed into concrete tangible artifacts.

Knowledge, intentions, and thoughts are used and developed in the making and embedded in the artifact, which thus gains a mediating role. In educational settings, this materiality is strongly associated with versatile learning that has denotative and connotative as well as media-specific and media-neutral potential and goals (Lindström, 2009). For example, when planning and making a wooden stool several technical problems occur and need to be solved. The developed solutions increase the individual material knowledge. At the same time, it increases a general problem-solving ability and gives a sense of empowerment in handling unexpected situations. In other words, a media-specific knowledge in wood techniques expands to media-neutral capacity for problem-solving.

The question in our digital age is also how to safeguard the communication in situations where students, teachers, materials, and tools are present. Digital encounters involving people, materials, and tools for the purpose of creating learning are possible, but it has become clear that this form of knowledge inevitably also needs analogous encounters where the material is concrete and tangible, and where different and concrete forms of communication can be used to enable learning. Learning in crafts takes place during a verbal and non-verbal communicative process when students need access to both planned and spontaneous, as well as material guidance from the teacher, and the opportunity to learn from and with other students (Johansson, 2008; Johansson & Andersson, 2017). In local education, the teacher has the opportunity for synchronous supervision, teaching, and reviewing both individually and in groups. In remote education the possibilities for supervision are different e.g., as the teachers' opportunities to challenge students' knowledge, suggest alternative solutions or draw attention to critical points is replaced by asynchronous responses based on the submission of pictures of completed assignments or short reports of completed work steps. Digital resources, such as videos on YouTube or films made by the teacher, are good complements to the teaching, but cannot replace the concrete guidance that the students receive in local teaching.

The two interesting papers in this track raise a discussion about the role of materiality in learning. The pandemic era has brought to the fore the discussion about materiality, digitality, accessibility and communication in learning situations. Porko-Hudd and Hartvik (in press) state in a research article dealing with educational crafts in the pandemic era that versatile communication and access to equipment and workshops are extremely important when striving for the learning that can take place when people, tools and materials interact. Is there a risk with an increasing amount of remote teaching that we lose touch with the tangible material and the learning that exists in making processes where individual ideas become artifacts? This is an important topic that needs to be addressed in future conferences.

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Thinking with Card

Tactile and Making-Based Resources for Active Remote Learning in STEM Subjects

Benjamin Hughes
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Thinking with Card is an online resource that encourages active learning through making activities linked to subjects within core STEM curricula. The (bilingual) resources are aimed at Key Stage 2 and 3 students (UK) and Middle School students (China) (approx. age 7-14). The project was launched in July 2020 in response to the pandemic and corresponding need for stimulating activities suitable for home and remote learning. The free downloadable models can be printed and constructed using simple tools and have shown to help students understand complex concepts which are difficult to grasp from textbooks or even demonstrations (e.g., the relationship between magnetism and electricity, or the function of a four-stroke engine). The physical nature of these resources is also helpful for those looking for active learning approaches that are more inclusive in relation to dyslexia, where visual thinking and mechanical skills come more naturally. The development of future card models has been built into a course module for industrial design students that promotes and enhances prototyping skills.

Keywords: materiality; making; active learning

Introduction

This project was developed in response to the twin issues of reduced opportunity for making activities in the school timetable and the need for engaging learning materials suitable for use both at home and at school (during and post-Covid). According to a constructivist model, students' ideas and understanding are assembled in the mind of the learner, rather than some kind of 'transmission' of the knowledge. It follows that this learning should be supported by rich, well-designed experiences that challenge preconceptions and encourage an interrogation of the material (Driver et al., 1994). The pursuit of a 'rich' learning experience here fits with the model of learning identified by Kolb (2015): "Rich experiences, such as those which change and surprise or use all the senses, are more memorable." (p. 90). These fuel a process of 'Experiential Learning' where reflective observation and abstract conceptualization complement active experimentation and concrete experience (Kolb 2015). While science subjects have traditionally focused on experiments and lab work, there is evidence that genuine enquiry is being replaced by prescribed pattern "cook-book" type experiments that are less effective in fostering genuine enquiry (Hofstein & Lunetta, 2004). An effective substitute has been found in the use of simulations of experiments that provide meaningful representations that are not often possible with real materials. The use of the term 'model' in relation to the teaching of science and maths has multiple uses including abstract, conceptual, analogical, synthetic, mental, concrete etc. but it is clear that the use of tangible, tactile three-dimensional objects form an important part of this area of learning (Eisenberg, 2002). Our interest in developing this project was to provide straightforward, easily accessible activities that could be undertaken with basic tools – providing not only a novel, concrete experience but also an artefact from which students can reflect and further engage in abstract conceptualization.

Workshops with Card Material

Card-based workshops have been successfully deployed in exhibitions as a way of engaging visitors in more active learning about the subject area (Hughes & Milton, 2006), and the potential for their use in teaching has been explored in the past, particularly in relation to areas of topography and mathematical models (Yamada & Kihara, 2017). This strategy was adopted in local workshops for schoolchildren (aged 6-11) in an attempt to promote making skills at an earlier age. Students in China have very little opportunity for hands-on making activities in the classroom and early on we found resistance to our offers of workshops and support in this area. These initial activities focused on making card mechanisms and structures linked to stories and festivals. In some cases the components were pre-cut ready for assembly, and in others the kids had to cut them out themselves before assembly and decoration. While the students clearly seemed to enjoy the activities and developed skills out of them, it was evident that this kind of work was deemed low status, not 'serious,' and best undertaken outside of school time by teachers. This was the catalyst for developing a new approach: to integrate making into the existing STEM curriculum as an 'active learning' aid rather than making for its own sake. This 'Trojan Horse' approach seemed to bear fruit, or at least gain traction with certain teachers. Whilst there is a great deal of pressure on both staff and students in the rigid Chinese education system, it has been acknowledged both centrally and by some enlightened teachers that new approaches are needed if the government's aim to foster creativity and innovation are to be achieved (Tatlow, 2019).

Active Learning

Active learning is a way of engaging students rather than treating them simply as 'receptors,' as is the case with a traditional lecture. Studies have shown these to be comparatively ineffective (Cerbin, 2018), even when combined with demonstrations (Crouch et al., 2004), when it comes to comprehension and long-term memory retention. 'Active learning' may involve reading, writing, discussing, analysis, problem-solving, synthesis, evaluation, but in the simplest terms has been described by Bonwell and Eison as: "Instructional activities involving students in doing things and thinking about what they are doing (1991)." Studies have shown that active learning is a highly effective strategy when it comes to teaching STEM subjects (Freeman et al., 2014). Subjects in this category tend to involve increasingly complex and abstract phenomena of which the student has no prior knowledge and cannot observe in a direct sense. In some subjects e.g., anatomy or chemistry, the use of models is well established and has been clearly shown to aid comprehension and reduce achievement gaps (Newman et al., 2018). In other subjects, the use of models is less well established, and the notion of students making the model themselves is completely novel. From a design perspective, this may be equated with the concept of 'learning-by-doing' with an emphasis on the importance of making.

Thinking with Card Project

This project combines both active learning and card-based workshop strategies with the aim that not only will students reap the benefits of increased comprehension and recall of complex phenomena, but that they will learn and develop practical skills in the process. These include: the safe use of knives, rulers and guides; cutting accurate shapes; accurate folding and construction techniques as well as exploration of basic mechanisms, topology of card structures, geometry, angular dimension and transformation (Huse, Bluemel & Taylor, 1994). These are core model making skills and helpful in a diverse range of prototyping activities. While there exist many more sophisticated and accurate modelling tools, it is widely considered that it is the direct experience of manipulating materials assists the kind of enquiry that facilitates a deeper learning experience (Yamada & Kihara, 2017).

The resource is located on a website, www.thinkingwithcard.com, from which teachers or parents can download a range of models for construction at home or school. The subject areas targeted include physical science (e.g., the relationship between magnetism and electricity, Faraday's Law of induction, Lenz's law and the Fleming Right Hand Rule), life science (e.g., the function of the epiglottis) and earth science (e.g., the processes of photosynthesis and respiration in plants). There are a range of models available in different curriculum areas and all models are available in English and Chinese. The website shows an animated version of each model which can be clicked to access the material needed to construct it at home. Each model includes the parts to cut out and a separate sheet of photo instructions to aid with the construction.

In order to make the models as universal as possible, they are each formatted for output in black and white to sheets of thin (e.g., 200gsm) A4 card (usually three or four sheets per model, including the instruction sheets). This means that they can be reproduced cheaply either at home or at school. Some models are also suitable for printing on paper if card is not available.

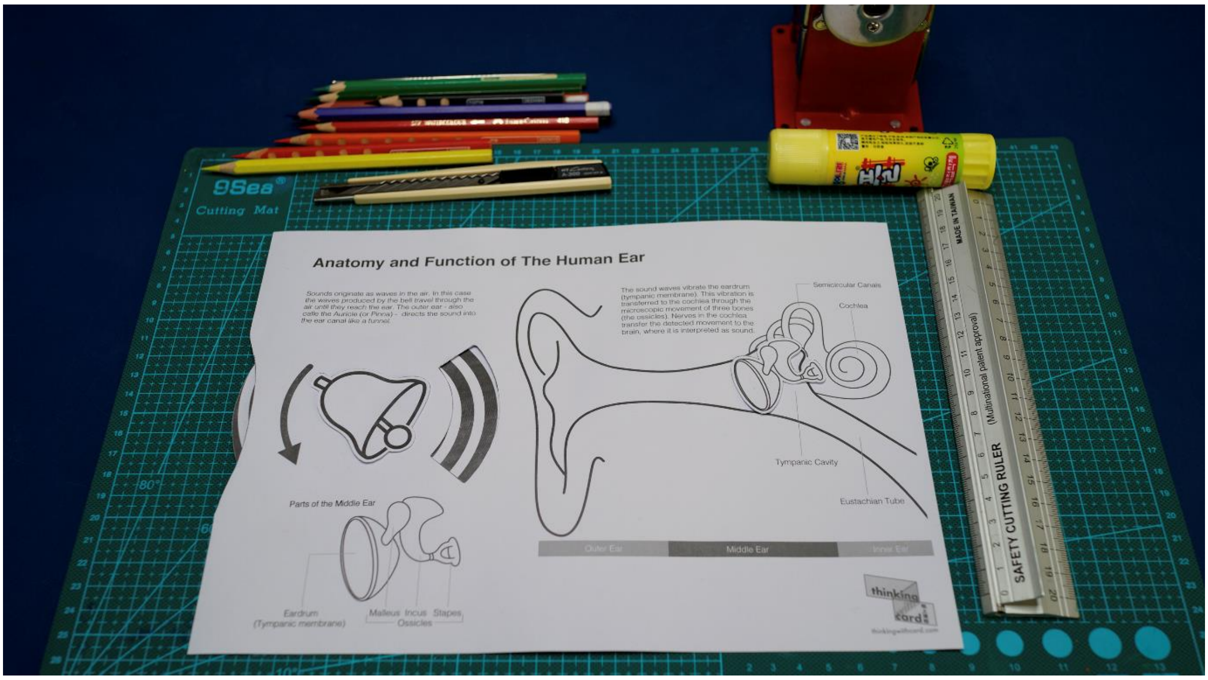

Figure 1. Example of a completed model showing the anatomy and function of the human ear.

Long Term Development of Project Material

A secondary area in which the project is being developed is in the development of the resources themselves. By establishing a standardised format and systematic means of communicating the models, we have been able to create a module for undergraduate and postgraduate students through which new models can be added to the resource. The identification, creation, refining and testing of the models is a deceptively complex challenge and a very rich learning experience. The use of card models is a central focus of the International Design Centre and one that has helped students develop a more hands-on approach to their work. This has been recognised as a crucial skill for designers (Yoshihara et al., 1991), but one that is not widely taught or implemented in China. At the beginning of the module, students are introduced to the project and then taken through a series of workshops to develop their skills in basic model making with card. They are then asked to identify an area of the Middle School curriculum on which they would like to focus on and are then supported through the conception, design and refining of card models in that area. A bid has been made recently to create an online MOOC version of the course which could be used to widen the scope of the project and generate further content.

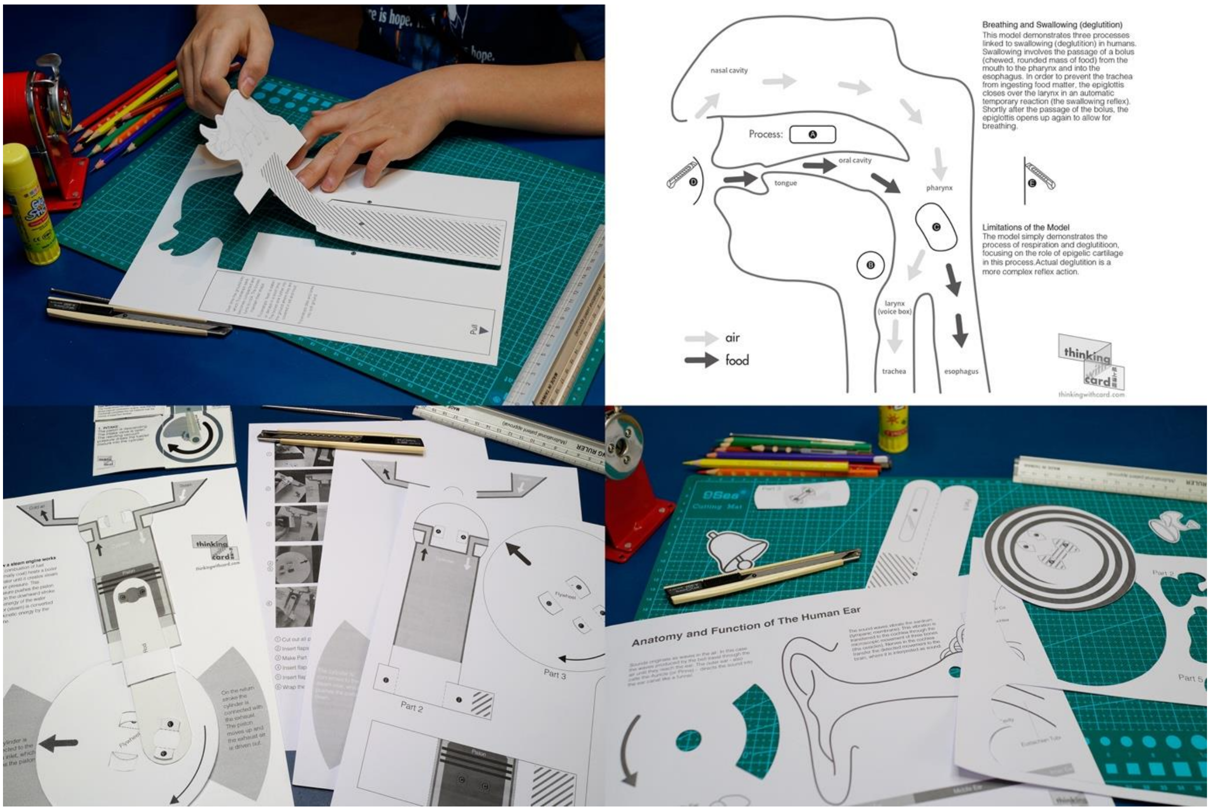

Figure 2. Some details of the resources, and instruction illustrations from the Thinking with Card resource.

Figure 3. Examples of the Thinking with Card resources and workshops run with students.

Testing and Conclusions

This project is in its early stages, but we have been successful in running several workshops to test the strategy on a local basis and obtain informal feedback from teachers. The workshops took the form of guided tuition in the building of the models held either in the design department or at a local school. Students attending were between 6-11. This is slightly lower than the target for the resources (7-14) but enabled us to gauge the level of interest amongst students, parents and teachers as well as to understand any difficulties experienced in making particular models. It was frustrating that the models of most interest to designers - those with the most complex and surprising mechanisms - were not always the most successful in terms of feedback from our teachers. The desire to create the kind of 'rich' learning experiences described in the introduction is a fun and challenging brief for most designers. Bringing life to static concepts and theories that might inspire a student is a great source of motivation. Without a comprehensive study to gauge students' reactions to the material, we only have some limited feedback from teachers. To date, some of the most positive feedback we received in this form was for a series of geographical study aids illustrating the different temperature and climate zones through the Chinese land mass. These are a complex series of maps with similar information that need to be memorised by each student. Perhaps the closest in form to existing standard textbook diagrams they are the least surprising models we created. Clearly the teachers recognised that the opportunity to not only draw the maps, but also to cut them out and be able to interact with them was an aid to comprehension and commitment to memory. It is exactly this kind of active learning that has been shown to enhance long-term memory retention, so it is encouraging to receive this feedback from teachers. There is a suspicion, however, that the teachers' enthusiasm was more down to the fact that the material might help students retain information needed to pass exams rather than fuel genuine interest and enquiry. This is indicative of the gap remaining in attitudes towards education in general. A fuller picture of the situation can only be found through production of further examples and more extensive testing. We still feel that there is a huge benefit to be gained from using card models to simulate and explain more complex phenomena particularly from the areas of life science and physical science. In relation to this, we are working with local teachers from the relevant subjects to advise on the format of the models.

Alternative Learning Styles, Card Models and Dyslexia

Dyslexia is not well recognised or diagnosed in China and discussion is generally limited to the effects in relation to the memorisation of Chinese characters rather than its wider impact on learning (Lin et al., 2020). Discussion with dyslexia specialists in the UK, however, suggests that the Thinking with Card strategy may be particularly helpful to dyslexic learners who respond well with visual and physical material. The models could help these students in the development of schema and visual memories that are more practical in relation to cognition and recall than text. These models of cognition are vital when it comes to the three stages of learning described by Mortimer (2008, p.124):

1. Getting the information in – modes of presentation
2. Processing the information – storing and retrieving
3. Getting the information out – modes of expression

This is an area that we intend to explore further in the future either by testing with dyslexic students and/or by taking advice from specialists in this area over the development of the resource.

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Imaginary Museums

A New Approach to the Learning and Assessment of Design History

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This paper outlines an approach taken to re-establish the status, significance, and implementation of the design history component of a practice-based undergraduate design course in China. The format for delivery and assessment were found to have stagnated into a curriculum module widely regarded as of peripheral interest. A project was undertaken to revise not only the scope of the teaching material so that it was more appropriate for remote learning, but also the mode of assessment. The traditional lecture format was replaced in part by an online course, augmented by widely available video and texts. In-person teaching was switched to seminar discussion and support of students' own research. In encouraging students to undertake research outside of the presented material, the course was able to shift the focus from the regurgitation of information to that of a more authentic enquiry. Essay submission has been replaced by a piece of design work through which the research may be presented to a new audience.

Keywords: design history; reflective practice; materiality

Introduction

The teaching of Art (and later, Design) history has long been the subject of debate in terms of the role it should play in more practice-based courses, as well as how best to enable the learning of students who may not be confident or proficient in writing (Huppatz & Lees-Maffei, 2013). Design History (along with other contextual studies) frequently has to contend with a lack of integration and perceived low status in relation to other 'core' components of a course, such as acquiring practical design skills or completing project work. As a result, there have been many attempts to overhaul the delivery of Design History content in design courses in recent years (Howell & Christensen, 2013). These often focus on bringing the material out of the lecture theatre and into a studio environment. While this acknowledges the difficulty many students have in relating to their own work to a contextual or historical perspective, the method of delivery and assessment of such courses does not tend to deviate from the standard slideshow lecture and essay.

It would be wrong to assume that this was a new issue. A major influence on the current structure of design courses was The National Advisory Council on Art Education (NACAE) in the UK, formed in 1958. Despite advocating the importance of art and design history in their first report (1960), by the time of their fourth report (1970) it was clear that the manner of this component's relationship to a student's practical study was still not yet fully understood. It is interesting that a report which has generated so much controversy over the years was surprisingly loose in its recommendations, but one aspect that was clearly expressed was that the History of Art (and design) should be integrated as far as possible into the curriculum, not siloed as a separate area of study (Coldstream, W. 1970).

The subject of this paper is an attempt to enrich the learning experience for first year undergraduate students who are encountering design history for the first time. The authors were responsible for the teaching and assessment of the course. While the content and delivery retained much from previous years, the scope of enquiry was widened significantly and a key objective was to remove the requirement for students to write an essay at the end of the course. In its place was a brief to design a museum experience. At the end of the process, students were asked for their thoughts and reactions in relation to the course to determine its success.

Background to the Problem

The fact that historical and contextual studies have traditionally been delivered outside of the studio environment by specialist teachers has understandably led to these elements becoming easily separated from students' principal area of focus and for unnecessary divisions to occur (Coldstream, 1970). Despite the original aims, and broad consensus around their importance, decades later the same conversations are being had regarding the integration of these complementary studies into the broader scope of students' learning. While the area of Design History has grown into a relatively mature discipline in its own right (Margolin, 2009), the discourse and patterns of understanding remain alienating to many students who are used to the studio patterns of exploration and critique (Raein, 2004). The teaching of these components remains largely confined to darkened lecture theatres and chronological slide presentations of objects and images. This is particularly true in China, where course components dealing with discrete areas of knowledge such as design history, are often derided as 水课 (shuǐ kè, water course), a slang term evoking 'going through the motions,' - an unavoidable necessity that requires no meaningful engagement on the part of teacher or student (Wang 2020). In common with other requisite complementary subjects, these are generally taught along narrow, prescribed lines to large groups of students in lecture theatres. The design history curriculum itself tends to fit an accepted narrative, focused principally on translated texts written in Europe and North America. These begin with the industrial revolutions in those countries and move through an accepted narrative of mechanisation and mass-production, periods of aesthetic and philosophical importance such as the arts and crafts, the Modern movement, the professionalisation of the discipline and maybe some more recent examples of design theory. This is a pragmatic approach from the point of view of delivering something that is both relatively contemporary and manageable and useful, but also a problem because it excludes so much that may be of relevance to a contemporary Chinese student audience including the history of innovation and aesthetic evolution. Walker (1989) proposed a distinction between the 'History of Design' and 'Design History,' but this does not seem to be well understood or widely implemented. Some accounts begin with the flint tools of prehistory, others with the mechanisation of production and the permanent separation of design activity from either craftsman or factory worker. Clearly both are valid, but the former is such a vast area, it needs somehow circumscribing so as not to become overwhelming or irrelevant. If the purpose of including contextual design history into more broad design programmes is to engender thoughtful, reflective and challenging practice amongst students (Huppatz & Lees-Maffei, 2013), then it follows that the student themselves should some influence in where these boundaries of enquiry lie. This critical approach has been suggested in the past by Victor Margolin (1996):

> *…a successful history of design for design students must contain elements that will be particularly meaningful to them. At the same time, students must understand that the story they are encountering is not the only one; other ways of interpreting the history of design are also possible. (p. 3)*

This interpretation gives far more scope for the student in terms of potential for their own research than the regurgitation of a 满堂灌 (mǎntángguàn, "Chalk and Talk") lecture series. This would generally be in the form of an essay assignment for which students are given little support and which is extremely time consuming to assess. The entire process, along with many aspects of art and design education in China, is considered laborious and inescapable (Yue, 2009). It is this context in which the project is situated, having arisen from four issues raised by staff regarding the course in the past:

1. Frustration around the poor integration of design history knowledge into students' practice;
2. The inadequacy of the essay in terms of a demonstration of learning;
3. The canon of Design History presenting little opportunity for genuine investigation and research on behalf of the students taking part;
4. The difficulty and delay experienced in effectively marking nearly 100 essays.

Revising the Course Structure

Following staff consultation, it was decided to overhaul the design history course to both expand the range of their understanding of design history and to explore alternative means of demonstrating this knowledge. The course in question is a three-week general Design History Course delivered during the first year of a four-year undergraduate course. It is attended by students following pathways towards qualifications in Industrial Design, Graphic Design, Craft and Applied Art. The focus is on providing students with an overview of Design

History from various perspectives and involve a degree of personal research into a specific area. Students were supported through a series of topics from “Design Before 1850” including design from both Chinese and European Ancient history, to “New Trends in Design” including artificial intelligence and automated systems. While seminars were conducted partially in person and partially online, much of the narrative content was delivered through a series of 10 online lectures by 何人可 (Hé Rénkě) a well-known Professor of Design and Dean at Hunan University (He, 2019). These cover the same wide timescale from pre-history to the 21st Century and are a concerted attempt to integrate at least a degree of Chinese industrial heritage into an accepted narrative of design history. Students were given reading lists of relevant books which were available to them in the library and encouraged to view documentaries that cover specific areas of design history such as the series produced and directed by Gary Hustwit: Helvetica (Hustwit, 2007); Objectified (Hustwit, 2009) and Rams (Hustwit, 2017).

In previous years the standard was to require students produce an essay to demonstrate the accumulation of knowledge. Tutors’ experience of this was that the essay task was reluctantly undertaken and proved difficult and time-consuming to assess. It normally involved the regurgitation of some part of the information delivered in lectures and was a poor indicator of learning taking place. In order to promote some genuine and novel enquiry, students were tasked to undertake a more detailed exploration of a relatively narrow (and self-determined) area of design history. This enabled the scope of the project to move beyond accepted chronologies and narratives and include interests and influences closer to home. In communicating their research and findings, rather than write an essay, students were asked to design a museum dedicated to the area of design history on which they were focused. This format served several purposes:

1. Students had to negotiate and decide on a topic of study. In many cases this may have received little or no coverage in the standard lectures, so they had to develop and execute their own plan of investigation and enquiry;
2. Students were required to think carefully about how to re-tell their story in a form other than the one they had researched;
3. Students had to confront their conception of what constitutes a museum;
4. In designing the museum and communicating this though models and a short movie, students had to consider how the story they wanted to tell could occupy a three-dimensional space and how this would be interpreted by a notional audience.

Students were exposed to multiple examples that challenged their generally stereotypical notions of what constitutes a museum and asked to think about such an institution in the broadest possible terms using examples of diverse thinking in the sphere of museology (Storrie, 2006). This gave rise to a broader discussion about the nature of museums and the shifting definitions that remain open to debate ever since the founding of the International Council of Museums (ICOM) in 1946 (Soares, 2020). This gave students the necessary confidence and freedom to move away from their preconceptions of museum architecture, contents, narrative and communication, and experiment with each element to a fuller extent.

Project Brief

Following an introductory course in Design History, groups of 3 students were asked to identify (in consultation with their Professor and tutors), plan, and conduct detailed research into an area of design history that they found interesting. In making this choice, students were prompted to consider the history of design through 5 different lenses: Technology in Design; Movements in Design; National and Global Cultures of Design; Companies and Collectives; and Individual Designers. The exact content and focus for the research phase were not fixed but students were provided with context and examples in each area from which a ‘map’ could be built of their knowledge. The findings of this research should be retold in a concise form as a hypothetical museum setting. Students were then asked to design the museum and communicate the experience of ‘visiting’ the museum through a short movie of maximum 3 minutes in duration. The film could incorporate live action, stills, models, 3d renderings, narration or any combination of these elements.

Students were given support through seminars to discuss the choice of research area, research methods and communication strategy. The aim was to create a diverse body of work rather than proscribe a particular outcome, solution, or ‘correct’ answer.

Outcomes of the Project

From over thirty submissions, four examples are presented below which give a representative cross-section of the outcomes received. Around half the submissions were entirely screen-based, whereas the other half were based on objects made by the students. This outcome was partly based on the confidence of students in 3d computer visualisations and partly on the encouragement to make physical models where possible.

Figure 1. "A Thousand Explorations of the Modern Movement," student work submitted in response to the revised Design History course.

An Exploration of Industrial Aesthetics

This submission was configured as a compact interior with multiple levels and rooms. Visitors enter on the ground floor and follow a labyrinth-type path through the history of modernism. The overall theme takes its inspiration from the De Stijl movement, with rectilinear blocks of colour framed by thick black lines. This style - used in painting, printmaking, architecture and furniture design by the likes of Piet Mondrian, Theo van Doesburg and Gerrit Rietveld provides a backdrop for the exploration of the wider themes of the modern movement. Tutors felt that this was a thoughtful way to achieve a more immersive experience as opposed to the sparse and caption-heavy exhibitions they were used to. Students had put a great deal of work into making scale models not only of the environment but also many of the objects within. It was evident that doing so had required a thorough and detailed understanding of the subject. This tangible link between the history of the discipline and making was felt to be a particularly strong outcome of the project.

Figure 2. Chinese Architectural Museum, student work submitted in response to the revised Design History course.

Chinese Architectural Museum

This museum was designed and developed inside the Minecraft platform (in common with two other submissions to the project). The visitor enters the museum through a city gate and is accompanied by a guide during the exploration. The museum features palaces, temples, theatres and gardens from various periods in Chinese history. Despite the rudimentary nature of the modelling and rendering within Minecraft, these buildings give a surprising level of detail in terms of layout, spatial experience and structure. Elements such as the building function, brickwork, roof details and 斗拱 (Dǒugǒng, 'supporting roof brackets') are explained in context and give a good overview of the material. More detailed information and maps of the museum are included on noticeboards throughout. The tutors felt that this was a clever interpretation of the brief and intriguing use of the technology. Whilst only realised in part, it was felt that this kind of museum was both entirely plausible and effective in its aims. The Minecraft format has a charm that is helpful in introducing a subject that some might otherwise feel was boring. The Education edition is used extensively for similar interactive and collaborative projects, in some cases also in relation to Chinese history. In 2017 a group of teachers developed an interactive game based on the Palace Museum ('Forbidden City') in Beijing. This was used to introduce secondary school students in Hong Kong to ideas and events during the Ming and Qing dynasties through first building the palace and then undertaking a series of tasks around it. (Zhu & Heun, 2017)

Figure 3. Museum of Dadaism, Student work submitted in response to the revised Design History course.

Museum of Dadaism

This museum is also created in the Minecraft environment but takes the form of a more traditional experience within a virtual building. The location takes the form of a monumental ziggurat-shaped marble building set in a formal landscaped garden. This was an attempt to present the figures and activities of the Dada movement in an absurd context and therefore in keeping with the creative strategies embodied within it. This example is less fully resolved than example two but nevertheless allowed the students to experiment with form in a way that a conventional essay could not do. The choice of Minecraft as a platform is clever in that it can be quickly realised without too much specialist knowledge. Tutors felt that the students had understood and the Dada movement clearly and expressed their research findings in a clear and comprehensive way. To demonstrate the absurd through a piece of architecture or design is far more difficult, and far more valuable to a designer as a learning experience, than merely describing it. This, the tutors felt, was a good example of the kind of multi-level thinking that they were trying to bring to the course.

Figure 4. "A Book of Designers," Student work submitted in response to the revised Design History course.

"A Book of Designers"

This submission reimagined the museum as a pop-up book. This was felt to be an extreme interpretation of a museum, but acceptable given the freedom provided in the brief. It is also the case that the book provides a three-dimensional representation of the subject and so fulfils the requirement in relation to the spatial element. In the book designers, objects and environments are all rendered in three-dimensional space and allow for an exploration of ideas and aesthetics without the rigid format of an essay. Tutors felt that this submission was lacking in focus and could be more resolved in terms of a consistent style but that the overall concept was effectively communicated and worth pursuing as a model for representing design history in the future. The range of topics was relatively wide so that no one area was really exposed in any depth. This more superficial exploration and analysis of the subject means that it is less easy to present something with a novel or engaging narrative - the story has been told too many times before. Nevertheless, the mode of delivery meant that it was easier to give this feedback and for the student to understand where the project may have been improved. This is much more difficult to achieve in an essay format where the bar can be exceptionally low in terms of novelty or engagement.

Feedback and Findings from the Project Experience

Following the completion of the project, students were asked to complete a questionnaire regarding their experience. 94 students undertook the three-week project and subsequently completed the questionnaire three weeks after their assessment through an anonymous, online platform. Questions were designed to expose students' individual learning experience and determine whether they considered it a valuable and worthwhile exercise. The results are collated below.

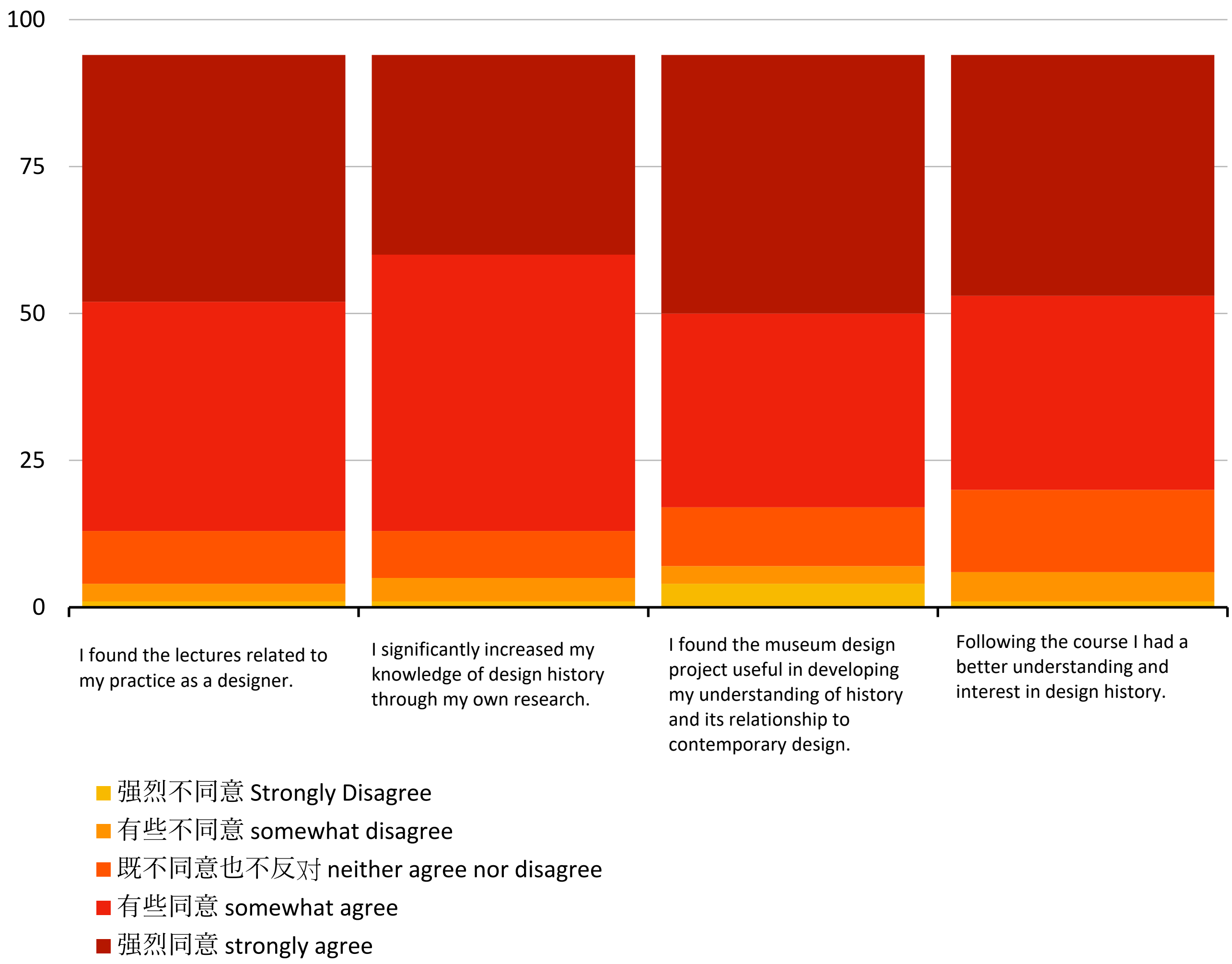

Figure 5. Student Feedback in Graphic Form. Actual percentages may be found in Appendix 1.

From these answers it is apparent that students found the revised course to be a worthwhile experience. Without equivalent results from a control group following a conventional design history course, we do not have any direct comparison. There are also difficulties in comparing assessment outcomes across year groups because the protocol in China is to employ a bell-curve grading system whereby a student's grade is in relation to their peers' performance rather than a particular standard. However, it should be noted that the course is traditionally unpopular amongst students and considered very laborious to assess by staff. The revised course was successful in turning this perception around and garnering enthusiastic responses from students. Tutors noted their experiences and observations in running the project and were interviewed in relation to this paper.

Conclusions

Design as an activity and discipline seems destined to permanently wrestle with its inherent ambiguities. These are particularly acute when considering the area of design history and how it is taught in higher education. The processes and outcomes of design merge with professional, aesthetic, philosophical and cultural values in an uneasy mix that is both essential but lacking in any established model (Dilnot, 1984). Rather than present a solution to the multiple inconsistencies inherent in the discipline, this project aims to relocate the material in a context that is more accessible to the audience and more malleable and open-ended in terms of outcomes.
The key elements of this revised curriculum component are twofold: firstly, the freedom for students to conduct their own research into an area of design history that may not conform to existing confined narratives and secondly, the ability to present these in a three-dimensional form rather than a written essay. The strategy of this approach is that additional freedoms will appeal to the instinct of the designer to re-invent and search for fresh means of representation.
The feedback from tutors and students appears to support this in relation to the revised design history course.

The questionnaire goes some way to representing the experience. Tutors felt that not only did students engage more readily with the presented material, but they were more ambitious in their own research and more inventive in seeking novel outcomes for the project. The delivery format successfully taps into students' desire to find new ways to express themselves in their work and was also notable in its ability to accommodate a range of different media, from model making, to virtual environments to card modelling and collage. Not only was this output more efficient in terms of the time needed for assessing each submission, but the outputs were more accessible amongst groups of students. This had the effect of raising expectations amongst students where an essay submission is not generally read by other students. It also helped with the assessment feedback process. It is far easier to make comparisons between physical and visual submissions than written ones and this helped students to understand and appreciate where their work might have benefited from more research or more development. The questionnaire suggests that a considerable proportion of students (86%) either agreed, or strongly agreed, with the statement that they had significantly increased their knowledge of design history through their own research. The authors believe that this approach is an appropriate implementation of the principles of active learning (Bonwell & Eison, 1991) which are of particular importance to design students. In addition, the strategy fits with the Design Centre's approach of 'Practical Design Education.' This aims to place physical design activity at the centre of all aspects of the curriculum in order to multiply the opportunities for engaging with the potential of design process in all its forms. It is a novel philosophy in China, where higher education continues to be led by assessment-driven learning models that are dominant in the school system.

The success of the project is not only significant for students taking part, but in the confidence is gives the staff team to implement further changes in the future. It demonstrates the potential for innovative curriculum revision that can enhance the learning experience for both students and staff.

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Appendix 1 - Questionnaire Results

Below are the results of the questionnaire. These were answered on an online form by all students taking part in the project. The questionnaire was circulated 6 weeks after the end of the project in order to give students time to reflect on the experience.

Q1: I found the lectures related to my practice as a designer:

选项 Choice	小计	比例 Proportion
强烈不同意 Strongly Disagree	1	1.06%
有些不同意 somewhat disagree	3	3.19%
既不同意也不反对 neither agree nor disagree	9	9.57%
有些同意 somewhat agree	39	41.49%
强烈同意 strongly agree	42	44.68%
本题有效填写人次 total number of responses	94	

Q2: I significantly increased my knowledge of design history through my own research:

选项	小计	比例
强烈不同意 Strongly Disagree	1	1.06%
有些不同意 somewhat disagree	4	4.26%
既不同意也不反对 neither agree nor disagree	8	8.51%
有些同意 somewhat agree	47	50%
强烈同意 strongly agree	34	36.17%
本题有效填写人次	94	

Q3: I found the museum design project useful in developing my understanding of history and its relationship to contemporary design:

选项	小计	比例
强烈不同意 Strongly Disagree	4	4.26%
有些不同意 somewhat disagree	3	3.19%
既不同意也不反对 neither agree nor disagree	10	10.64%
有些同意 somewhat agree	33	35.11%
强烈同意 strongly agree	44	46.81%
本题有效填写人次	94	

Q4: Following the course I had a better understanding and interest in design history:

选项	小计	比例
强烈不同意 Strongly Disagree	1	1.06%
有些不同意 somewhat disagree	5	5.32%
既不同意也不反对 neither agree nor disagree	14	14.89%
有些同意 somewhat agree	33	35.11%
强烈同意 strongly agree	41	43.62%
本题有效填写人次	94	

Section 07

Sketching & Drawing Education and Knowledge

LEARN X DESIGN 2021
Engaging with Challenges in Design Education
6th International Conference for Design Education Researchers
Shandong University of Art & Design | Jinan, China

Track 07: Sketching & Drawing Education and Knowledge

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Design sketching and drawing (education and knowledge) are inherently visual and multimodal (cognitive coding) and rapidly evolving in contemporary culture. Today, sketching and drawing research in design education is primed for reinterpretation and new contextualisation. Discussions about analogue and digital sketching, live and online education, traditional and emerging visual domain contexts, generative and explanatory visual knowledge, and emerging technology tools and methods have seeded the ground to reassess our relationships with the role and values of sketching, drawing education, and visual knowledge in general. This track includes three articles and two workshops that explore these emerging trends. The first article is a visual paper (a non-written academic output) and explores the power of sketchnoting and visual knowledge as taught to first-year design students. The second paper is a case study examining how a hand-drawing course was successfully converted to a hybrid digital/analogue, live/online course during the COVID pandemic. The third paper explores the experiential reading differences between and visual (sketched) and verbal (written) research articles. Our first workshop explores how emerging virtual reality (VR) technologies are changing traditional design workflows. Workshop participants will ideate, sketch, simulate, and produce a 3D-printed artefact. Our second workshop will utilise Miro, an emerging robust visual-based tool that helps users organise their content wholistically. Participants will visualise a research project and enable collaboration opportunities using the tool. Sketching, drawing, and visual knowledge are rapidly evolving, and the contributions from this track should expose design educators to current thoughts and activities that demonstrate these changes.

Keywords: design education; distributed collaboration; visual papers; sketchnoting; online drawing

Introduction

As designers, visual knowledge, or mental imagery, is arguably the primary sensory modality that informs our cognitive coding and, in turn, meaningful learning and decision making. We are also proficient in processing external experiences through our other sense modalities, such as auditory, haptic, gustatory, and olfactory. These multiple modalities of interpreting experiences ("multimodal") inform our cognition, memories, and learning to create "nested" or "hierarchical" mental codes in our minds that establish "wholistic" associative structures of knowledge (Sadoski, 2013).

Designers are also trained to communicate visually; we see, sketch, draw and perceive; edges, spaces, relationships, light and shadow (contrast), and the whole (gestalt). The basic skills of drawing “are not drawing skills… they are perceptual skills” (Edwards, 2012). Our wholistically informed perceptions enable us to comprehend, interpret and structure artefacts, interfaces, experiences, and services when compared to typical written academic outputs.

In contrast, written academic publications represent "linear" associative knowledge structures, where knowledge rationally aligns in a prescriptive order. Currently, the preponderance of design-centric research disseminates in text format reflecting the long-held psychological position that 'the language of thought is "unimodal" and abstract, reflecting a process of internalised words and sentences' (Paivio, 1991). These written academic articles and journals reflect centuries of tradition. They also constrain knowledge-generating methods to individuals and outputs innately aligned with the written languages' unimodal/linear mental representations.

The primary distinction between the verbal and nonverbal cognitive processes, as discussed, is that they organise and transform information differently. The verbal system generates 'sequential' structures of complexity (phrases, sentences), while the nonverbal system generates transformations on (a) 'spatial dimension' (size, shape...), (b) sensory properties (colour, sound, touch…) and (c) movement (time, motion…) all elements that can be expressed in a drawing or sketch, Fig. 1 (Paivio, 1991).

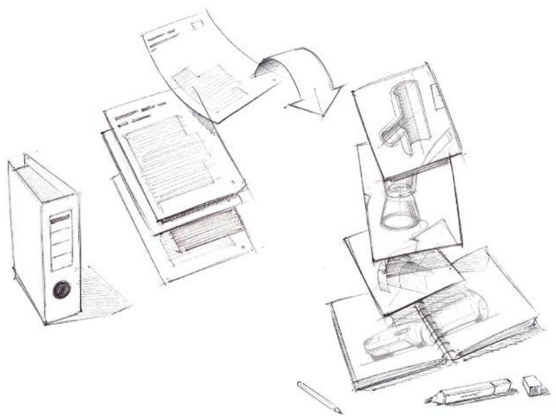

Figure 1. Written versus visual information (sketch by Hoftijzer)

Design sketching and drawing (education and knowledge) are inherently visual and multimodal. Designerly acts of drawing externalise thoughts through aesthetic, behavioural, cognitive, and communicative functions (Tversky, 2011) and effectively and accurately share nonverbal knowledge with a diverse audience. Drawing also supports two purposes: exploration and creativity, and, explanation and communication (Hoftijzer et al., 2019, Hoftijzer, 2018) which are primary goals of academic outcomes. Furthermore, cognitive experiments have demonstrated that human learning, memory, and thought are multimodal and can be amplified through imagery (Paivio, 1991).

Given that imagery plays a significant role in cognition, it is not surprising that design academics have begun taking advantage of digital technology advancements that allow multiple forms of coding to disseminate their research outcomes and expand the role of sketching. By utilising visuals, researchers increase their ability to think, explore, structure, develop, reflect, communicate, and disseminate their findings in journals and conferences globally. For example, this year's LXD conference welcomed, for the first time, visual research outputs (non-written output) in most of the conference tracks.

Paper Contributions

For the 2021 Learn X Design conference, track 7 - Sketching and Drawing Education and Knowledge has welcomed one visual and two written papers and presentations along with two workshops addressing how design sketching and drawing education and knowledge are evolving.

The first paper, entitled "Sketchnoting Experience of First-Year Students" by Verena Paepcke-Hjeltness, Annaka Ketterer, Ella Kannegiesser, Madeline Keough, Victoria Meeks, and Ayla Schiller, is a visual paper demonstrating a thoughtfully drawn and communicated research outcome relying primarily on sketched images rather than words. The paper provides an overview of sketchnoting, what it is, how it's used, and provides student examples of its use in Math, Sociology, and Chemistry courses. It builds on the hypothesis that sketchnoting positively influences learning and study behaviours, academic performance and engages individual creativity and productivity. This paper demonstrates how engaging multiple modes of cognition and sketching skills benefits an individual beyond the traditional uses of artefact/form-based sketching knowledge.

The second contribution, "Online Comprehensive Teaching on Digital Hand-drawing" by Ming Shu, addresses the experience and tools utilised in converting a live hand-drawing course to an online course due to the COVID pandemic. It discusses some of the challenges and, more importantly, the benefits of a new hybrid online drawing educational experience. The emergence of software and online tools has enabled drawing tutor's new methods of analysing and evaluating student drawings and demonstrating drawing principles. Through a combination of live and digital presentations, this new hybrid method of sketching and drawing instruction will have a long-term impact on educational methods. This paper will also introduce global design educators to online digital tools in China that might not be readily available in Western countries.

The third offering, “Exploring the Experiential Reading Differences between Visual and Written Research Papers” by Bryan Howell, Asa R. Jackson, Henry Lee, Julienne DeVita, and Rebekah Rawlings, is a qualitative case study assessing the experiential reading differences between a visual/pictorial and a verbally written research paper. Survey participants were recruited from design, engineering, and business domains. The survey incorporated questions based on a “think, feel, and do” structure. Did you “think” the paper's content is coherent, clear, precise, and succinct? Did you “feel” your reading experience was pleasurable, satisfying, did it convey confidence, and was it interesting, or was it irritating, frustrating, and distracting? What will you “do” with the content you read, will you cite, share, or personally apply it? The study included a comprehension quiz and tracked reading time and the number of times content was revisited. When results were averaged across all participants, the results were similar. However, when results were assessed by discipline, the data indicated distinct differences in reading experiences. Visual papers were received similarly by all disciplines, and written papers exposed tangible differences between disciplines. These results reflect Hamilton’s findings (2019) that fundamental differences exist in how different disciplines view and understand the world. Could this outcome reflect the differences in verbal and nonverbal cognitive processes and how they organise and transform information differently? Does the wholistic approach to communication of a visual paper enable less interpretation or a unified understanding of the content? Was the verbal paper poorly organised in a linear, rational order? What role does disciplinary training have in establishing cognition traits? This study exposed more questions than it answered, providing an abundance of fodder for future studies.

Workshops

The first workshop, “New Immersive Workflows for Design and Production” by Mauricio Novoa Muñoz, Wendy Shang Jose Manuel Rodrigues, Bryan Howell, and Jan Willem Hoftijzer, introduces improvements to distributed collaboration for ideation, sketching simulation, and 3D printing using immersive virtual reality (VR). This workshop is designed to discuss, collaborate, share and experience how traditional and emerging technologies can combine to create improved ideation, sketching, simulation, and production, design workflow. Participants will experience (or witness) how sketches are transferred into a virtual reality program, developed into a 3D simulation, and printed in 3D. Workshop leaders will be distributed in Australia, the Netherlands, and New Zealand, demonstrating the flexibility of the new technology. Participants will be invited to share their own experiences in implementing new technologies in their educational settings.

The second workshop, “Visualising Your Knowledge and Connecting the Dots” by Verena Paepcke-Hjeltness, helps participants create visual maps to uncover shared interests for future collaboration efforts. Participants will utilise Miro boards to sort and share knowledge. Miro is another emerging digital tool that helps users organise memories and data to create nested, hierarchical coding to establish wholistic associative structures of knowledge. Participants will apply metaphors to their research projects with the aim to foster collaboration with other designers. Verena explains that knowledge can be, at times, so coded in a discipline-specific language, that it is not accessible to other disciplines. Making this coded knowledge visual and discoverable by others through visual conversations provides a method for conference participants from diverse backgrounds to identify opportunities for collaborations and discussions, Fig. 2.

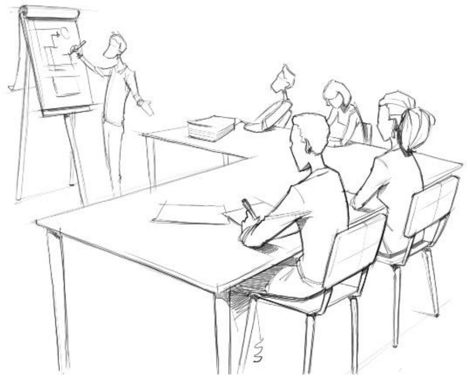

Figure 2. Workshops that concern noting and sharing visual knowledge (Sketch by Sypesteyn)

Final Remarks

Today, sketching and drawing research in design education is primed for reinterpretation and new contextualisation. Discussions between analogue and digital sketching, live and online education, traditional and emerging visual domain contexts, generative and explanatory visual knowledge, and emerging technology tools and methods have seeded the ground to reassess our relationships with the role and values of sketching, drawing education, and visual knowledge in general. We welcome and look forward to all our track presentations, discussions, and workshops and look forward to future contributions and projects in the next Learn X Design conference.

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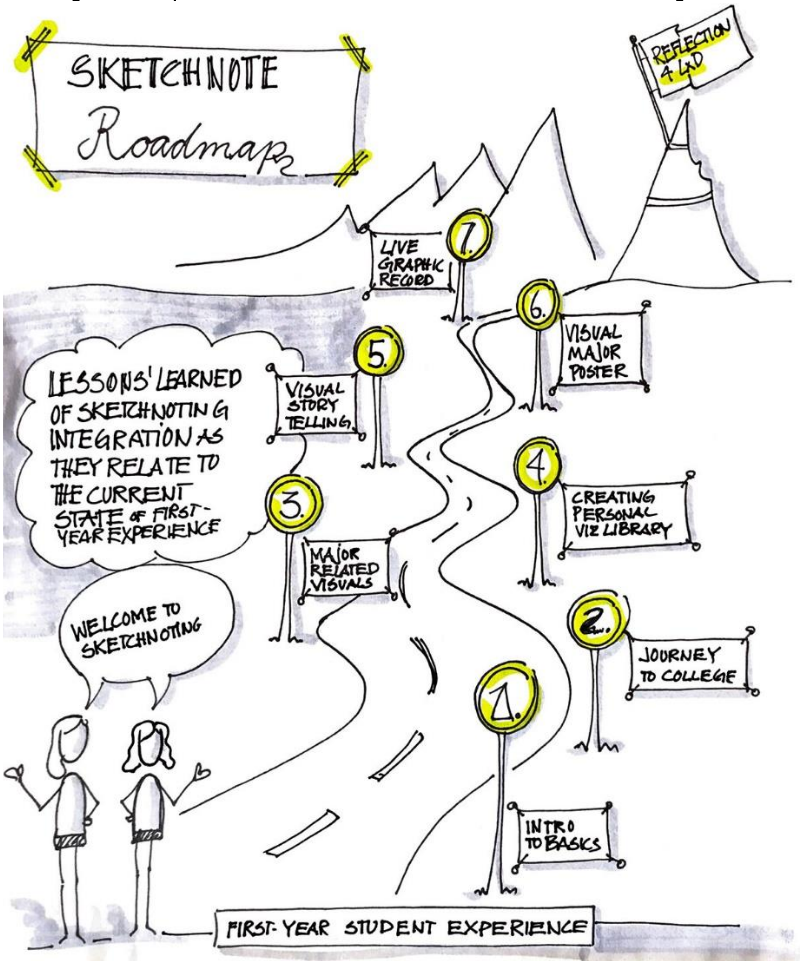
Sketchnoting Experience of First-Year Students

An investigation into the what, where, and how of this way of visual sense-making

Verena Paepcke-Hjeltness, Annaka Ketterer, Ella Kannegiesser, Madeline Keough, Victoria Meeks and Ayla Schiller
https://doi.org/10.21606/drs_lxd2021.01.258

This visual paper follows the sketchnoting experience of a group of first-year honours students as part of a research seminar. The paper shows an overview of sketchnoting, what it is and how to use it, shares examples of lectures and study notes, and visually discusses its benefits and overall lessons and takeaways. It builds on the hypotheses that sketchnoting can regularly positively influence learning and study behaviours and boost academic success while being both creative and productive.



Keywords: sketchnoting; visual learning; visual sense-making

Introduction to Sketchnoting

An exploration into what it is, how to apply it and the benefits of visual learning.

Figure 1. A reflection of what is sketchnoting informed by experience and literature (McGregor, 2018; Perry and Weimar, 2017; Rohde, 2013)

Figure 2. The basics of how to sketchnote (Erb, 2012; Neill, 2020; Rohde, 2013)

Figure 3. Student's interpretation of the benefits (Dimeo, 2016, Paepcke-Hjeltness & Lu, 2020; Smith, 2012)

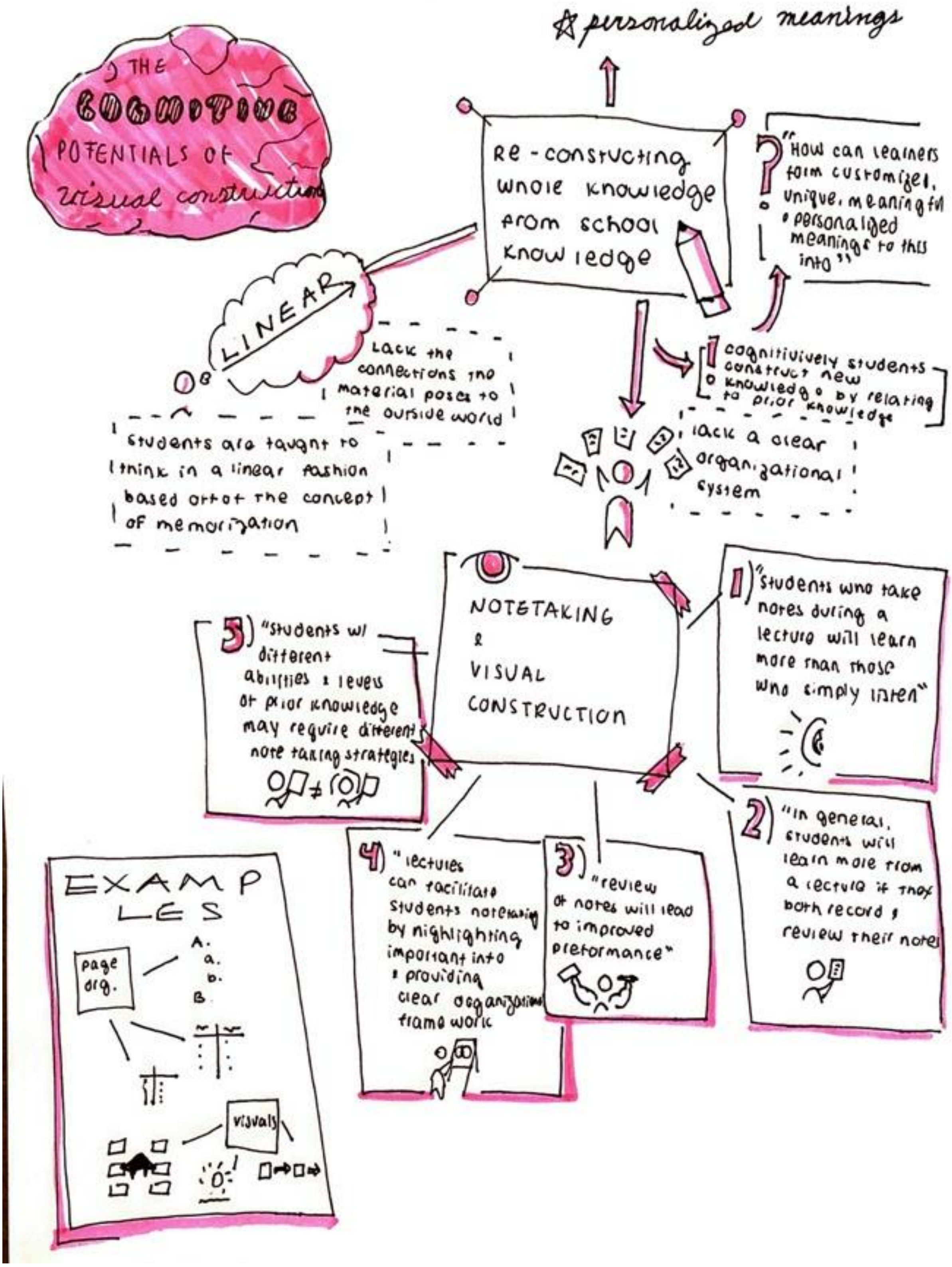


Figure 4. Visual synthesis of Shambaugh's The Cognition Potential of Visual Construction (1995)

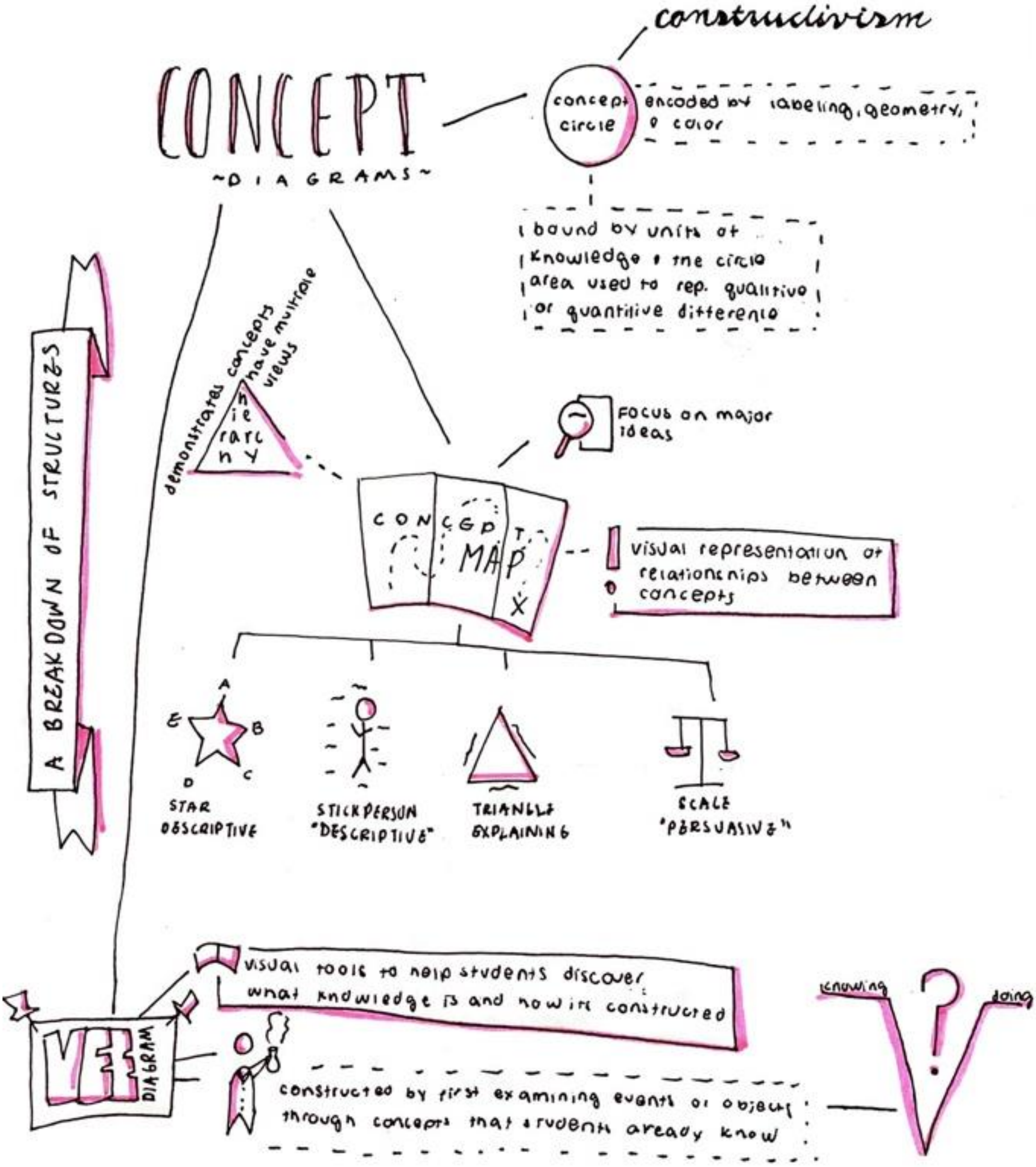


Figure 5. Continued Visual synthesis of Shambaugh's The Cognition Potential of Visual Construction (1995)

Applications of Sketchnoting in the Classroom

Applying visual learning, over the course of 15 weeks students sketchnoted all their lectures in every class. The lecture classes were mostly conducted virtually in an asynchronous format with pre-recorded lectures. Sketchnoted courses ranged from general electives such as mathematics and chemistry and major specific such as sociology and design showing that sketchnoting can be applied to fields from design to STEM.

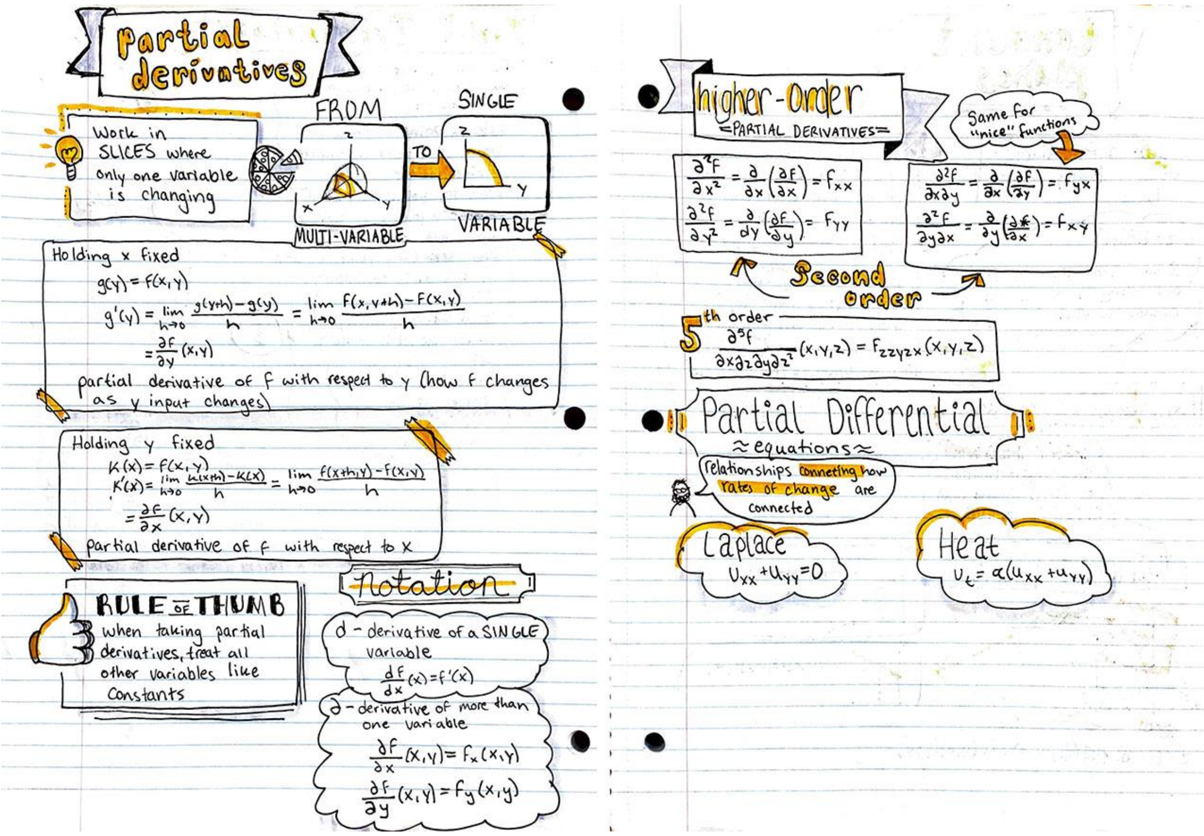


Figure 6. Mathematics course lecture sketchnotes

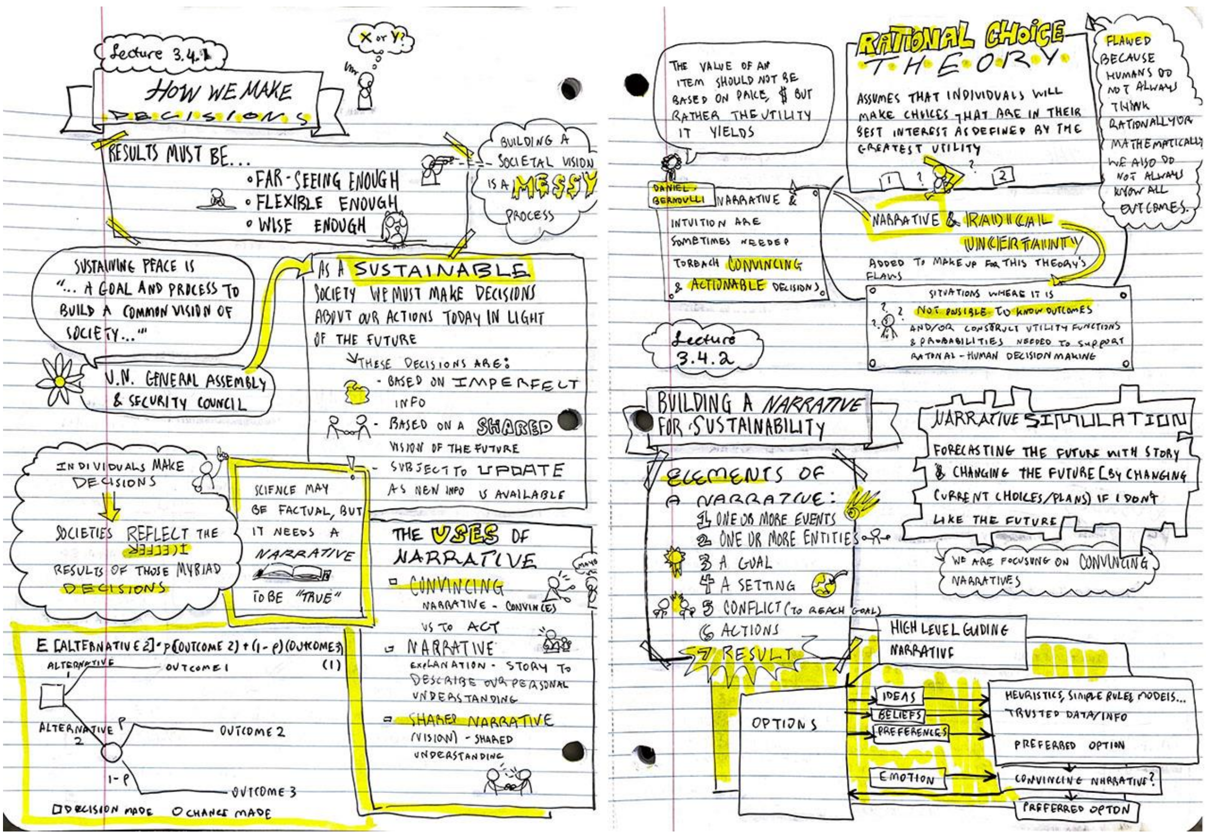


Figure 7. Sociology course lecture sketchnotes

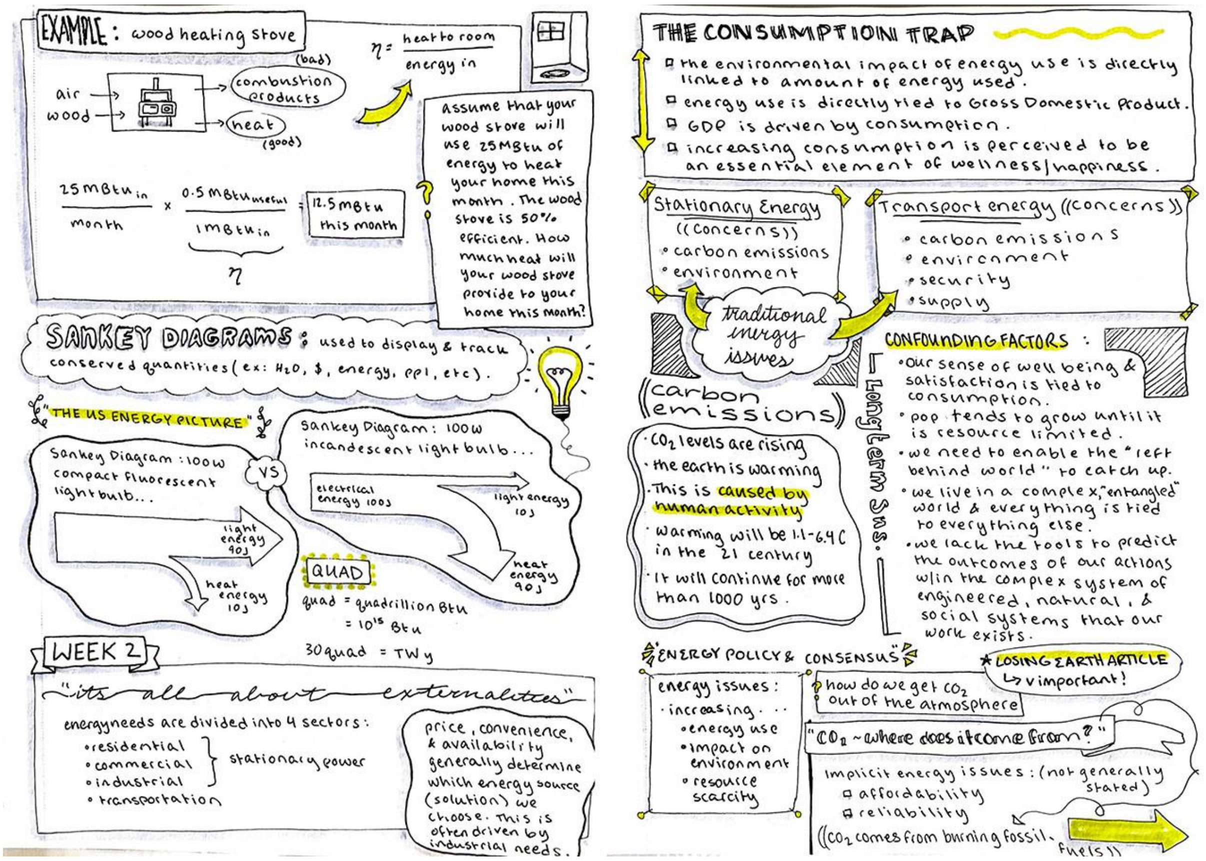


Figure 8. Sociology course lecture sketchnotes

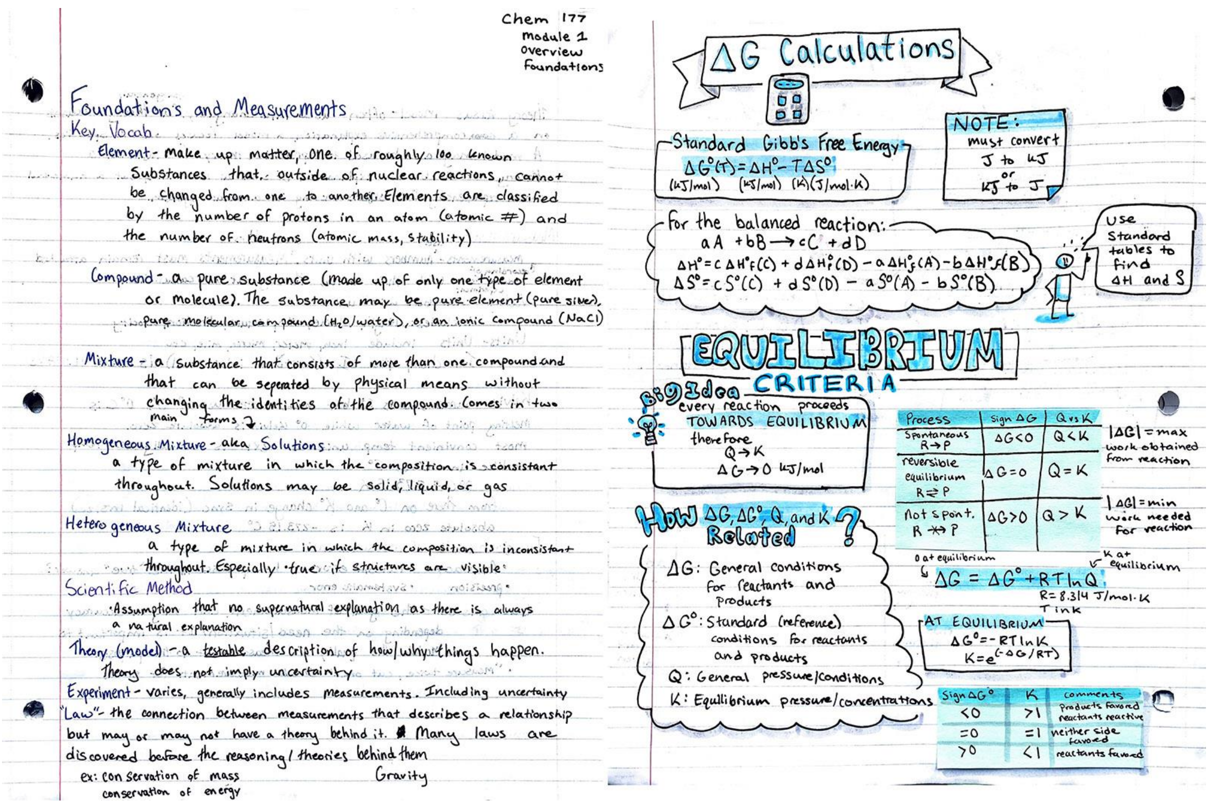


Figure 9. Chemistry lecture notes before sketchnoting and after 14 weeks of practice

A Discussion of Sketchnoting in the Digital Space

As part of the visual learning experience the team visually explored the value of sketchnoting based on the weekly sketchnoting practices with a focus on the digital and technology driven space. Taking the recent shift from face-to-face to predominantly virtual class modalities into account. Visualized are the main takeaways:

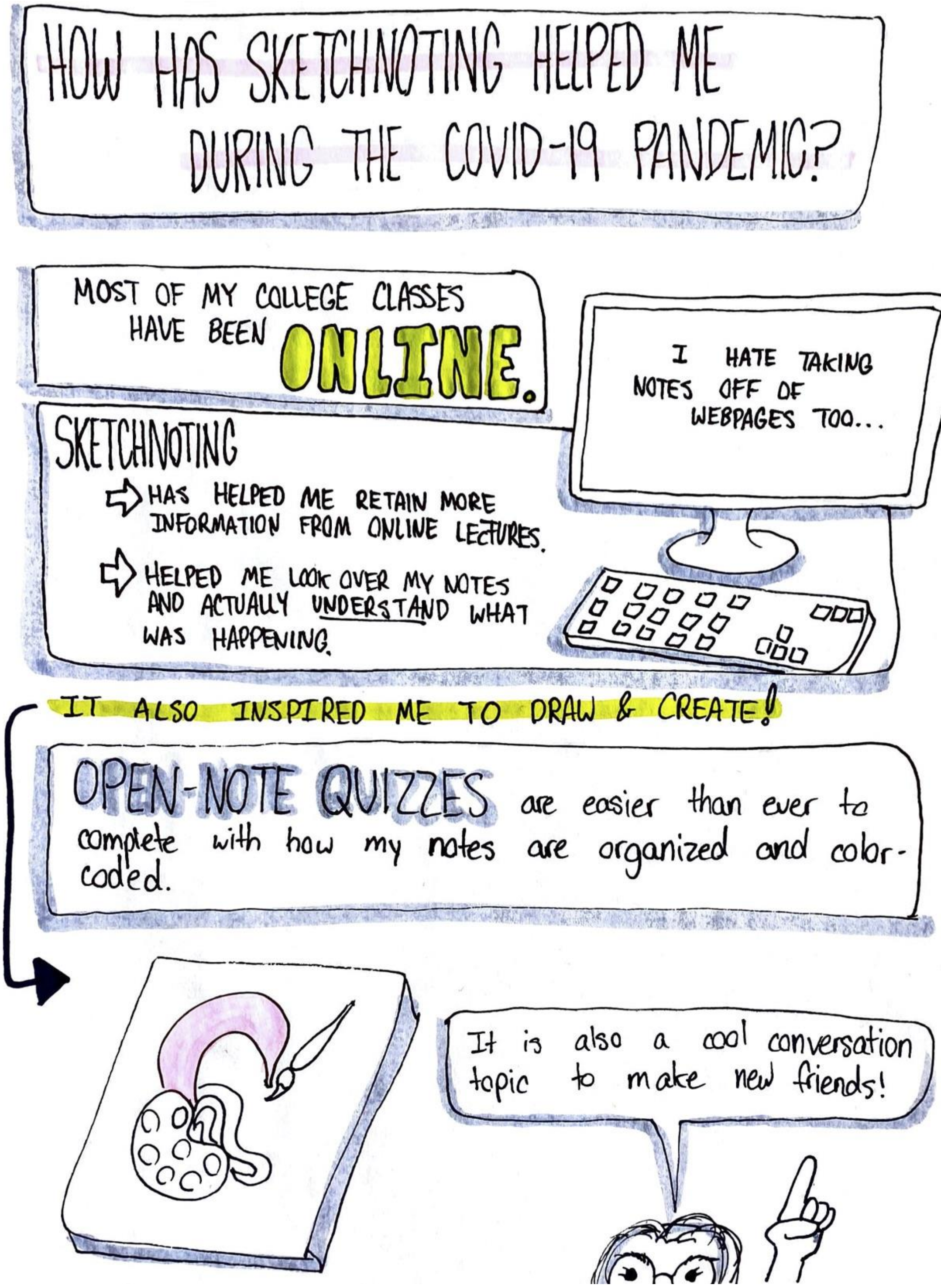


Figure 10. The value of sketchnoting in the virtual classroom

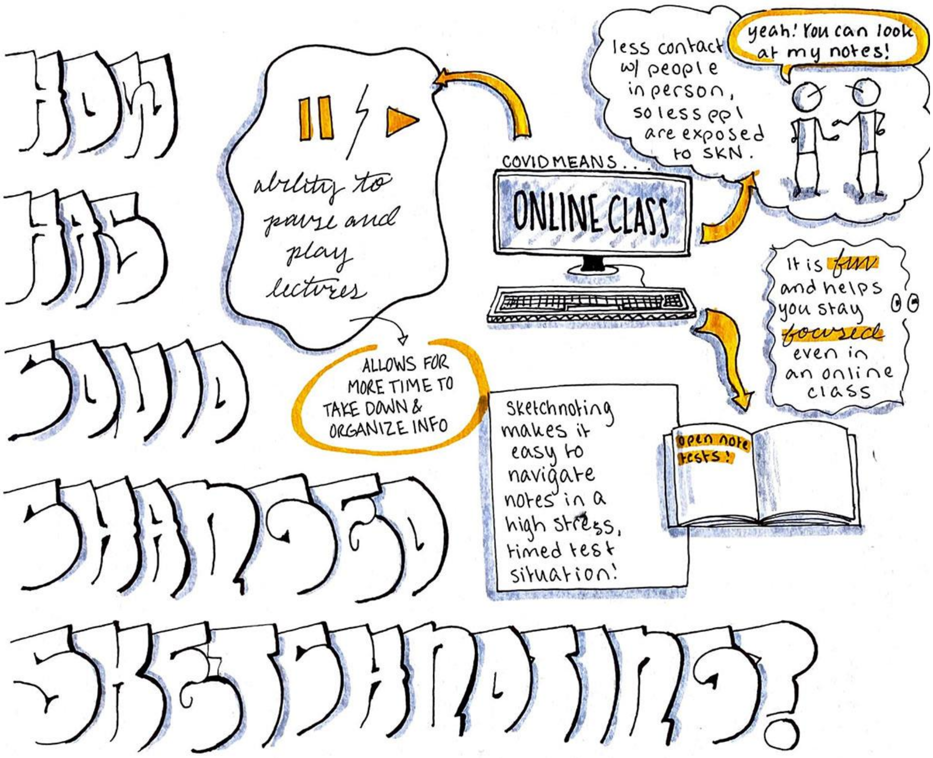


Figure 11. The value of sketchnoting in the virtual classroom continued

Based on this learning experience the team continued the discussion on how technology has influenced sketching in general.

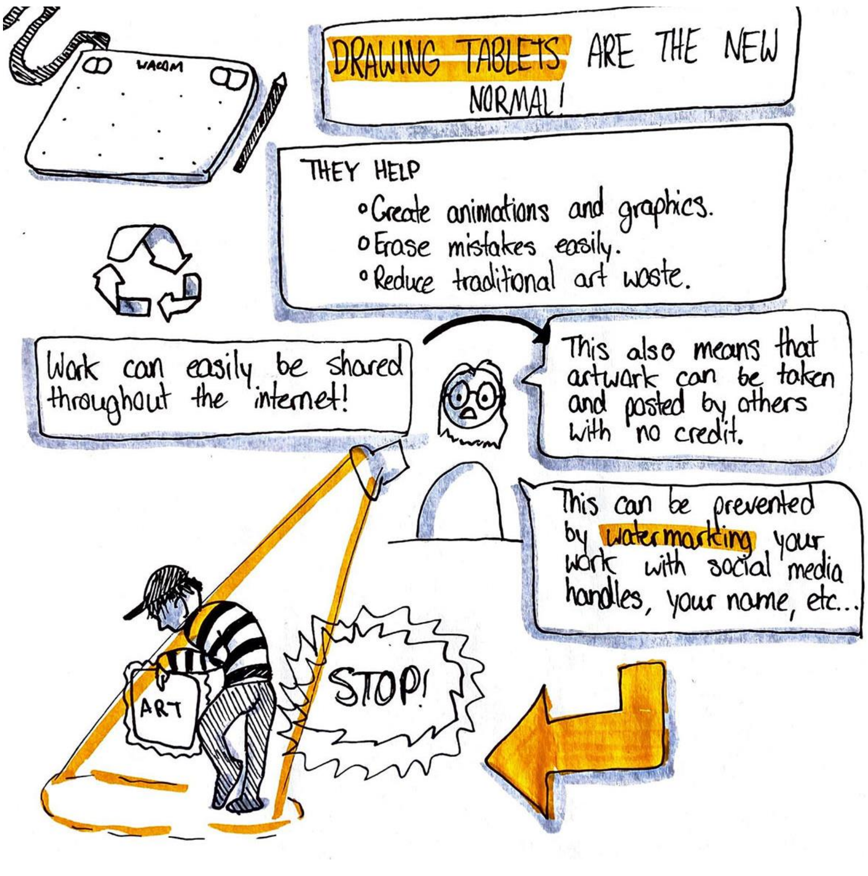


Figure 12. Sketching in the digital space

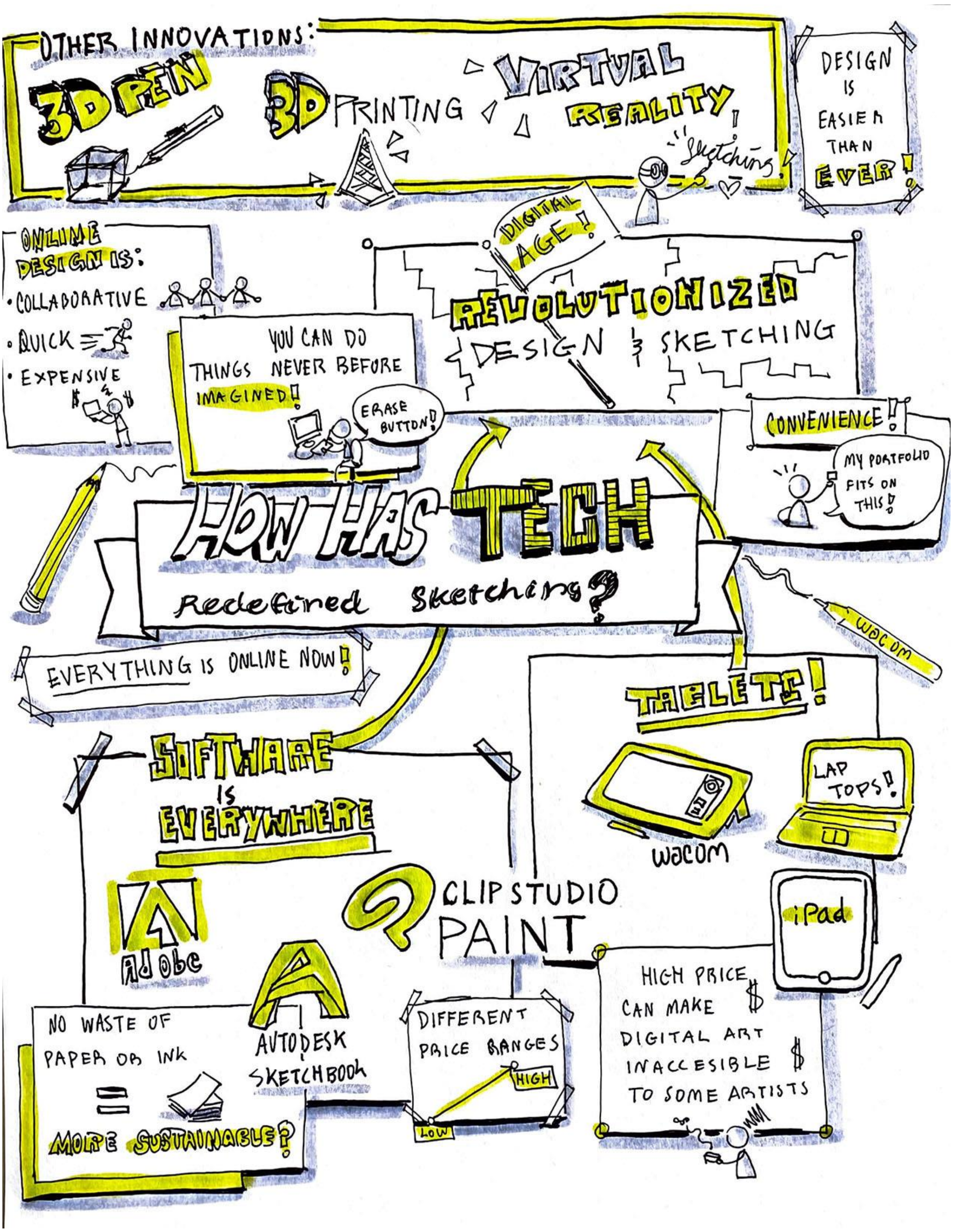


Figure 13. Sketching in the digital space, continued

Major Takeaways

Reflections on 15 weeks of sketchnoting daily lectures, weekly activities and a live virtual brainstorming.

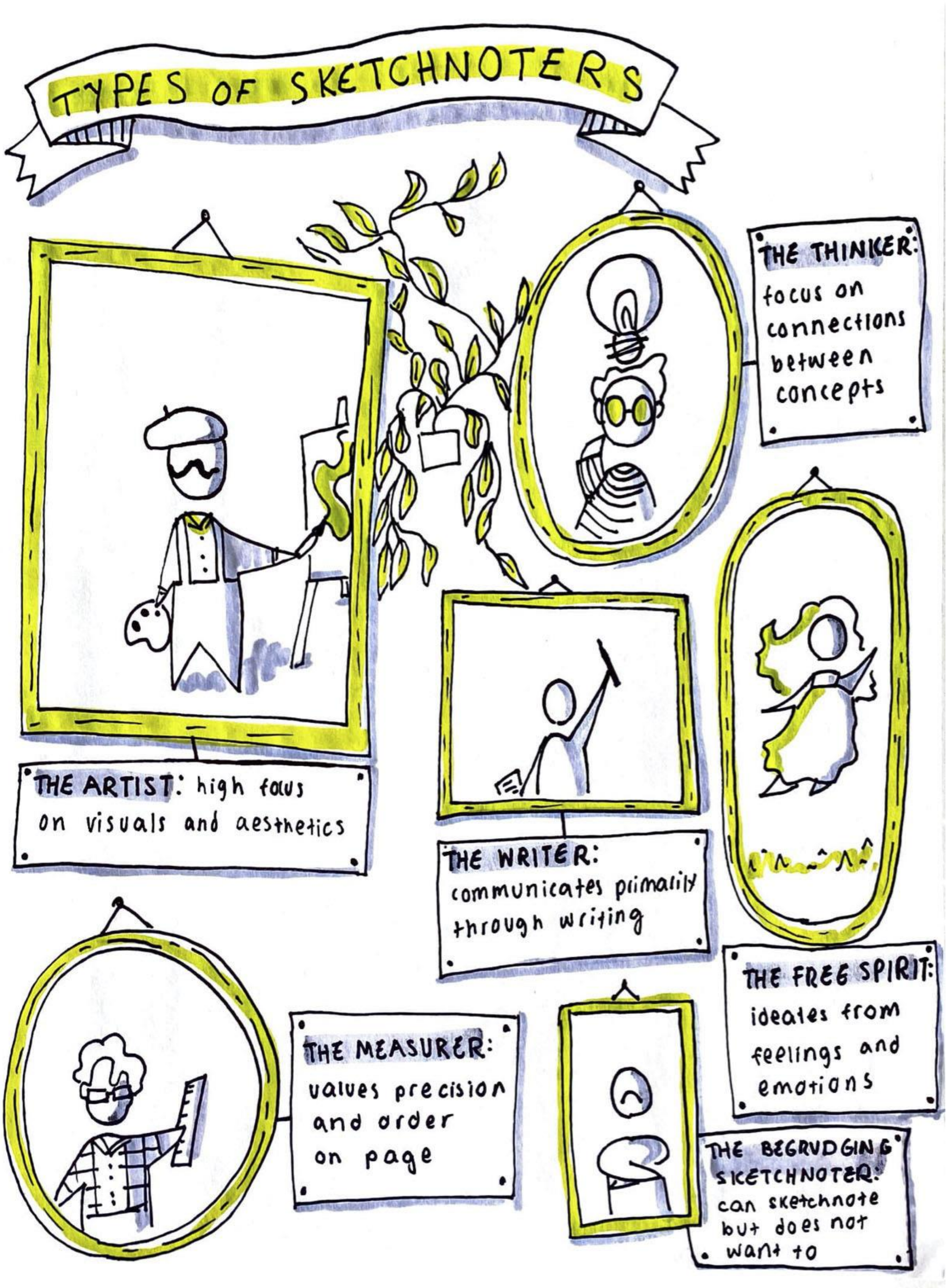


Figure 14. Everybody has their own handwriting, visual voice and approach to sketchnoting.

There is no right or wrong about sketchnoting, everyone has their own style and visual voice.

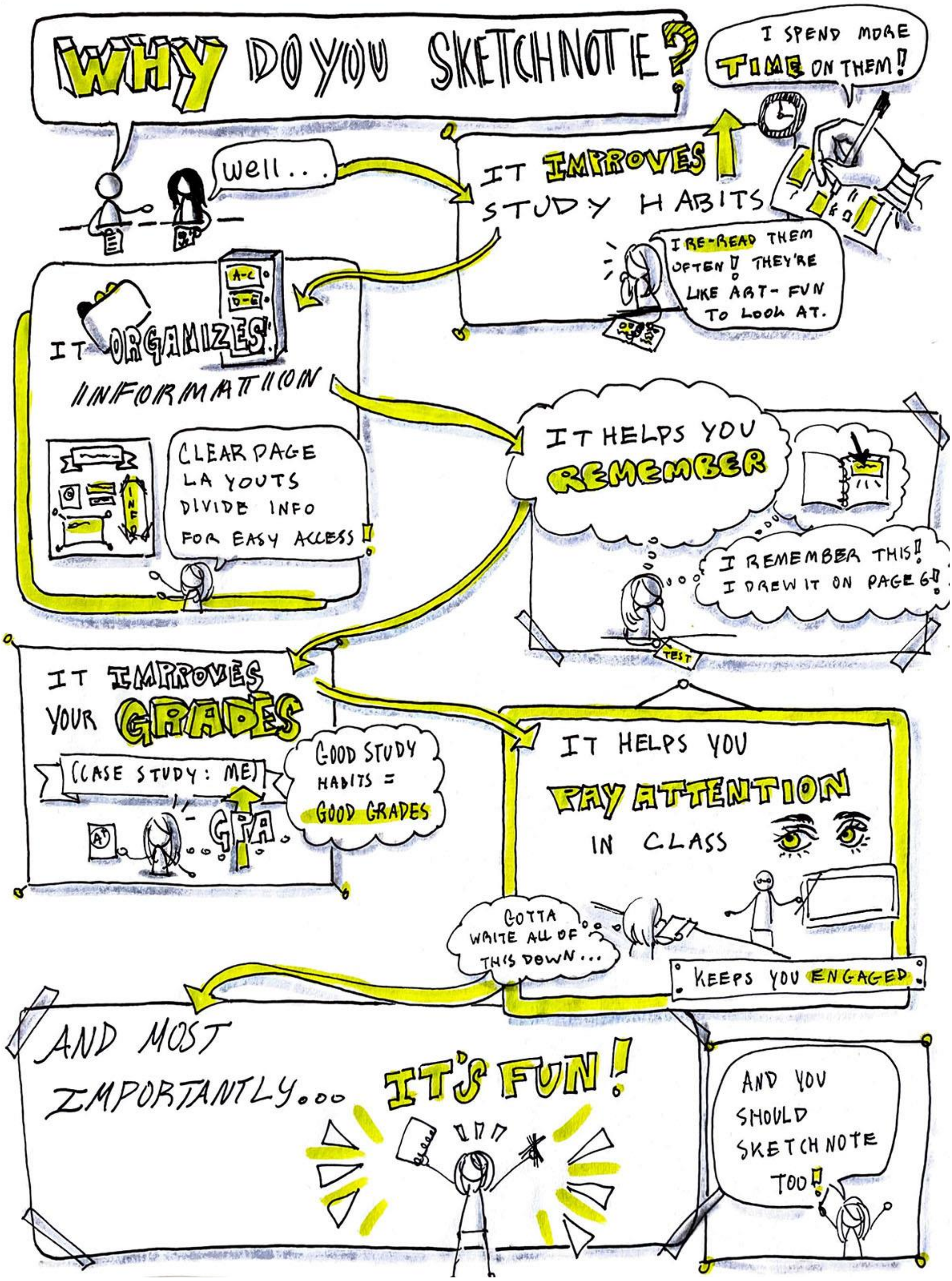


Figure 15. Sketchnoting can improve study habits, led to better grades because information is processed through verbal and visual channels. (Caviglioli, 2019; Paivio, 1990)

Conclusion

The following sketchnotes are a visual summary of the students' feedback on their learning, growth and perception of sketchnoting as a learning and teaching methodology addressing the hypotheses that sketchnoting regularly can positively influence learning and study behaviours and boost academic success, while being creative and productive.

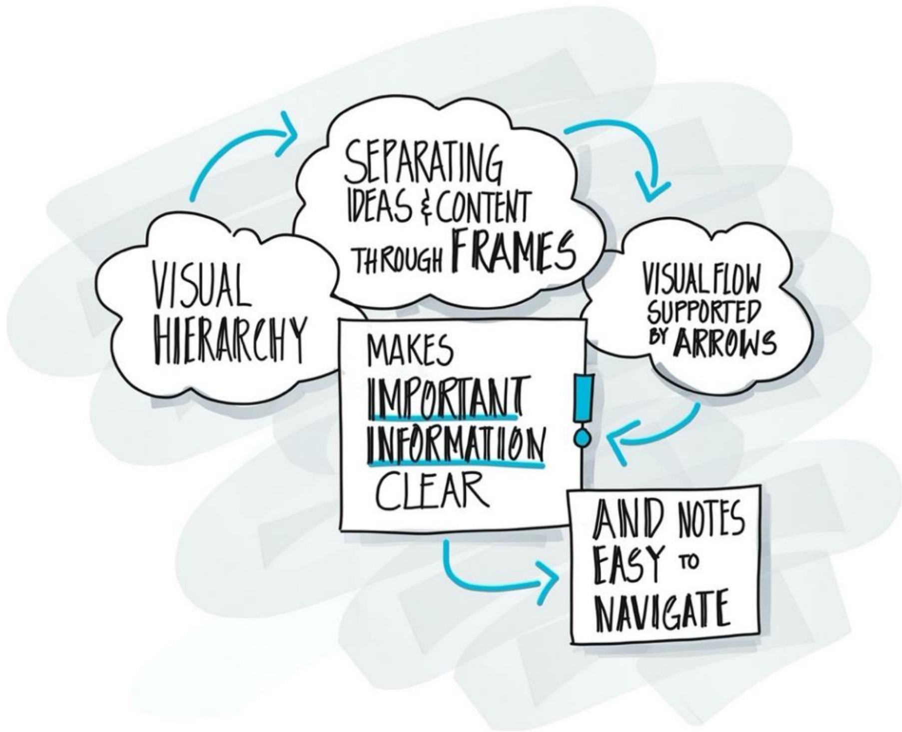


Figure 16. Visual hierarchy, framing content and connecting it via frames and placement supports flow and makes important information clear and notes easy to navigate

Figure 17. Notes were engaging, fun, encouraged to revisit, improved study habits and academic success

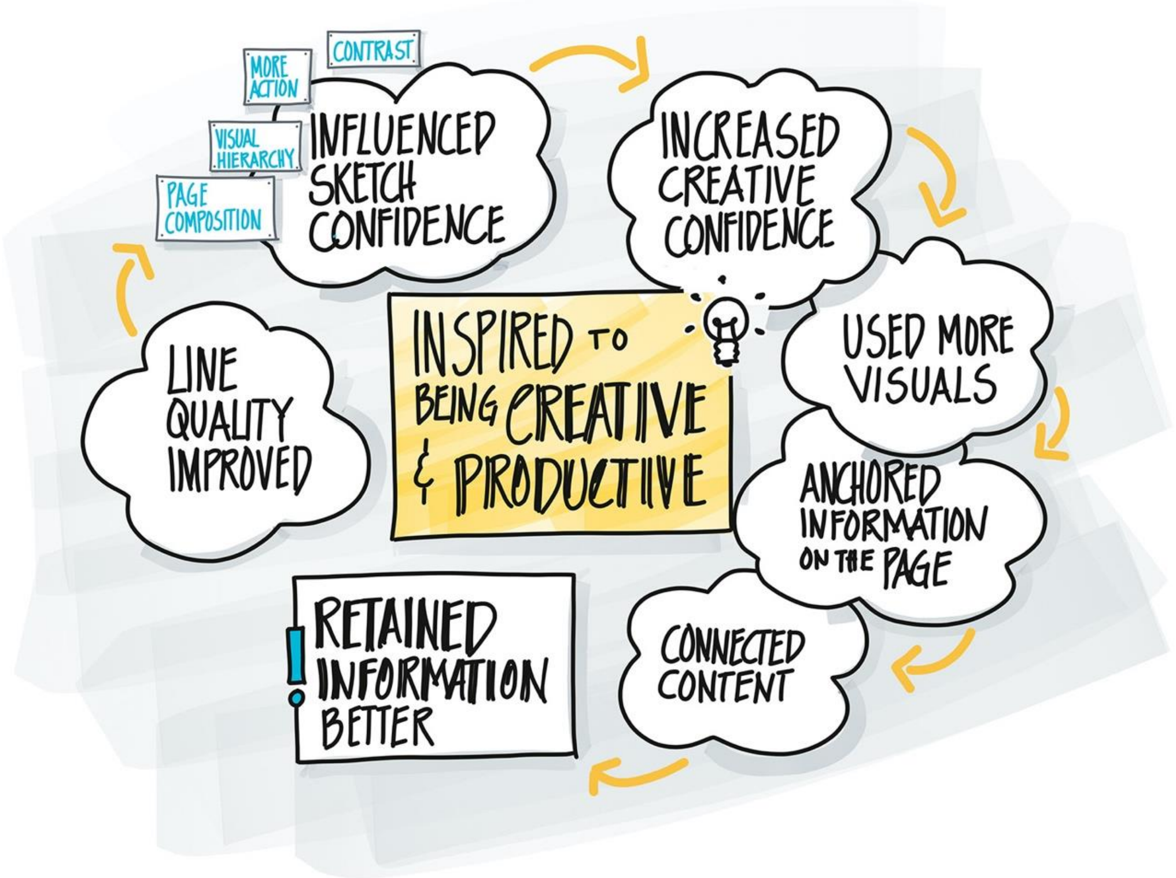


Figure 18. Sketch and creative confidence increased. More visuals were used, anchoring and connecting content, which led to retaining information better

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Online Comprehensive Teaching on Digital Hand-drawing

As Modeled in the "Hand-drawn Design Expression" Course

Ming Zhu
https://doi.org/10.21606/drs_lxd2021.02.139

Digital hand-drawing techniques have been widely used in the international design field. Under the influence of the COVID-19 epidemic, online education has become an important way of teaching and learning. Based within the online platform, teacher screen sharing and digital hand-drawing can demonstrate the principle and process of drawing to the students more intuitively to tutor and evaluate coursework. In the design and development of the online "Hand-drawn Design Expression" course, the application of live digital hand-drawing allows students to learn the course content directly and visually by mixing and matching live PowerPoint lectures and paper hand-drawn lectures together to form a new mode of online teaching of design education courses.

Keywords: hand drawing; online education; digital hand drawing; live demo

Introduction

With the rapid development of digital technology, including digital screens, tablet PCs, digital boards, and other learning tools that have emerged in the daily work and study of design teachers and students, paper hand-drawn teaching in the traditional offline mode is facing new opportunities and challenges.

The "Hand-drawn Design Expression" course is a professional foundation course within the School of Architecture and Landscape Design at Shandong University of Art and Design. The course provides a practical curriculum for students to master the hand-drawn design method, convey the important expression of design thinking, and communicate design intent. The teaching purpose of this course is to enable students to understand the principles of hand-drawn expression and drawing methods through theoretical lectures and paper hand-drawn training. Students will master the relevant expressions and technical points of the profession and fully understand the role of hand-drawn expressions to convey the designer's ideas with an intuitive image.

The offline teaching of this course mainly includes three parts: 1-PowerPoint teaching, 2- analysis and demonstration of hand-drawing on paper, 3- on-site evaluation of classroom homework. The sudden onslaught of the COVID-19 epidemic has made it impossible to give traditional face-to-face courses, and online education has become the primary means of education. In this online education environment where face-to-face contact is impossible, the teaching of this course relies on software and digital hand-drawing equipment to support and expand the three parts of the course. At the same time, with the help of an online platform and paper hand-drawing tools, this course also supports paper demonstration by live video, one of the three elements of teaching the course. Under the condition of ensuring that all educational elements of the course are not missing, we try to achieve or approach the homogeneity and equivalence with offline teaching through online comprehensive teaching methods.

Hand-drawn design expression is a basic skill that designers should possess, the key to training design expression by "using hands." Due to the non-ubiquity of digital hand-drawing equipment and the fact that the online course was arranged within only four months after the class entered the university, digital hand-drawing was not an option for the students of this course. In this context, the training of hand-drawn design expression on paper is essential for the students in this first-year class. However, I also hope more students can understand digital hand-drawing early on. If we can take advantage of this opportunity of online teaching to strengthen the first-year students' abilities to express hand-drawn designs on paper through comprehensive teaching methods, I believe that in the future, no matter whether they are holding ink pens or capacitance pens, they can express their design intentions clearly.

Selection and Testing of Online Teaching Platform

According to the requirements and characteristics of online teaching of this course, I chose Tencent QQ and Enterprise WeChat as two online platforms for trial use.

Tencent QQ is an instant messaging software that covers a variety of mainstream operating platforms of computers and mobile phones while also supporting multiple functions such as online text and voice chat, voice call, video call, file exchange, file sharing, email, and so on for both individuals and groups. Before the pandemic, I established QQ groups with my students in other courses I taught.

Enterprise WeChat is a communication and office software exclusively for businesses, created by Tencent, and retains the same communication experience as Tencent QQ on the Internet. The Enterprise WeChat platform of Shandong University of Art & Design provides network interconnection between all teachers, teachers and students, and teachers and classes within the school (Fig. 1).

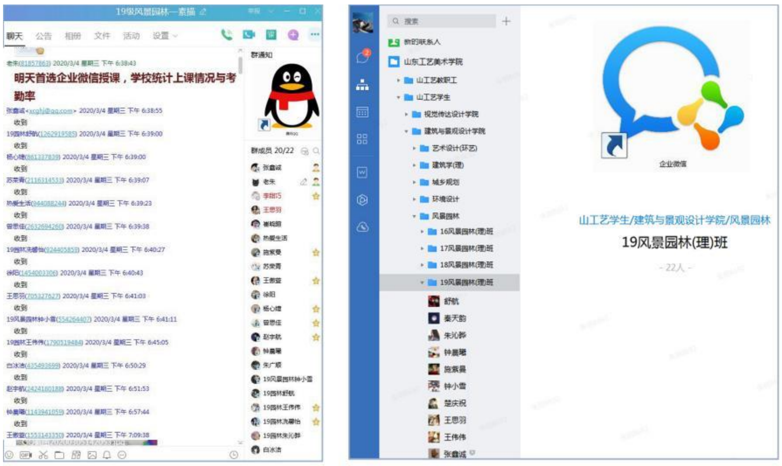

Figure 1. Tencent QQ on the left and Enterprise WeChat on the right

One week before the start of the course, I rehearsed and interacted with my classmates about the online teaching of the course and tested the operation and fluency of sharing live screen and live video on the two platforms to prepare in advance for online practical teaching. The purpose of the rehearsal was to help teachers and students understand the characteristics of the two platforms in advance, accumulate online teaching experience, and predict possible problems in online teaching.

After testing, I concluded that both platforms met the requirements of online teaching for the course. Although Tencent QQ has been widely used by students daily, Enterprise WeChat can see whether students in class groups have read and watched the information and live video released by teachers. Its function as a real-name system is beneficial, making live broadcasts, meetings, management, and interaction clearer. Because of its advantages and students' usage habits, the class group on Enterprise WeChat was finally chosen for live teaching and in-class communication, while the class group on Tencent QQ was used as an auxiliary platform to share training content, collect students' homework, and communicate after class.

Course Information

For this study, the class I worked with was a landscape gardening class for first-year students at Shandong University of Art and Design. The landscape gardening class is technically a science class, which does not require a professional art exam to enroll. The design expression course for the landscape gardening major is divided into four parts, including hand-drawn professional mapping, hand-drawn design expression, computer design expression, and model making design expression (Fig. 2). Before the start of the hand-drawn design expression course, the students had already studied the courses of sketch foundation (36 sessions), color foundation (36 sessions), hand-drawn professional mapping (48 sessions), and form composition (36 sessions) (Fig. 3). Due to the lack of painting foundation before entering the school and the relatively short length of earlier courses, the students' ability to free paint is still insufficient when they begin the hand-drawing course.

In addition, the lack of face-to-face interaction made the online teaching of this course full of expectations but more challenges as well.

Figure 2. Four parts of the design expression course hand drawn mapping, expression, computer design, and model making

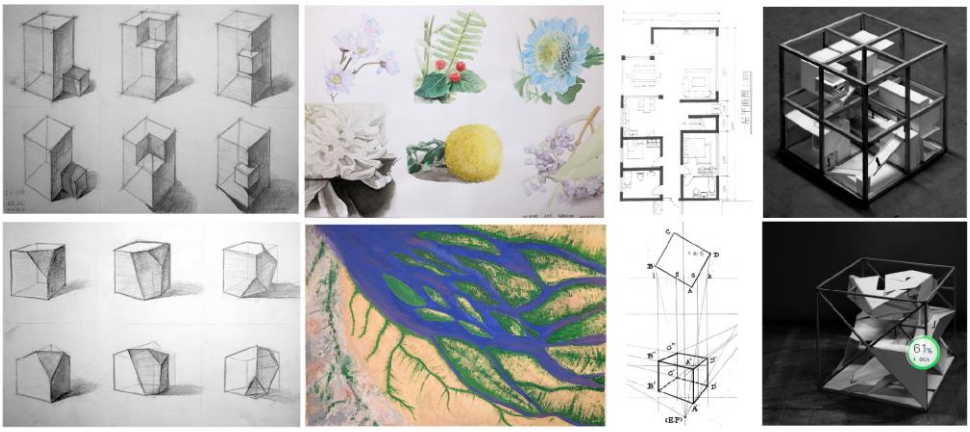

Figure 3. Prerequisites for the course, sketch foundations, colour foundations, mapping, and form composition

Online Course Design

The “Hand-drawn Design Expression” course lasts for three weeks for a total of 36 hours. Building on the prerequisites, the course utilizes a three-step approach of copying, imitating, and creating, in a step-by-step manner. The online education includes live lectures using PowerPoint supported by Enterprise WeChat, live digital hand-drawing demonstration and analysis on a digital screen combined with software, a live demonstration on a cell phone, combined with paper materials, and live tutorials on coursework combined with digital hand-drawing, with real-time Q&A interaction throughout.

The purpose of the analysis and demonstration of digital hand-drawing is to enrich the teaching of the online course so that students can see, learn, and understand the principles and process of painting before the actual painting training, as well as improve the efficiency of the paper hand-drawing teaching demonstration after the analysis and demonstration of digital hand-drawing. The digital hand-drawing and paper hand-drawing in the live class also reduces the crowding of non-pandemic in-person classes so that every student in front of the screen feels that they are in their “best place.”

The student’s learning materials and assignments are uploaded in batches over three weeks, with one training content per week, gradually increasing the workload and difficulty. As students approach the course objectives, the students’ psychology adapts to the intensity of the course. The course assignments are also completed offline in one week as a training phase. The electronic version of their assignment is collected in advance through the Tencent QQ group. The digital hand-drawn assignments are assessed in the online classroom on Enterprise WeChat using the digital screen (Fig. 4).

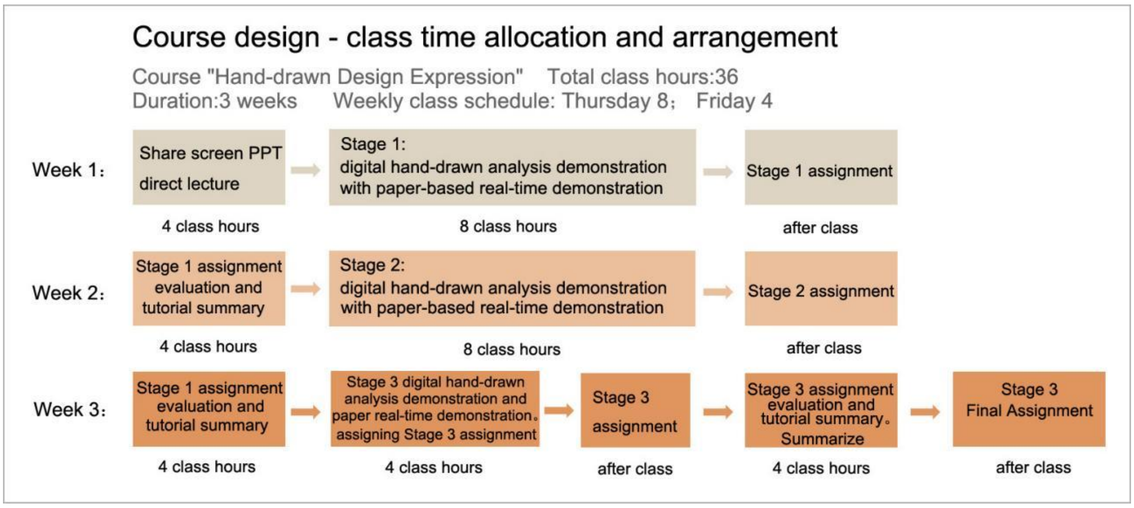

Figure 4. Class time allocation and arrangement

In the original phase of the lesson plan, the first week introduces new material and a tolerable workload, the second week introduces new material and increasing working pressure, by the end of the second-week course, students may have figured out the teacher's online teaching rules. In the third week, short re-pressurization of assignments was adopted to avoid slacking off in the online education format. The assignments assigned after the class on one day would be assessed in the morning of the next day, and the next day course would end with the final assignment requirements. At the same time, for the short booster assignments, there will be a constant stream of questions from students to the teacher via text or voice from the online platform during class time, and the teacher should be ready to answer them at any time (Fig. 5).

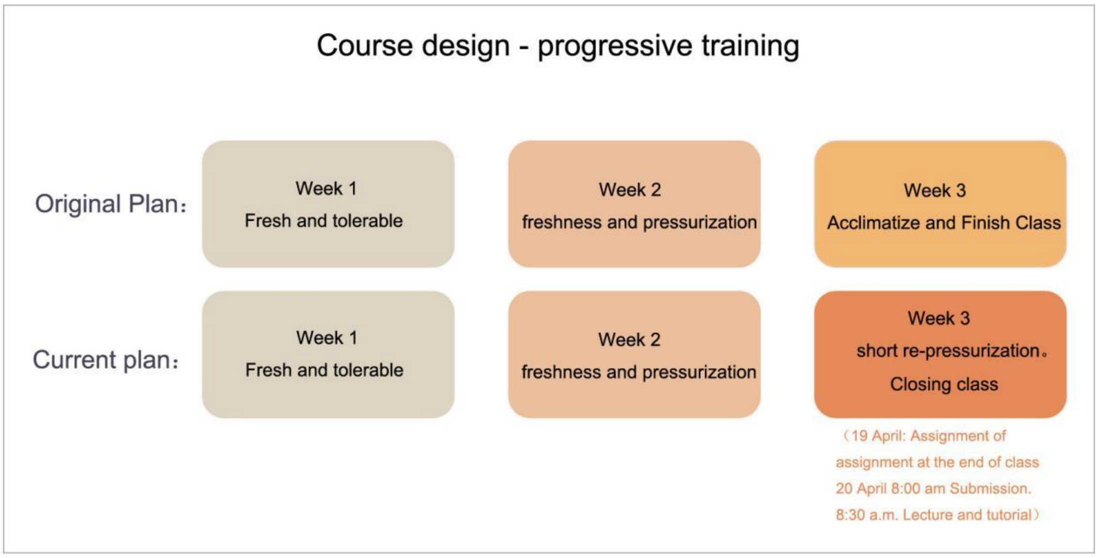

Figure 5. Progressive training loads, comparing the original curriculum with the new online curriculum

Application of Online Comprehensive Teaching Methods

Teaching Methods and Application of Online Lectures

Using the screen-sharing function on the Enterprise WeChat platform, and with the help of PowerPoint and my hand-drawn practical works and teaching experience, I taught the theoretical knowledge of the course, expressed in the following points:

- Hand-drawn expression is one of the ways for designers to express their design intentions, and it is one of the basic skills that designers should possess.
- This course should pay more attention to the connection with the previous knowledge, and it will also play an essential role in design study and design research in the future.

- Hand-drawn design expression should not only enhance the appeal of the picture (emphasize the beauty of the drawings) but also clarify the design ideas (emphasize the transmission of design information).
- Common methods of hand-drawn design expression and paper drawing media.
- Environmental sketch practice and line modeling painting.
- Basic knowledge and precautions of coloring using marker pens.
- Coloring techniques of marker pens in environment sketch and space design.
- Logical hand-drawn analysis and expression generating by spatial form.
- Analysis and appreciation of works.

The purpose of the live explanation for the above nine aspects is to let students fully understand the course content of Hand-Drawn Design Expression (Fig. 6).

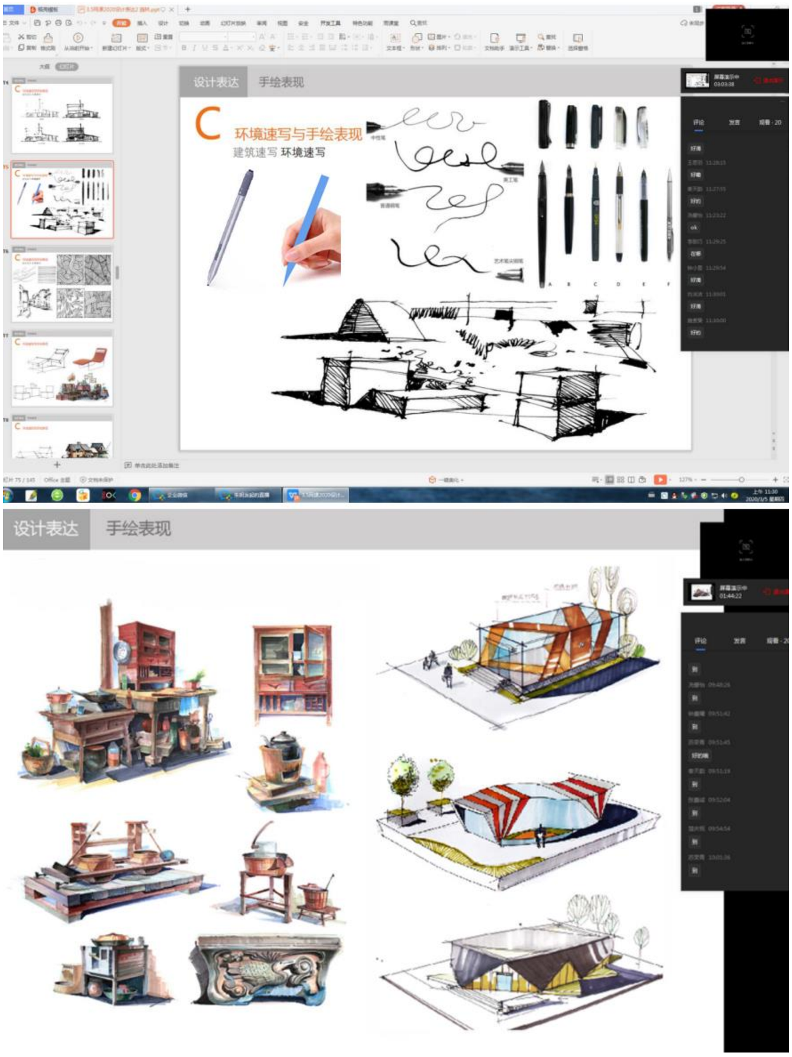

Figure 6. Live PowerPoint lecture after sharing the screen from the teacher's side

This is the first online course of this course. As this course previously has been taught in person, online teaching keeps students feeling fresh. Although some students did not turn on their cameras, I still thought that they were by my side through their interactive words and familiar voices, which was different from the rehearsal a week before the start of the class. With many online courses in our school using Enterprise WeChat at the same time, I worried about network congestion and occasionally ask students about their experience, such as whether my voice was clear or when I started screen sharing, and whether there was any delay on the student's side in the PowerPoint lectures. As the course progressed, we proved that Enterprise WeChat can be used as an online education platform smoothly and whose live screen-sharing function provides a clear and new teaching experience to educators and students.

Selection and Application of Online Digital Hand-drawing Teaching Tools

One of the challenges of teaching this course was using digital hand-drawing for analysis and demonstration in online teaching. Therefore, after the theoretical lecture, we analyzed and demonstrated the relevant hand-drawn elements through live digital hand-drawing, according to predetermined teaching goals that incorporated common problems from previous in-person classes. Through the operation of a digital screen, ArtRage, Sketchbook, and Photoshop software, students could review the knowledge of the previous course, analyze the key points while focusing on each stage of training. The digital analysis demonstrations go over the following topics:

- the characteristics and considerations of drawing lines in hand-drawn design expression
- the considerations of perspective
- the freehand drawing of basic forms using lines
- the structural hand-drawn analysis of single complex forms
- the structural analysis and perspective analysis of combined forms of architecture and landscape
- the coloring analysis and considerations
- the hand-drawn analysis and considerations of the logic of spatial form generation

Allowing students to observe the digital hand-drawing demonstration online while analyzing the hand-drawing training is an excellent way to teach many concepts and skills and offers a clear foundation to build upon in future training. Each stage of the digital hand-drawing analysis demonstration process is explained through the microphone while drawing, and real time interaction between students and teachers is achieved through on-screen text and voice (Fig. 7). Drawing digitally on a screen required me to adapt how I drew. Because the small amount of friction between a capacitive pen and a digital screen is minimal, even after a film with similar tactile properties of paper was applied to the digital screen, it does not accurately replace the feeling of resistance when using an ink pen or marker on paper. To account for the lack of friction, in the days after the epidemic ended and returned to school, I added replaceable silicone sleeves to the stylus for my iPad digital hand-drawing tablet, which to some extent solved the problem of the friction being too small and affecting one’s hand habits.

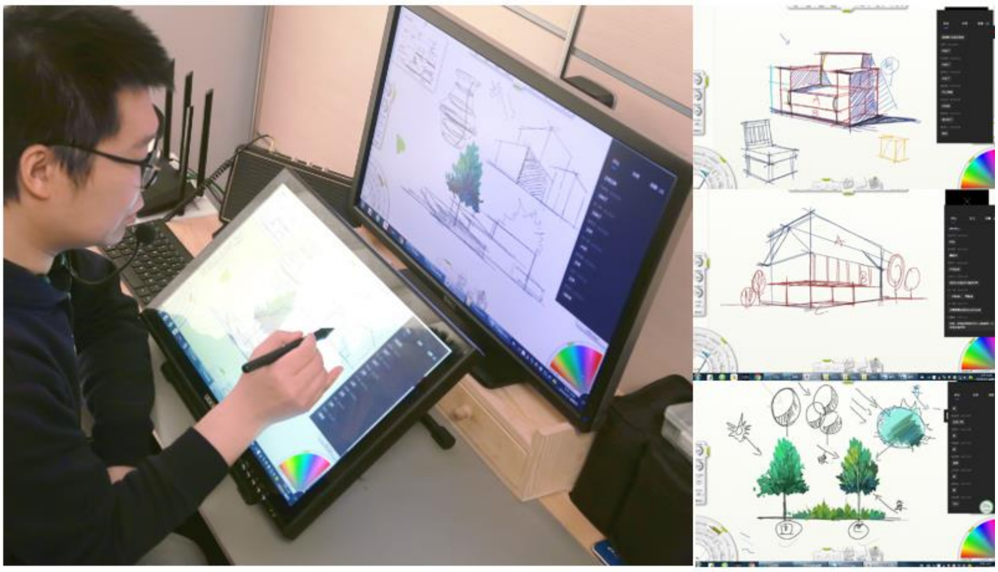

Figure 7. Analysis, demonstration lecture using digital hand-drawing

For digital hand-drawing software, ArtRage has a wide range of digital hand-drawing adaptability, and its color blending function can be close to reality to simulate the color properties after color mixing, which provides a good display for teaching and grasping color relationships. Sketchbook’s digital hand-drawing functions and handwriting tools are closest to the professional perspective of spatial design. In addition, Sketchbook’s complete marker color spectrum also helps to select colors when digital hand-drawing. Photoshop, one of the most popular software programs, can open pictures in batches and provide room to demonstrate with brushes, which is most suitable for analyses of many works. During online teaching, we are not limited to the digital hand-drawing function of a single software and should switch software at any time according to the

teaching needs and teaching requirements of different knowledge points (Fig. 8).
Utilizing the many digital tools during the analysis and demonstration portion of drawing principles enables thoughtful summarizing of the mistakes that students made in previous live classroom teaching, enriches the online content, allows students to intuitively feel the importance of hand-drawing abilities and the charm of digital hand-drawing. This teaching method makes up for a variety of learning problems that students may encounter in the absence of in-person teaching and has a good supporting effect on the online learning and online paper hand-drawing demonstration of this course.

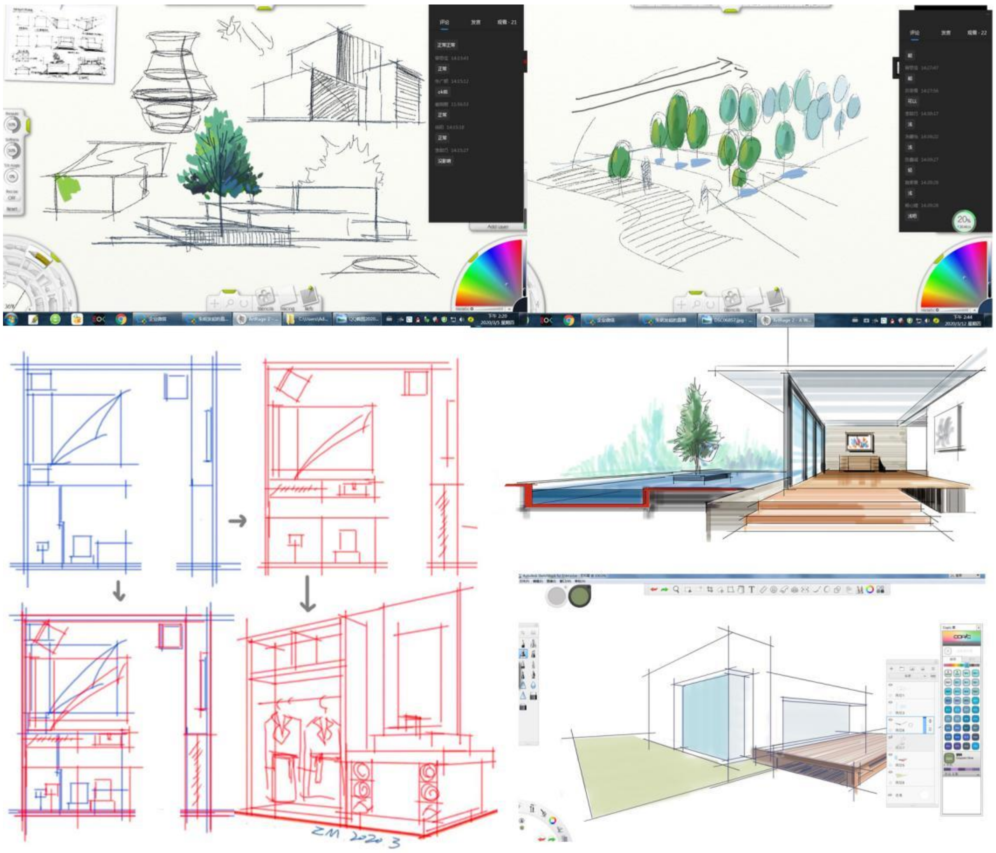

Figure 8. Characteristics of different digital hand-drawing software.

Live Online Paper Hand-drawing Demonstration

After the digital hand-drawing analysis and demonstration of the key points and the focus on the hand-drawing process, the live equipment was replaced. The cell phone camera was used to enter the online paper demonstration live session, and the key points taught in the previous digital hand-drawing were implemented into the paper practice through hands-on demonstration.
Given my personal drawing habits and the convenience of online teaching, my students and I chose the convenient and fast drawing tools of pens and markers. My experience with pre-digital hand-drawing demonstrations of drawing principles and notes made it possible to draw directly with efficiency during the paper demonstration for each stage of instruction (Fig. 9).
Paper hand drawing live content includes:

- Single and combined furniture line drawing and marker performance demonstration.
- Plant line drawing and marker performance demonstration.
- Space plan, elevation drawing, line drawing, and marker performance demonstration.
- Environmental sketch line drawing and marker performance demonstration.
- Space design in the marker performance demonstration.
- Space morphology generation in the marker performance.

The use of markers brings convenience to the live teaching of online paper hand-drawing demonstrations. The number of markers owned will significantly impact the drawing results due to its weak color mixing function.

For this experience, I concluded that when the number of markers is large, the separate categorization of markers of different shades at the teacher’s end is more helpful for the efficiency of drawing in online teaching.

Figure 9. Switching to a live cell phone demonstration of hand-drawn paper

Online Digital Hand-drawing Assessment and Tutoring for Coursework

The coursework training is conducted outside of class, using a weekly homework submission and summary and a weekly assessment and tutorial to increase the training content (Fig. 10) gradually.
After the off-class training assignments are submitted and summarized through the Tencent QQ platform, we continued to use the sharing screen under the Enterprise WeChat and combined it with digital hand-drawing for lecture, counseling, and error correction. The online assessment and correction of students’ assignments are conducted one-on-one in front of the class, where each student who is assessed must turn on the microphone and maintain an online voice call with the teacher. While one student’s assignment is being assessed, other students are also online to watch and listen to the lecture. Such an online assessment model is very similar to the offline teaching assessment model, except that digital hand-drawn error correction replaces paper hand-drawn error correction. The goal of both forms is to find out students’ problems and avoid others’ mistakes through the assessment.

Figure 10. The offline conduct of assignments and the collection and aggregation of electronic versions of assignments

The use of digital hand-drawing combined with voice interaction can be very intuitive to point out the problems of each assignment and each drawing, and then through the digital hand-drawing real-time drawing demonstration correction so that students can understand the problems of their work at a glance. The modified legends of digital hand-drawing can be sent to students separately, making this application of digital hand-drawing more suitable for online teaching mode and provides convenience for online learning at the students’ end. (Fig. 11).

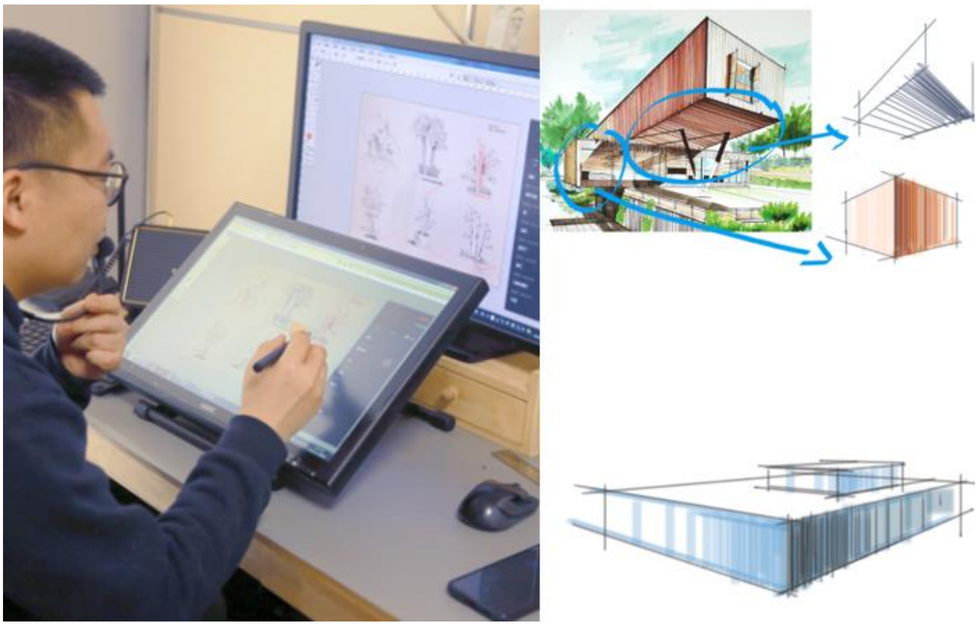

Figure 11. Visual online assessment and tutoring of assignments using digital hand drawing

Interaction and Q&A of Online Education

The online interaction and Q&A of this course are carried out in real time with the live lecture, live demonstration, live tutorial, and evaluation, and online answers and targeted demonstrations are provided for students' questions and doubts at any time. Because online education is relatively free from the limitations of in-person teacher-student meetings, teachers and students not only communicate and interact with each other online at any time during the course teaching cycle but can also easily communicate online after the course is over. In this teaching method, students were encouraged to ask more questions, and the teacher's side of the online lesson focused on implementing the key knowledge through voice queries in real time (Fig. 12).

Figure 12. Online real-time Q&A

Audience Factors and Instructional Feedback in Online Hand-drawing Teaching of this Course

Students have the advantages of dormitory learning atmosphere, classroom learning atmosphere, college learning atmosphere, and personal self-discipline during in-person teaching, while online education is based on personal self-discipline wrapped in the home learning environment. The support of digital hand-drawing for online education enables students to fully grasp the principles of painting, fully understand the painting process, and clearly understand the problems that arise in the assignment, which greatly increases the

visualization and freshness of online education. The online live teaching after the synthesis of digital hand-drawing and paper hand-drawing allows each student studying at home not to worry about the location factor when watching the teacher's demonstration, and to learn and understand the points taught by the teacher repeatedly through video playback, which improves the efficiency of learning.
The assignment grade will be based on the accuracy of modeling drawing, proportional relationships, perspective relationships, color expression effects, smoothness of morphogenetic logic, the rationality of morphogenetic logic, detail of morphogenetic logic, layout of the drawing, overall coordination of the drawing pictures, etc. As an important reference, taking the weekly stage coursework performance as an indicator, with the progressive difficulty and intensity of the assignment, the proportion of excellent scores above 90 gradually decreases, which is a normal learning phenomenon (Fig. 13).

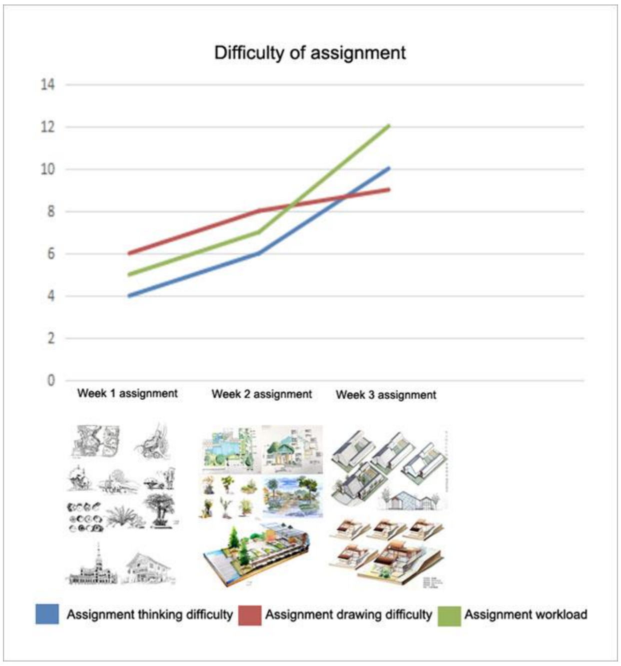

Figure 13. The difficulty level of weekly assignments

27% of the students master the course knowledge and requirements and score the highest marks of 90 + points. 50% of the students embrace the course knowledge and requirements and score between 85 and 89 points. 14% of the students met the course requirements and related objectives with a score between 80 – 84 points. There are still 9% of the students with average or below course work performance, and further care and strengthening are needed in the details of their work, proportional relationships, coloring, and other aspects (Fig. 14).

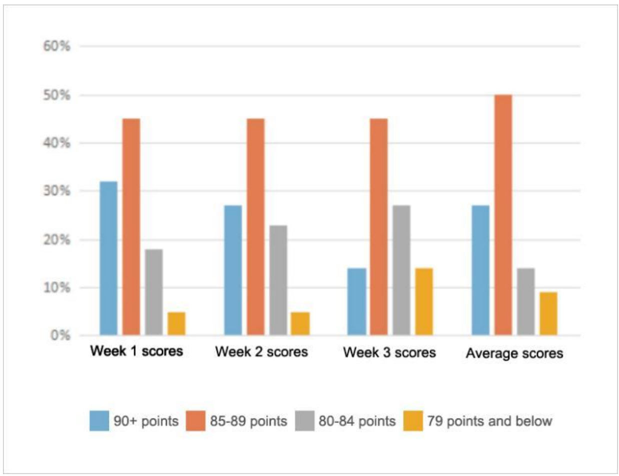

Figure 14. Grade distribution

In the subsequent exhibition of the course assignments, the online instruction has made some progress by comparing it with the Stage 3 assignment, which was the most difficult assignment in the same course in the previous session. The reasons for the summary are:

- The online instruction showed and explained the previous term's homework through the sharing screen.
- The digital hand-drawing after the sharing screen has made a more visual analysis and demonstration of the problems that occurred in the previous term's homework.
- The online learning avoided other time consumption in school, which made the students' time outside of class more available.
- Online teaching has been unavoidable because of the COVID-19, which has led to more in-class and out-of-class interaction and communication between students and teachers than previously in-person classes.

From the statistics and comparison after the exhibition of works, it is concluded that the course has achieved the expected teaching effect and teaching purpose by implanting the online integrated mode teaching with digital hand-drawing as an important means (Fig. 15).

Figure 15. Comparison of Class of 2019 In-Person Teaching and Class of 2020 Online Teaching Stage 3 Assignments in the Coursework Exhibition

Summary and Outlook

The teaching of this online course is done by sharing screencasts and live videos so that the important aspects of the original in-person teaching are not missing. The analysis, demonstration, and lecture after the cooperation of digital hand-drawing and voice reflect the practicality of this course and the importance of teacher demonstration. The digital hand-drawing demonstrations bring to light the problems that should be paid attention to in the process of paper hand-drawing and pave the way for the paper demonstration; the digital hand-drawing completed after sharing the screen solved the difficulty of offline assignment evaluation and tutoring and eliminated the nature of single voice evaluation which improved the efficiency of teaching and learning.

Digital hand-drawing can be widely used in many design courses in the online classroom. After this online course, I continued to apply digital hand-drawing to my upper-level online design course. Through the implementation of digital hand-drawing, I feel that digital hand-drawing is not only for circling the important knowledge points and assignments of the online course but also for visualizing and drawing the problems that need to be analyzed and faced in the course through digital hand-drawing. Thus, it opens up the students' thoughts and helps them find the problems in their drawings and design. The digital hand-drawing demonstration on the teacher's side greatly facilitates and expands the correction and extension of design ideas in online course education and plays a guiding and instructive role in achieving educational goals (Fig. 16).

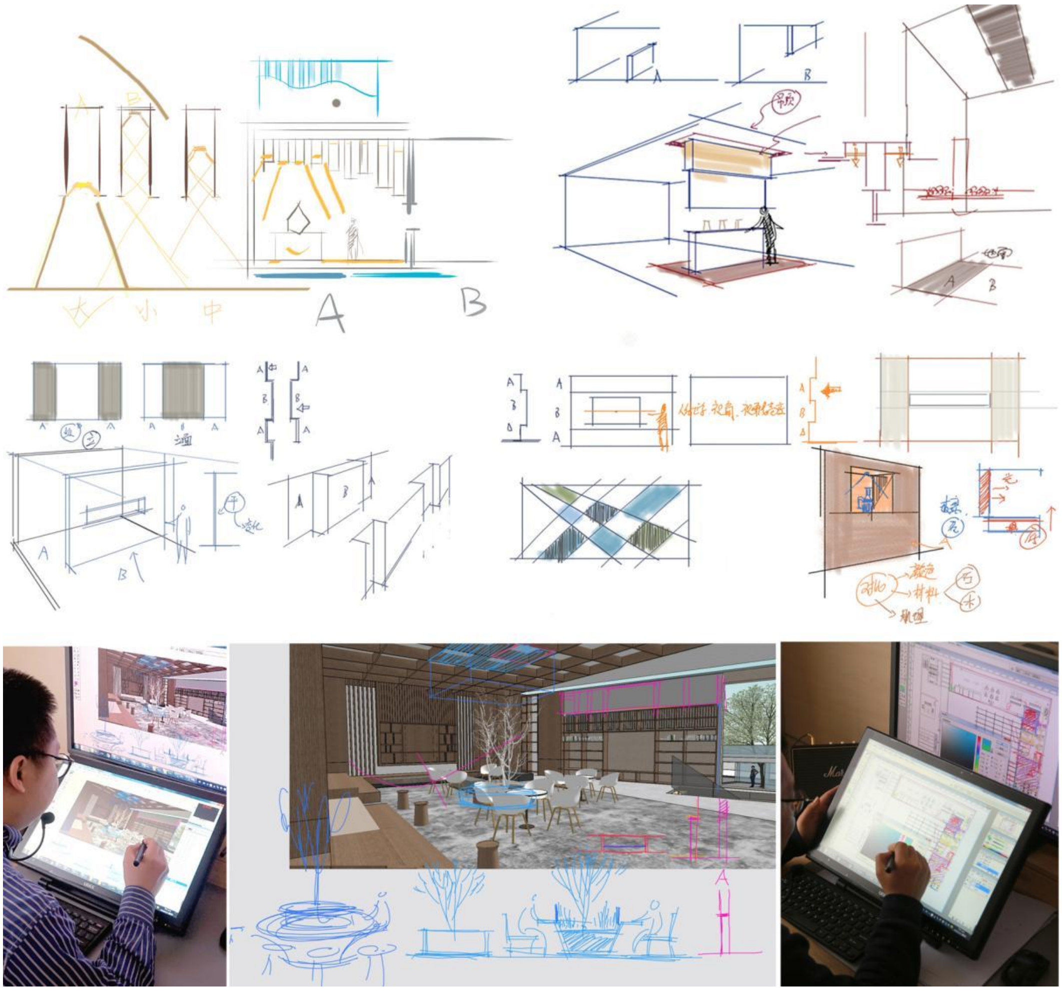

Figure 16. Digital hand drawing in 3rd and 4th grade online instruction

During the online teaching period of the epidemic, I, as a teacher representative, made a school-wide video report and shared my experiences in teaching digital hand-drawing. The comprehensive teaching method of this course became a typical case of online teaching in Shandong Province on behalf of Shandong University of Art and Design. This online course gave my peers and me a new understanding of digital hand-drawing. After the epidemic ended and I returned to school, I purchased a new digital screen and iPad. I was also pleased to find that the number of tablets used by my peers for digital hand-drawing increased significantly in the offline teaching of the upper grades. In the third year in-person teaching design course, students have started to use digital hand-drawing to communicate with me about their design plans, which may symbolize that digital hand-drawing has begun to light up the design life of students.

Our in-person teaching has been fully restored, and the online teaching of "Hand-drawn Design Expressions" now includes digital hand-drawing and paper hand-drawing combined, and this teaching experience will continue to inform offline teaching in the future. Because of the experience of this online education, we should continue to implement digital hand-drawing on the teacher's side for in-person teaching so that the theoretical lectures may be complemented by drawings demonstrations. We should let the advantages of digital hand-drawing assessment continue to apply in in-person teaching to improve the efficiency of assessment. The real-time operability of digital hand-drawing, the storability of digital images, and the convenience of paperless operation provides a new vitality to design education (Fig. 17).

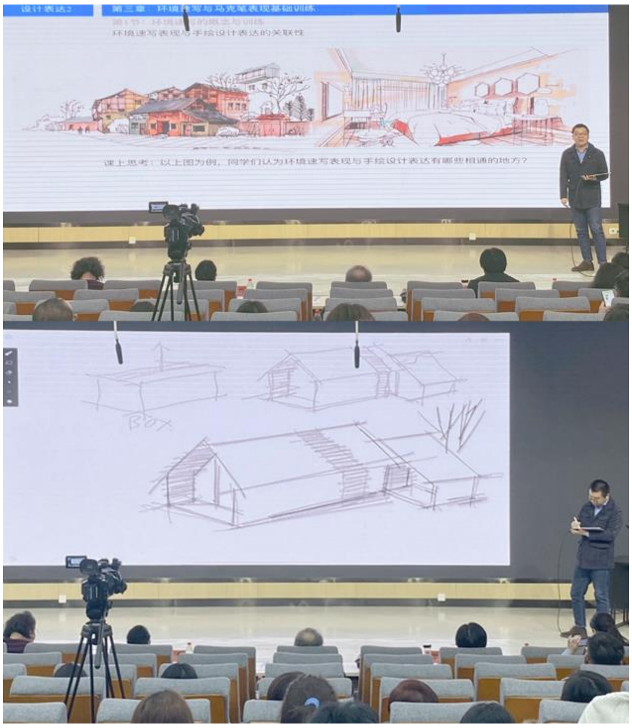

Figure 17. Theoretical lecture using an iPad in in-person teaching with digital hand-drawn analysis

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Exploring the Experiential Reading Differences between Visual and Written Research Papers

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Visual or pictorial research papers have emerged in recent years in academic conferences as a non-written archival contribution. Dual Coding Theory teaches us that visual knowledge is distinct from written knowledge and is arguably a universal language (Dreyfuss, 1984), with the ability to communicate complex ideas with clarity, precision, and efficiency (Tufte, 2001). This study explores the reading experience differences between visual and written research papers containing identical content from design, engineering, and business disciplines. Reading experiences were assessed using a 'think, feel, and do' survey, and comprehension was assessed with a quiz. Participants tracked time spent reading and how many times they revisited information. Visual papers provide an improved overall reading experience. Quiz comprehension results were mixed, showing no advantage of one modality over the other. Participants reading visual papers revisited information twice as much as those reading written papers. Designers, engineers and businesspeople were favourably united in their visual paper reading experience ratings but were not on their written paper ratings.

Keywords: Visual Papers; Pictorial Papers; Non-Written Academic Output; Design Learning; Assessing Reading Experiences

Introduction

Academic conferences, symposiums, and journals have recently begun adopting technical advancements to publish non-written output called pictorials or visual papers as a standard form of knowledge dissemination. For example, in 1990, the academic journal Postmodern Culture (Postmodern, 2018) became the first electronic peer-reviewed journal, a pivotal leap in academic publishing. Ten years ago, the JoVE journal, the first peer-reviewed scientific video journal, embraced digital publishing advancements and utilised visual formats to disseminate knowledge (JoVE, 2021).

More recently, organisations such as the Association for Computing Machinery's, Creativity and Cognition Special Interest Group have begun processing pictorial contributions at their conference using the same review standards as research papers. These non-written outputs are recognised as an archival contribution and presented and archived as equivalent to full papers (Pictorials, 2021). Other organisations that have adopted the same initiative include the Design Research Society's Learn X Design conference (LearnxDesign, 2021) and The International Association of Societies of Design Research (IASDR, 2021). However, not all organisations have committed to recognising non-written output as a valid form of knowledge dissemination. For example, the Design Society's (DS), Engineering and Product Design Education (E&PDE) conference welcomes visual papers at their conference but does not recognise them as archival contributions and does not publish them in conference proceedings (E&PDE, 2019).

Academic epistemology is rooted in written literacy, with most original research papers published in written text format reflecting the long held psychological position that 'the language of thought is unimodal and abstract, viewed as internalised words and sentences' (Paivio, 1991). This belief in linear modes of communication has built and maintained the dominant structure of epistemology within academic publishing. However, experimental psychologists in the 1960's began recognising the powerful mnemonic effects mental imagery had on memory performance over verbal stimuli (Yates, 1966). In the 1970s, the psychologist Allen Paivio (1991) ran quantitative experiments demonstrating that 'cognition is served by two modality specific systems that are experientially derived and differentially specialised for representing and processing information concerning nonverbal objects, events, and language' laying the foundations for Dual Coding Theory (DCT). The primary distinction in the theory is that verbal and nonverbal processes organise and transform information differently. The verbal system generates 'sequential' structures of complexity (phrases, sentences) while the nonverbal system generates transformations on: (a) 'spatial dimension' (size, shape...), (b) sensory properties (colour, sound, touch…) and (c) movement (time, motion…). DCT experiments demonstrated that human learning, memory, and thought are multimodal and can be amplified through imagery (Paivio, 1991).

Given that imagery plays a significant role in cognition, it is not surprising that academics have begun taking advantage of technological advancements that allow multiple forms of coding. By utilising visuals, movement and sensory modalities, researchers can increase their ability to communicate and disseminate their findings. Multiple studies have shown how visual diagrams or tables decrease the amount of time it takes a reader to understand complex concepts (Ainsworth, 2008). Tufte (2006) reports that pairing maps and images with words (multimodal coding) can improve cognition and memory. Paepcke-Hjeltness (2021) discusses how the theory of dual coding aligns with the goals of sketchnoting to analyse, synthesise and communicate ideas and information with more significant impact. The pioneer of modern data visualisation, W.E.B. Du Bois noted that dry, academic prose was not quite as engaging, memorable or applicable as visuals (Edward et al., 2018). In some fields, visuals are considered universally comprehensible (Dreyfuss, 1984; Tufte, 1990) and can communicate complex ideas with clarity, precision and efficiency (Tufte, 2001). These examples suggest that diversifying modes of coding in academic publishing should enable improved reading and learning experiences. Visual papers are trending in academic circles; however, there is little previous research on how readers perceive them. Do visual papers provide a better, worse or simply a different method of conveying information? This paper explores how unimodal papers (written) and multimodal papers (visual) are experienced by individuals from three different disciplinary backgrounds: designers, engineers and businesspeople.

Method

This study explores the reader's experience with unimodal and multimodal research articles by utilising the 250-year-old tripartite psychological classification of all mental activities— 'the cognitive, affective, and the conative aspects; that is to say, every instance of instinctive behaviour involves a knowing of something or object, a feeling in regard to it, and a striving towards or away from that object' (Mendelssohn, 1755, and McDougall, 1921, as cited in Hilgard, 1980).

The design community has translated these psychological classifications into designerly terms: think (cognitive), feel (affective) and do (conation). 'Think, feel, do' is frequently used by contemporary designers in creating experience maps. These maps often include business related components to help companies visualise the attitudes and behaviours of users and provide a deeper understanding of consumers' needs and desires, or in our case, participant reading experiences (Adaptive Path, 2013). For this study, participants completed a think, feel, do questionnaire after reading the paper's introduction, method, results, and discussion sections.

Disciplinary Value Differences

Participants from design, engineering and business were recruited to explore whether disciplinary character traits and values affect the reading experience. Hamilton (2019) observed disciplinary differences in communication and ways of knowing between design, engineering, and business students and found fundamental moral value differences between the three disciplines using The Moral Foundations Questionnaire (Haidt et al., 2008). Finally, this study tracked participant ratings by discipline to explore whether disciplinary methods of thought, memory and thinking respond differently to unimodal or multimodal reading experiences.

Survey Tools

A questionnaire was created and administered to participants using Adobe Acrobat with checkboxes and free answer boxes. The questionnaire was emailed to participants who completed the form on their personal computer and emailed results back to the researchers.

Participants

A convenience sample of 30 adult participants completed the questionnaire. The gender ratio was unequal, with 11 participants identifying as female and 19 as male. The females varied in age from 21 to 61, with a mean age of 31.45 years. The males varied in age from 21 to 52, with a mean age of 29.00 years.

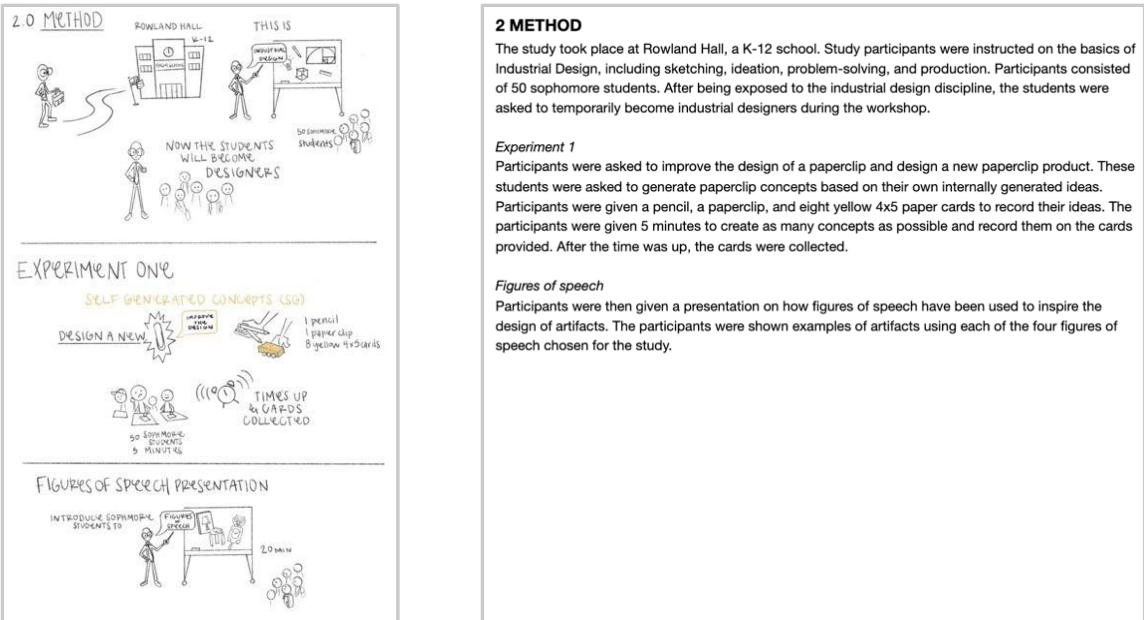
All participants were recruited from three disciplinary domains: design, engineering, and business—fourteen of the participants identified as designers, eight as engineers, and eight as businesspeople. Panellists were located primarily in the Mountain West and East Coast of the United States. Nine participants identified themselves as industry professionals, 19 as higher education students, and two as neither students nor professionals.

Researchers and participants incorporated COVID-19 parameters throughout the study, and panellists received no compensation for participation.

Stimuli

Participants received a fillable PDF packet containing (a) study instructions, (b) either a visual or written paper of identical content, (c) reading experience surveys and (d) a quiz. A previously published visual paper about creativity methods (Howell et al., 2020) was used for the study. This paper was initially written in a visual format and was translated to a written format. Multiple researchers reviewed the content of both papers to assure matching content (Fig. 1).

The visual and written papers are physically subdivided into five significant sections: (a) abstract, (b) introduction, (c) method, (d) results and (e) discussion. Each section ends with a survey assessing the reader's experience reading that section and the time it took to read the section. The abstract section and accompanying survey acted as a primer to introduce participants to the paper's general content and structure. For participants who had not previously read a visual research paper, this allowed them to practice the format before continuing with the study—in addition, completing the survey questions at the end of the abstract prepared participants to monitor critical aspects of their reading experience. Study results excluded the abstract survey ratings.



2 METHOD

The study took place at Rowland Hall, a K-12 school. Study participants were instructed on the basics of Industrial Design, including sketching, ideation, problem-solving, and production. Participants consisted of 50 sophomore students. After being exposed to the industrial design discipline, the students were asked to temporarily become industrial designers during the workshop.

Experiment 1

Participants were asked to improve the design of a paperclip and design a new paperclip product. These students were asked to generate paperclip concepts based on their own internally generated ideas. Participants were given a pencil, a paperclip, and eight yellow 4x5 paper cards to record their ideas. The participants were given 5 minutes to create as many concepts as possible and record them on the cards provided. After the time was up, the cards were collected.

Figures of speech

Participants were then given a presentation on how figures of speech have been used to inspire the design of artifacts. The participants were shown examples of artifacts using each of the four figures of speech chosen for the study.

Figure 1. Shows the Method section of both the visual paper on the left and the written paper on the right. Both samples convey the same information.

Surveys

The surveys assessed participants' cognitive (think), affective (feel), and conative (do) experiences while reading the paper. The questions utilised a five-point scale, anchored with the endpoints 'Not at all' (1) and 'Very' (5) and incorporate three or four words reflecting the think, feel, do categories. Participants also tracked the time it took to complete each section and the number of times they revisited paper content. Participants recorded both elapsed and cumulative time in minutes and seconds at the end of each completed section.

Quiz
A nine-question quiz was administered after the reading was completed to assess comprehension. The first question asked participants to recall product examples discussed in the paper. Questions two and three identified the total number of study participants and the referenced professional design discipline. Question four reviewed the paper's idea generation methods. Questions five and six identified high and low numerical performance scores in the results section. Question seven identified steps in the study process. Questions eight and nine identified the number of student samples collected and the percentage increase in student idea creation in the study experiments.

Background
The last section of the packet collected participant's names, ages, status (student, employed in industry, or other), disciplinary background, and whether they had heard of or read a visual paper before this study. Participants also described the 'reading experience in one word'.

Procedure
Participants were emailed the digital packet, informed that completing the study would take between 15 and 25 minutes and requested the packet be returned within two days of receiving it. Next, participants used their computers and chose when and where to read and respond to the study questions. First, they read the study instructions explaining the packet contents, including all materials and their organisation, which included explanations of the sample research paper content and the purpose of the primer section, the experience surveys, the quiz and demographic data collection.
Participants then read either the visual or written paper and responded to the four section surveys and tracked their elapsed time. Participants were free to revisit the paper's content during this portion of the study and asked to track how many times they revisited information. Participants were asked to answer the quiz questions without revisiting any portion of the research paper they read. Finally, they filled in their demographic and background information, saved the file and emailed it back to the researchers.

Data Analysis
Researcher's input received data into a spreadsheet and sorted it by visual and written papers, and the three disciplines: design, engineering, and business.

Results
The results portion of this paper is divided into three sections. Section 1.0 compares the visual paper results with the written paper results from all respondents. Section 2.0 compares the disciplinary differences between visual and written paper results. Section 3.0 reports participants prior knowledge of visual papers and provides a single word assessment of their reading experiences.

Section 1.0
Average total ratings for both the visual and written paper.

Cognitive/Think Experience
Participants rated their experience reading based on four aspects of cognition: (a) coherence, (b) clarity, (c) precision, and (d) succinctness, on a scale from 1: not at all, to 5: extremely — the higher the number, the better the experience.

Table 1. Cognitive word ratings

Paper	*Coherent*	*Clear*	*Precise*	*Succinct*
Visual	4.22	3.95	4.03	4.28
Written	4.07	3.92	4.15	3.82
% Difference	*3.56%*	*0.84%*	*-2.89%*	*10.89%*

Participants who read the visual paper noted higher coherence, clarity, and succinctness, while the participants who read the written paper noted a higher level of precision.

Positive Affective/Feel Word Ratings

Participants rated their experience reading based on four aspects of positive word emotions: (a) pleasure, (b) satisfaction, (c) confidence, and (d) interested, on a scale from 1: not at all, to 5: extremely — the higher the number, the better the experience.

Table 2. Positive emotional word ratings

Paper	*Pleasure*	*Satisfaction*	*Confidence*	*Interested*
Visual	4.03	3.97	4.00	3.98
Written	3.11	3.28	3.78	3.71
% Difference	*22.79%*	*17.20%*	*5.42%*	*6.93%*

Participants who read the visual paper rated their experience higher in pleasure, satisfaction, confidence, and interest. However, the data shows remarkably disparate levels in ratings of pleasure and satisfaction.

Negative Affective/Feel Word Ratings

Participants rated their experience reading based on three aspects of negative word emotions: (a) irritation, (b) frustration, (c) distraction, on a scale from 1: not at all, to 5: extremely. For comparison between positive and negative emotional experiences, the numeric data from the negative emotional word experience ratings were reversed — the higher the number, the better the experience.

Table 3. Negative emotional word ratings

Paper	*Irritation*	*Frustration*	*Distraction*
Visual	3.98	4.05	3.73
Written	4.18	4.23	3.77
% Difference	*-5.02%*	*-4.53%*	*-0.89%*

Participants who read the written paper rated their experience as less irritating, frustrating, and distracting.

Conative/Do Ratings

Participants rated their likelihood of taking action on three accounts: (a) citation, (b) sharing with peers and (c) application, on a scale from 1: not likely to at all, to 5: extremely willing to — the higher the number, the better the experience.

Table 4. Conation ratings

Paper	*Citation*	*Peer Sharing*	*Personal Application*
Visual	3.00	3.17	3.36
Written	2.72	2.98	3.15
% Difference	*9.44%*	*5.79%*	*6.24%*

Participants who read the visual paper were more likely to cite, share and apply the information from the sample research paper.

Combined Think, Feel, Do, Reading Ratings

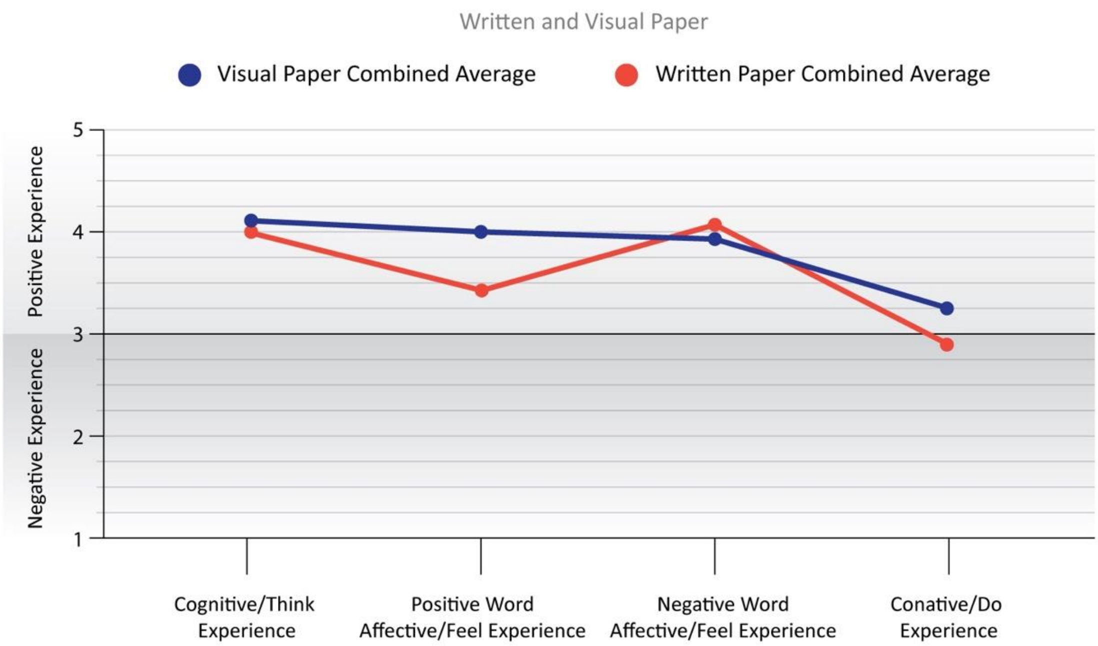


Figure 2. Total combined average of visual versus written reading experience for the think, feel, do categories

The total combined average for each category indicates that readers generally have a better experience reading visual papers than written papers.

Average Number of Times Participants Revisited Information

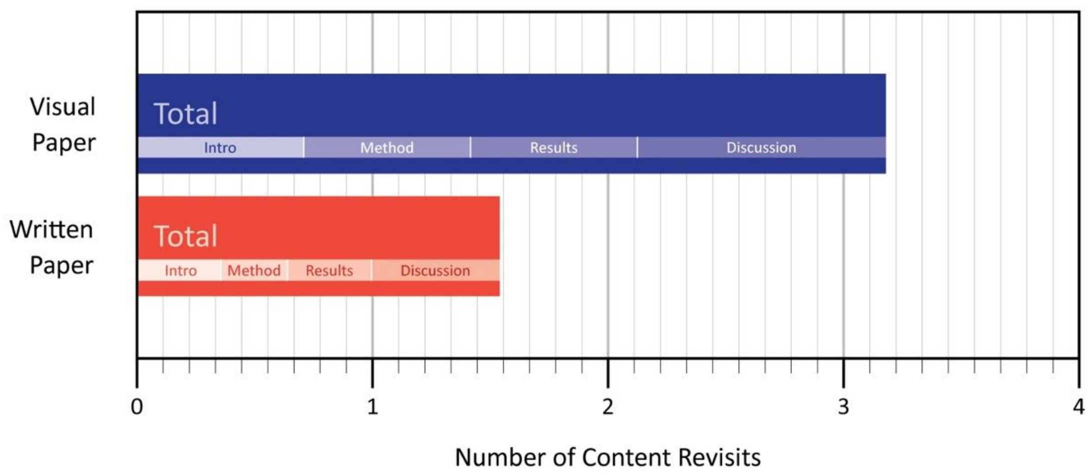


Figure 3. Average and Total number of times participants revisited the research papers content while they were reading

Participants who read the visual paper revisited information 47.83% more, or twice as often, as participants who read the written paper.

Quiz and Timing Results

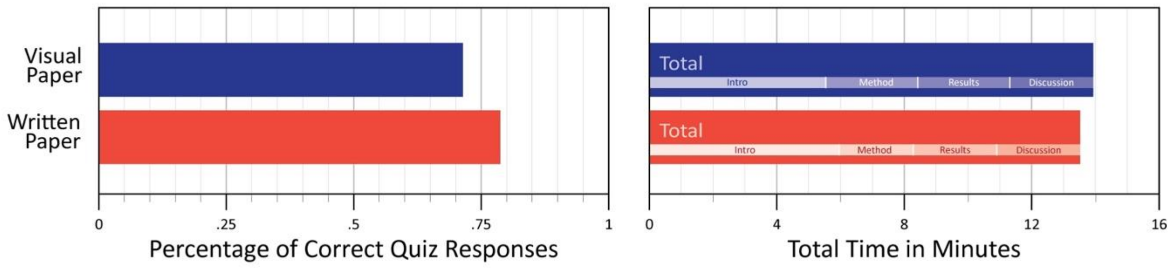


Figure 4 (left) is the percentage of correct answers for the quiz questions by both visual and written papers. Figure 5 (right) indicates how much time, in minutes and seconds, it took participants to complete the reading portions of the packet. The quiz timing is excluded from the total.

Average quiz results indicate that participants who read the written paper took slightly less time (within a minute) than those reading the visual paper. In addition, participants who read the visual paper took less time to read the introduction, results, and discussion sections but took slightly longer to read the method section.

Section 2.0

Average total ratings for both visual and written papers in design, engineering, and business disciplines.

Reading Experience by Disciplines

The averages for the think, feel, do categories of the survey by the three disciplines, design, engineering and business, are reported in Fig. 6 for the visual paper and Fig. 7 for the written paper.

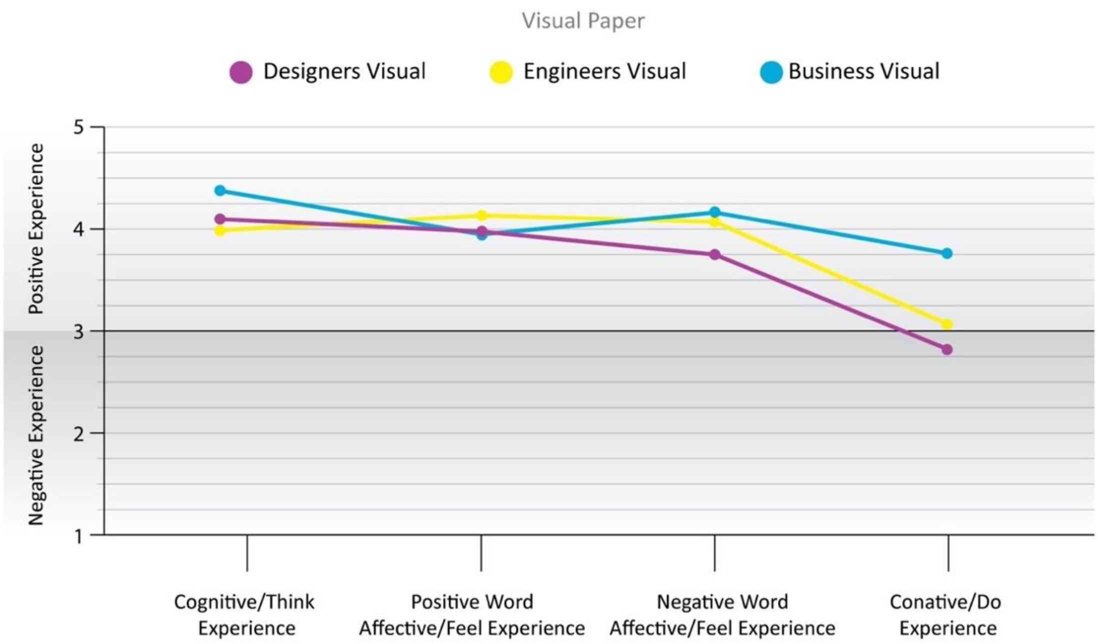


Figure 6. Scores from the reading experience surveys showing the disciplinary differences for visual papers

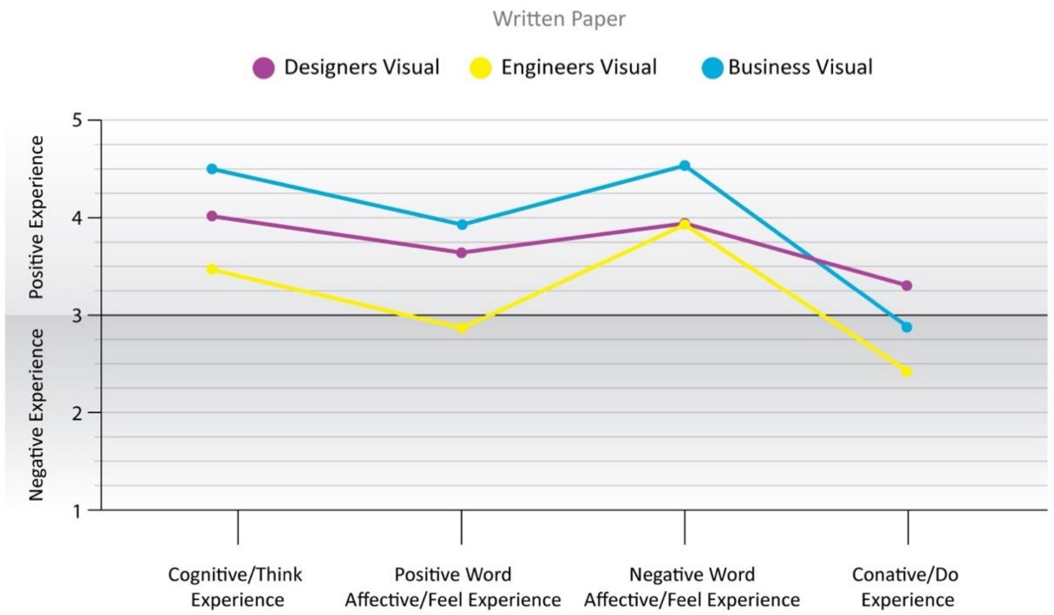


Figure 7. Scores from the reading experience surveys showing the disciplinary differences for written papers

By comparing Figs. 6 and 7, it is evident that the reading experience is relatively similar between the disciplines for visual papers. In contrast, the reading experience is entirely dissimilar between the disciplines for the written paper. The visual paper scores are within 0.3 points for the cognitive, positive and negative affective word experiences, while the conative score is nearly a 1.0 difference. On the other hand, the written paper scores indicate a 1.0+ difference in cognitive and positive word effective scores, just under 1.0 score difference in conative and a .5+ difference in negative affective words.

Combining Fig. 6 and 7 into a single graphic, Fig 8, indicates that the designers reading experience in both modalities are generally more similar than for the businesspeople and engineers. The designer's greatest score difference was a .5+ in the positive affective word category. In contrast, the engineers report the greatest ratings difference in the cognitive category with a .2+ difference and a 1.3+ difference in the positive word category, more than double the difference of the designers. Businesspeople showed the greatest score difference in both the negative word and conative categories. Engineers also show a noticeably lower written paper reading experience compared to other disciplines.

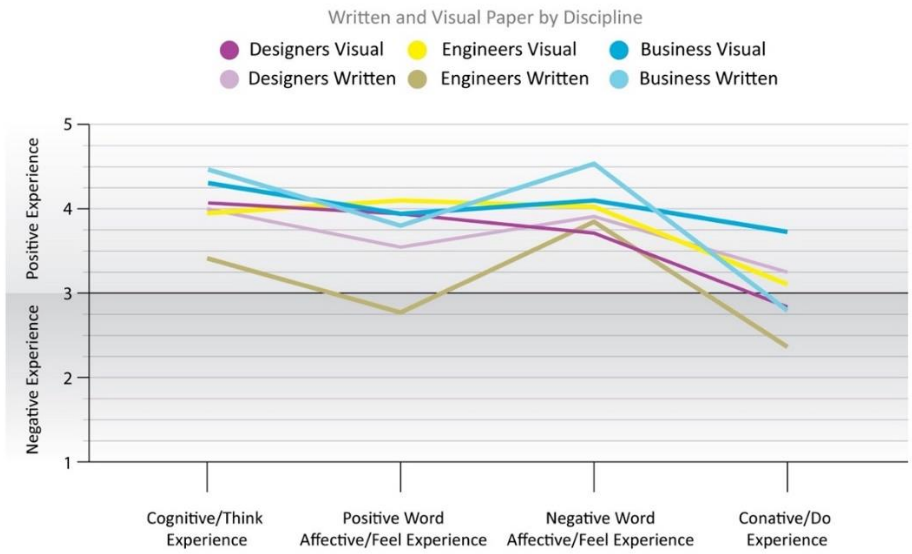


Figure 8. Fig. 6 and 7 combined into a single graph showing the reading experience survey scores by discipline

Revisiting Information by Discipline

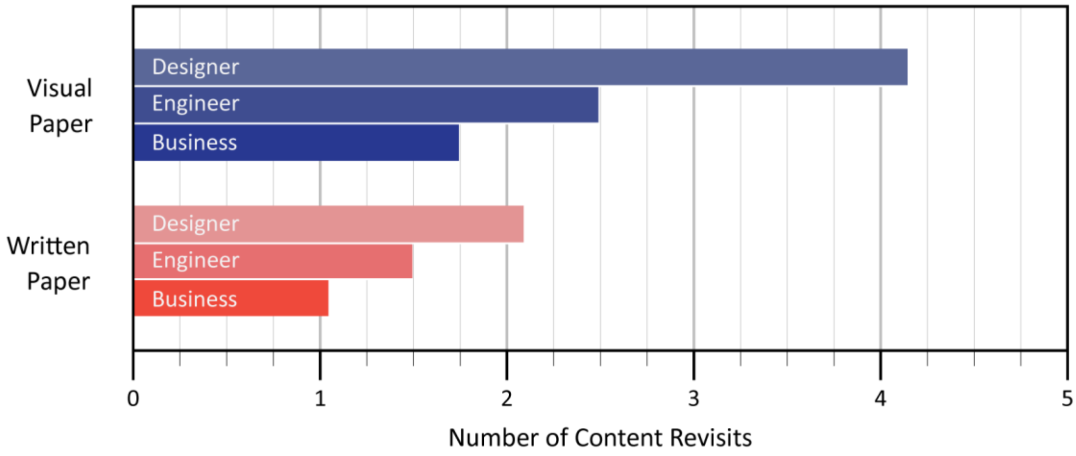


Figure 9. The number of times participants revisited information in the study research paper by discipline

Participants in each discipline reported they revisited information significantly more reading the visual paper as the written paper. This graph is also interesting because it highlights noticeable differences between the disciplines in how often they revisit the information in both modalities. Designers are revisiting information twice as often as businesspeople in both papers.

Quiz results by Discipline

The nine-question quiz results, Fig. 10, indicate that businesspeople perform the same in both modalities. However, the engineers and designers who read the written paper performed nearly 15% better (engineers) and 7% better (designers) than those that read the visual paper.

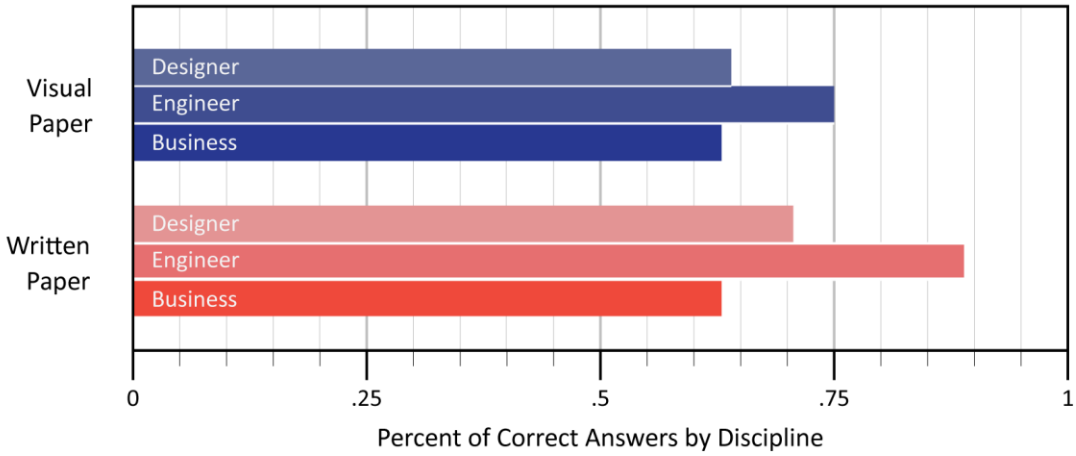


Figure 10. Percent of correct answers for the quiz questions by discipline between for both written and visual papers

Timing Results by Discipline

Study participants timed how long it took to read their respective papers.

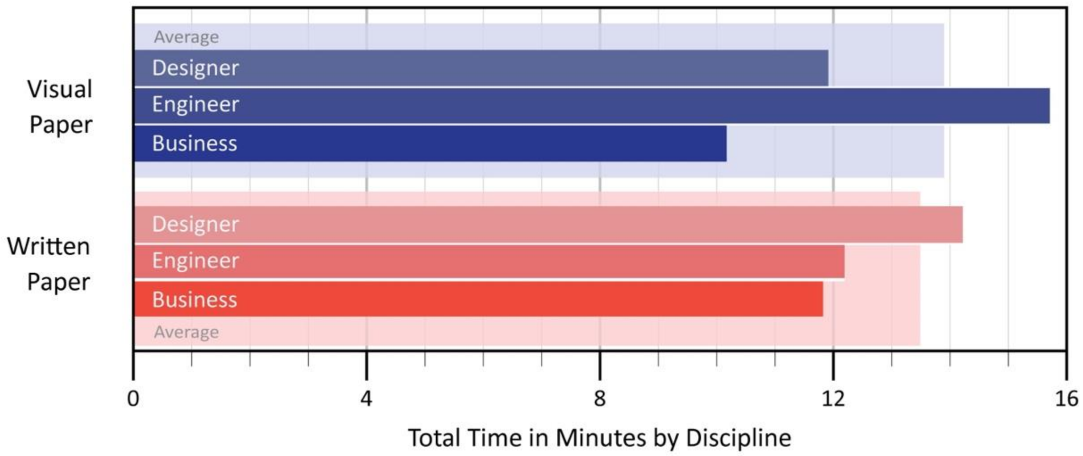


Figure 11. Indicates how much time, in minutes and seconds, it took participants to complete the reading portions by discipline. The total average for visual and written papers (Fig 4) is shown in the background. Again, the quiz timing is excluded from the total.

In the previous section, Fig. 4 indicated that visual papers took longer to read than written papers. However, when time is broken out by discipline, designers and businesspeople read the visual paper in 22% (2.33 m) and 15% (1.31 m) less time than the written paper, while engineers took 19% (2.56 m) longer to read the visual paper. These results suggest that participants disciplinary differences might significantly affect how participants react to unimodal (primarily linear) or multimodal (including spatial, sensory, movement) coding methods. This performance difference between disciplines is notable and needs further study.

Section 3.0

Results of participants prior knowledge of visual papers and provides a single word assessment of their reading experiences.

Single Word Results

A brief questionnaire at the end of the study asked participants to describe their reading experience in one word.

Table 5- The percentage of positive, neutral and negative single words reported by participants regarding their reading experience

	Positive Words	Neutral Words	Negative Words
Visual Paper	60%	27%	13%
Written Paper	47%	33%	20%

Words depicted in larger type in Fig. 12 were repeated by multiple participants. The descriptor words have been interpreted and organised by the researchers as depicting negative, neutral, and positive reading experiences from left to right.

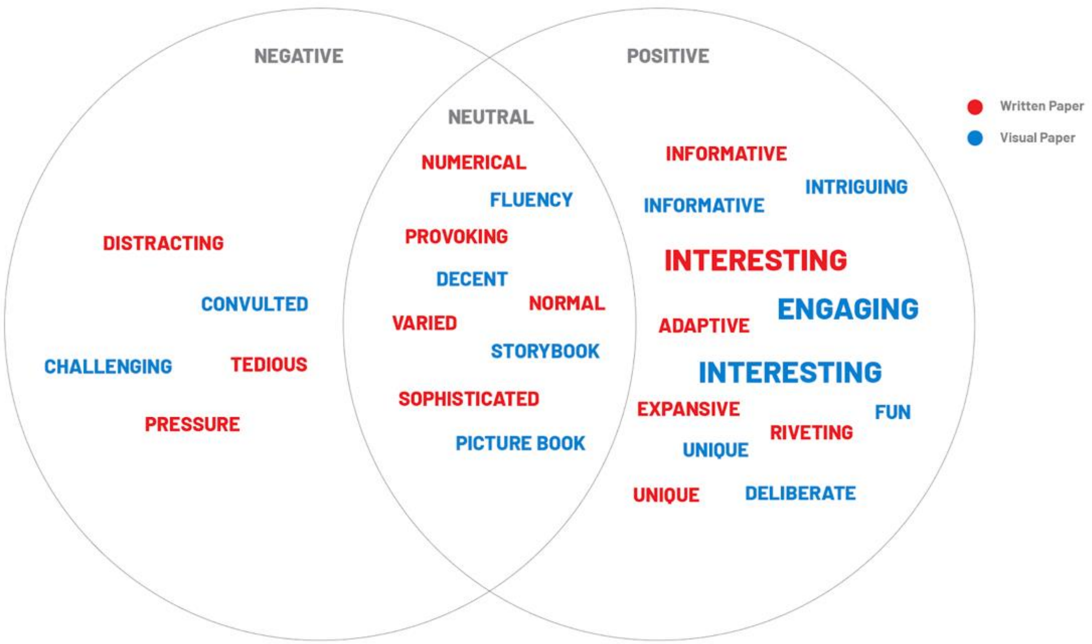


Figure 12- A word map indicating positive, neutral and negative individual words reported by participants regarding their visual or written paper reading experience

Previous Experience with Visual Papers

Participants were asked whether they had 1) heard of a visual paper before or 2) read a visual paper before.

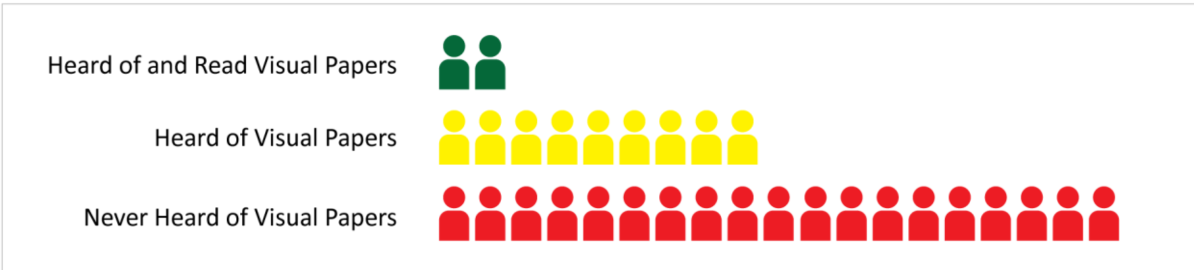


Figure 13- Number of participants who have previously heard of and read visual papers

Six designers, three engineers, and zero businesspeople had heard of visual papers before this study. One designer, one engineer and zero businesspeople participants had read a visual paper before this study. In total, 30% (9) of all participants had heard of a visual paper before this study, and 6.66% (2) of all participants had read a visual paper before this study. While visual papers may be trending in academic conferences, they are not yet commonly known or read.

Discussion

Think / Cognitive Differences

The flat cognitive reading responses (Table 1, Fig. 2) indicate that basic cognition occurs equitably between the two modalities. Researchers incorporated content revisiting, percentage of correct quiz responses and total time reading to explore the cognitive differences between the two modalities. Quiz results and reading also suggest cognition is equitable between the two modalities. However, that content revisitation occurred twice as much in the visual paper than the written paper and is not currently understood and discussed below.

Feel / Affective Differences

The positive affective word responses indicate that visual paper readers experienced increased pleasure, satisfaction, confidence, and interest in the reading experience (Table 2, Fig. 2) than the written paper's readers. However, in contrast to those results, the negative affective word responses, irritation, frustration, and distraction, slightly favoured the written paper over the visual paper (Table 3, Fig.2). This seeming contradiction in results could be caused by participants well established familiarity reading verbal papers and

the newness and excitement of reading visual papers.
Another possibility to explain the distinct positive word score difference between visual and written papers is that images could be more stimulating to interpret as they might require more mental explorations to define the message and meaning.
Studies have shown that emotions have a significant impact on cognition, attention, and memory. For example, Tyng et al. (2017) and Dolan (2002) have shown that emotion impacts learning. That a visual and written paper with identical content cause different emotional responses supports the notion the humans respond well to multimodal presentations involving imagery and that visual papers could increase cognition.

Do / Conative Differences

An essential currency within academic publishing is a citation, which generally indicates a paper's impact. The visual paper used in this study is slightly more likely to be cited and shared than the written paper (Table 4 and Fig. 2) indicates that utilising imagery amplifies dissemination. This result is possibly due to the increased positive emotional experience that occurred reading a visual paper. It could also reflect our contemporary culture that enables imagery to be easily shared and consumed over mobile phones and is thus more accessible in specific contexts. Further study is needed to understand this phenomenon as visual papers are not currently found in traditional research paper outlets, but results indicate that visual papers might innately provide easier dissemination and citation than written papers.

Disciplinary Differences in Reading Experiences

The differences in reading experiences between design, engineering, and businesspeople participants varied noticeably between visual and written papers, as shown in Figs. 6, 7, and 8. This result introduces several new questions. For example, why does the visual paper (Fig. 6) display relative consistency in reading experience while the written paper (Fig. 7) shows a dispersed reading experience? Would different disciplines improve their cognitive, affective and conative conditions if knowledge was created and disseminated using multiple modes aligned with their disciplinary values? What are those disciplinary differences, are they innate in the individual or instilled by the disciplinary training they go through?
Participant anecdotes highlight the disciplinary value differences of multimodal papers. For example, one study participant from design described reading the visual paper as 'fun,' a term not often heard in the academic publishing community. On the other hand, another participant from engineering, who had never heard of or read a visual paper, observed: 'I found the use of most images throughout this paper often unnecessary and a waste of space, time and effort'.
In any case, these outcomes suggest that multimodal content (visual) provides increasing equitable reading experiences between multiple disciplines over unimodal (verbal) content and that a visual-based genre of academic papers, when normalised, could become the favoured form of dissemination in the future.

Revisiting Information

Results showed that participants revisited visual papers twice as often as written papers overall and between the three disciplines. On average, designers revisited information in the visual paper a total of 4.14 times, which is 1.65X more frequent than engineers, and 2.36X more frequent than businesspeople. Similarly, designers revisited the written paper's information a total average of 2.05 times, which is 1.64X more frequent than engineers, and 2X more frequent than businesspeople. Thus, overall, designers revisited information in both the visual and written papers more than engineers and businesspeople, even though engineers took the longest time reading both the visual and written papers.
Researchers debated whether this was a positive outcome indicating participants felt comfortable returning to previous information to reinforce content or a negative outcome because they were struggling to comprehend the material. Alternatively, this could also be the natural results of reading unicode or multicode information and is neither positive nor negative but the natural way readers practice multicode learning (Paivio, 1991). It could also represent confusion with the medium, methods, or a lack of interest in the paper's topic. This phenomenon requires further research and insight to meaningful explain the motive behind revisiting content.

The Quiz

Results from the quiz portion of the study reveal few definitive discoveries. Fig. 4 illustrates little difference in quiz results, and Fig. 10 show that engineers perform better in both modalities than the other disciplines and increasingly so if they had read the written paper. There was measurably no difference in performance for the businesspeople, and the designers performed slightly better with the written paper. The researchers believe the quiz portion of the paper needs to be upgraded for future studies and the results statistically assessed.

Timing

The length of time it took to read a visual paper versus a written paper was similar when measured wholistically against each other, even though participants revisited information twice as often on a visual paper than on a written paper (Fig. 5 and Fig. 11). However, disciplinary differences were notable. Engineers required the longest amount of time to read visual papers, designers took the second-longest, and businesspeople took the shortest amount of time. The designers took the longest for written papers, then the engineers and then the businesspeople, indicating a difference in how the different disciplines consume information. Surprisingly, the designers and engineers trained in visual communication took more time reading than the businesspeople.

It is also notable that it was the first time that most participants had ever read a visual paper. The amount of revisiting combined with the lack of experience reading visually is a striking phenomenon and counterintuitive. This outcome indicates there is some level of efficiency gained in visual paper over written papers.

Single-word Responses

When asked to describe the visual paper in a single word, participants provide 60% positive words versus 27% neutral words and 13% negative words. In comparison, the written paper received a less warm response. For example, two participants that read the visual paper described it like a 'story' or 'picture' book, while two that read the written paper described it as 'sophisticated' and 'normal.'

For the visual paper readers, clear connections were made between the paper and general visual literature, such as children's picture books. Beckett (2012), a researcher on children's literature, states that picture books are considered the ultimate crossover genre... because of their multimodal format or otherwise 'inescapably plural' attributes (Lewis, 1990). Beckett also states that 'innovative graphics between text and image provide multiple levels of meaning and invite readers on different levels by all ages. Thus, it is plausible that research published through visuals might be accessible to a broader audience, similar to picture books.

Familiarity

The data in this study demonstrated that most study participants were not familiar with visual papers; only 30% of participants had heard of visual papers, and a mere 7% of participants had ever read a visual paper before. Compared to the 100% of participants who had heard of and read a written paper before, one could argue that this is an unequal starting ground for assessing and comparing comprehension rates between written papers and visual papers. An argument could be made that in this study, the data yielded from the comprehension scales of visual papers are disadvantaged due to the participants' lack of familiarity and practice engaging with the visual method of presentation in comparison to the written method of presentation. In future studies, to create a fairer assessment when comparing the comprehension rates of visual and written papers, it may prove beneficial to obtain a group of study participants who have experience reading visual papers and written papers.

There are, however, some benefits of testing the comprehension rates of individuals who are unfamiliar with the practice of reading visual papers. For example, collecting data on the time it takes for individuals to read a visual paper, more specifically, the individuals who have never read a written paper, could provide insight into visual communication efficiency.

The average reading time of the participants who had never read a visual paper before was 12 minutes and 29 seconds. The average time of the 15 participants, all of whom had read a written paper before, was 12 minutes and 49 seconds. The data shows that, on average, the participants who had never read a visual paper read the visual paper an average of 20 seconds faster than the students who read the written paper.

Furthermore, on average, the participants who read the visual paper revisited the content from each section 47.84% more often than those who read the written paper. When contrasting this revisitation data against the overall time averages, the increase in revisitation rates among readers of the visual paper implies that the visual paper readers were exposed to the content more times than the readers of the written paper and managed to do so in less time. Of course, it must be noted that reading speed and revisitation rates may not correlate with comprehension rate; however, the efficiency rate of visual communication is relevant.

Looking Forward

This research study was a preliminary effort in measuring and assessing the experience of reading visual papers. The results of this data have provided researchers with insight into the study's content that were

adequate and those that need improvement. The study's successful aspects included reading experience scales, revisitation measurements, the compilation of demographic information and the qualitative questionnaire. Aspects of the study that require modifications include the quiz structure, timing methods and the study's distribution format.
In subsequent research, sample sizes will need to be larger and more equally distributed between the design, engineering, and business disciplines. Future research may also benefit from study participants who are familiar with reading visual papers. The more extensive study will utilise internet-based software to distribute the study and automatically track participants timing. Additionally, the quiz's general goals and related questions need to be revised for clarity.

Conclusion

As addressed in our study, the results support the hypothesis that visual papers affect how readers interact with, understand and experience knowledge. The increase in positive emotions and emotions associated with reading the visual paper indicates that visual papers may be more accessible, memorable and engaging than their written counterparts. Results also indicated that visual papers are more likely to be cited, shared and applied. These results point to the overall benefits of continuing to develop multimodal (visual) papers for journals and conferences.

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Visualizing Your Knowledge and Connecting the Dots

Creating Visual Maps to Uncover Shared Interests for Collaboration

Verena Paepcke-Hjeltness
https://doi.org/10.21606/drs_lxd2021.04.259w

This workshop focuses on knowledge exchange to foster collaboration across disciplines. Participants will apply metaphors to visualize their research and projects using the online platform Miro, creating a virtual repository to start (or continue) conversations. How can we transfer knowledge and connect across disciplines in academia in non-traditional ways? Although barriers to connect virtually are now lower than ever before, there is a plethora of knowledge and research that is not accessible, visible, or discoverable to all researchers equally. How can we connect academia to practice and vice versa? All too often pertinent research developed in academia doesn't make its way to practice and on the other side businesses and industry are often too occupied meeting deadlines to either pursue their own research or to immerse in academic publications. This workshop aims to foster visual conversations to connect conference participants of diverse backgrounds to identify opportunities to collaborate with and learn from each other.

Keywords: knowledge exchange; sketchnoting; visual maps

Workshop Requirements

Technical Requirements & Materials

- A computer and internet bandwidth that can handle being on Zoom and Miro.com at the same time
- Basic knowledge of miro.com: How to navigate, use sticky notes, use text frames, use icon tool, upload images, use pen tool (https://www.youtube.com/watch?v=pULLAEmhSho, https://www.youtube.com/watch?v=Zbde_j3CbYo)
- Pen and paper
- A phone, tablet, or camera to upload sketches to Miro

Pre-workshop Prompts

Participants will be given access to the Miro board prior to the workshop. Each participant will find a frame with their name on it. These frames will guide participants through the pre-workshop steps and questions to answer. These questions build the foundation for the workshop activities. Alternatively, participants will be given access to a template to print out and fill in.
Note: they will be asked to transfer the contents to the Miro board during the workshop or upload the template as an image.
Questions for the pre-workshop prep:

1. What is your background?
2. What projects are you currently working on? What is your research focus?
3. What are you interested in collaborating about?
4. When you think about your research/work what image or activity comes to mind? What metaphor could describe It?
   Does it feel like smooth sailing, climbing a mountain, being in a maze, crossing the ocean in a small

boat or big yacht, hiking a trail or through unknown territory, traveling in space or deep diving? Is it an adventure or planned activity? If it was a landscape, would it be a city, an island, a forest, would there be mountains and rivers?

Workshop Outline

During this 60-minute session academics, students, and professionals are led through a process to visualize their interests and research focus with the aim to find connections for collaboration and knowledge exchange.

Process

1. 5 min: Give introduction to facilitators, and overall logistics.
2. 5 min: Give introduction to workshop and goals and share examples.
3. 15 min: Participants transfer their research/project metaphor prompt to Miro. This can be a sketch uploaded to their frame, sketched on Miro, or a visual using Miro icons, frames, arrows, and text.
4. 5 min: Participants highlight where they see areas for collaboration, where they would like input, or simply connect with someone who has expertise in a specific area.
5. 20 min: Each participant will be given 1 min to pitch where they seek input, advice, or are looking for collaborators.
6. 5 min: Each participant will browse the Miro board and leave notes on other boards to connect.
7. 5 min: Wrap up the workshop, share next steps and continue the conversations.

Note: Participants can opt in or out to make their boards public so that participants of following workshops can connect with them through this platform.

Workshop Outcomes

A visual repository to exchange knowledge and to connect during the conference and beyond.
The goal is to create visual maps on miro.com that showcase the individual's background, interests, current work and identifies opportunities to connect with others. These maps would be accessible throughout the conference and beyond to all conference attendees. The visual maps would be locked; however, participants would be ablet to leave notes, comments, feedback, and make suggestions for collaboration.
Examples of possible long-term outcomes: if successful, this workshop could lead to new connections between researchers for collaborative research and grant proposals; it could connect faculty and student mentees, faculty, and peer mentors; it could connect faculty for global collaborative courses, or practitioners and academics for joint projects or sponsored courses.
Continuation of accessibility to the workshop Miro board would create an alternative platform to foster conversations and connections.

Examples of Previous Workshops

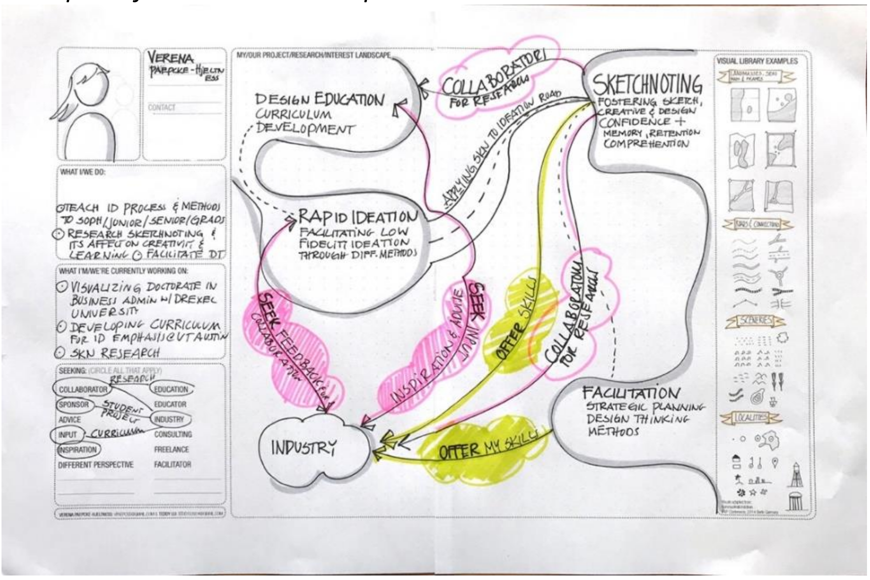

Figure 1. Example of previous workshop paper template

Figure 2. Workshop outcomes from the International Design Conference (IDC 2019), Chicago, IL, USA

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New Immersive Workflows for Design and Production

Improvements to Distributed Collaboration for Ideation, Sketching, Simulation and 3D Printing

Mauricio Novoa Muñoz, Wendy Zhang, Jose Manuel Rodriguez Diaz, Bryan F. Howell and Jan Willem Hoftijzer
https://doi.org/10.21606/drs_lxd2021.05.269

Today, there is a lot of hype about new technologies such as immersive virtual reality (VR). After more than five decades, the unfulfilled prophecy that VR would be available to everybody seems to be nearby. These development raises the need to find out how is that design and its education will be influenced by technological change and how they can also benefit from it. The aim of this workshop is to collaborate, share and discuss on how traditional and new means for ideation, sketching, simulation and production can form a better design workflow. The participants will be invited to contribute analogue or digital concepts (e.g., pen and paper, tablet). A selection of sketches will be transferred to a virtual reality program and developed into a 3D simulation for later 3D printing. The team of presenters will work in flexible and distributed locations in Australia, Netherlands, New Zealand, Spain, and the United States of America. Participants will be invited to share their own circumstances, views, and aspirations in relation to the implementation and potential of new technology in their own design education.

Keywords: design education; distributed collaboration; interaction design; user experience; virtual reality

Aims of the Workshop

The aim of this workshop is to collaborate, share and discuss on new forms of ideation and co-design based on recent developments on flexible and distributed technologies. Participants integrated by academics and professionals from the areas of architecture, design and industrial design will be invited to brainstorm and discuss together on the potential benefits of VR for digital sketching, simulation and production. The presenters from Australia, Netherlands, New Zealand, Spain, and the United States of America will demonstrate how a selection of sketches (pen and paper, tablet, and stylus) can integrate a workflow that uses 3D VR simulation and 3D printing output. The practical collaboration among presenters and participants intends to also gather views on the influence and implications relating to the implementation of new technologies for design and its education in different parts of the globe. Workshop participants' feedback will be evaluated and be made available with the hope of starting a community of practice (CoP) on new means for sketching, design and visualisation following the conference.

Background

Visionaries have promised that immersive and virtual environments would become an affordable reality and a tool for design (including architecture and other fields of design) and innovation for the last fifty or more years. After a slow start in the 1930s with the description of *stereopsis* (Bowers, 2001), the 1950s with the invention of the first virtual reality (VR) experience theatre *Sensorama* (Heilig, 2018) and the first VR headsets in the 1960s, such as, *The Sword of Damocles* (Sutherland, 1968), technology is now catching up with their aspiration of digital immersive experiences in the form of extended realities (XR) that include augmented (AR), mixed (MR) and virtual (VR) environments (Milgram, Takemura, Utsumi, & Kishino, 1995). These technologies seem closer to becoming a creative and communication tool for designers and people in general. However, in general, design education seems to be slow in their adoption. Recent economic pressures created by globalisation and the Covid-19 pandemic have thrust the interest in this type of technologies further since more work is increasingly done in *working-together-apart* scenarios that are distributed (synchronous and asynchronous). Many design projects also do not sleep as these keep progressing concurrently 24/7 in different concurrently coordinated global locations towards the production of *design artefacts* (e.g., objects, services, systems).

Workshop Methodology

The workshop will integrate

- The practical contribution by participants in the form of sketches and their design and education perspective on the potential for implementation of new technology in their own parts of the planet
- The practical demonstration by presenters that is open to the audience's active participation
- The collaboration among presenters and participants that intends to brainstorm on
    - The influence and implications relating to new technologies for design and its education in different parts of the globe
    - The challenges for technological transformation and/or enhancement of design education based on a Substitution, Augmentation, Modification, Redefinition (SAMR) Model for technology innovation (Puentedura, 2006, 2010)
    - The means to promote change and adoption of digitalization and new forms of education and practice based on a Reach, Act, Convert, Engage (RACE) Framework for technology perception and change of behaviour (Chaffey, 2010)
- The start of
    - A cadastral map on potential implementation and use of new 3D VR and 3D printing and manufacturing technology for the design profession and its education.
    - Future Community of Practice (CoP) on immersive technologies and workflows for design and production (Lave & Wenger, 1991; Wenger, 1998)
    - The use of an ongoing and open digital point of connection (MIRO board) that will stay open through and after the conference to support the CoP

Workshop Outline

This workshop is divided in two sessions and requires participants' preparation before them. The workshop pursues the collaboration, sharing and discussion on new forms of ideation and co-design based on recent developments on flexible and distributed technologies. Participants will be invited to brainstorm and discuss together on the potential benefits of VR for digital sketching, simulation, and production. The presenters from Australia, Netherlands, New Zealand, Spain, and United States of America will demonstrate how a selection of sketches (pen and paper, tablet, and stylus) can integrate a workflow that uses 3D VR simulation and 3D printing output. The practical collaboration among presenters and participants will be the base to collect views on the influence and implications created by new technologies for design and its education. The Workshop also intends to set the foundation to start a CoP with the participants on new means for sketching, design and visualisation following the conference.

Before Workshop

Participants: Preparation before workshop. Please

- Download the Miro and sign up to the app. You can run Miro from your Desktop or, alternatively, from a browser of your preference https://miro.com/login/
- Familiarise yourself with Miro and how to use it
    - https://academy.miro.com/courses/getting-started-with-miro
    - https://www.youtube.com/watch?v=pULLAEmhSho
- Sign in or sign up to Miro and enter our working space at:
    - https://miro.com/app/board/o9J_lvs4lA4=/
- Please upload your sketch contribution to MIRO and send it to m.novoa@westernsydney.edu.au
    - Remember to send an image at low resolution (75 to 120 dpi) and not at high resolution for printing (300 to 600 dpi) since VR works at screen resolution

        - Regardless, make sure that your image is legible before sending it.
- Contribute and indicate
    - Sketch samples on pen and paper or digital format. You can email them or upload to this MIRO board before the first session
    - Do you have any experience on VR?
    - Would you participate actively while wearing a VR headset or simply as audience through Zoom?
- If participating actively, please
    - Remember that the Gravity Sketch app works with 6 DoF VR headsests (e.g., Rift, Rift S, Quest 2, HCT Vive)
    - Either,
        - Sign up and log in to Steam VR: https://store.steampowered.com/steamvr, or
        - Sign up to Oculus site: https://auth.oculus.com/login/?redirect_uri=https%3A%2F%2Fwww.oculus.com%2F
    - Download and install Gravity Sketch app (education) via Steam VR or Oculus to your PC or headset
    - Sign up to a free Gravity Sketch LandingPad.Me account: https://landingpad.me

First Hour

Introduction (20 minutes – lead Mauricio)

Presenters will introduce the workshop and its format with a brief contextualisation on how the digital tools landscape for design is changing. They will also promote their SIG for Sketching and Visualisation at the Design Society and propose the opportunity to start a similar SIG at the Design Research Society but with its own angle. The breakdown of this section is as follows

- Setting up: Miro, Zoom
- Presenters' expertise (Bryan, Jan Willem, Jose Manuel, Wendy, Mauricio)
- Audience introductions (e.g., where are you from, what is your field in design education)
- Rationale for the session:
    - Aims and background
    - Quick overview of new workflows for design and production
        - Technology evolution from 2D to 3D and singularity of CAD
        - VR and 2D graphic design (lead Wendy)
        - VR and 3D printing and production (lead Wendy)

Participation, Discussion and Q&A (40 minutes – lead Mauricio, Wendy, Jose Manuel)

Participants are invited to ideate and discuss with the tools recommended prior to start the workshop. Please download them before the first and second workshop. Sketch contributions prior to the first hour can be done with analogue (pen and paper) and/or digital means (e.g., Autodesk Sketchbook, Photoshop, Procreate). Participation and discussion will be greatly based on two interrelated theoretical frameworks for new technology and digitalisation as recommended by Kramer (2020). First, Puentedura (2010) SMAR model. The acronym stands for four key factors that affect the introduction and use of technology in education: substitution, modification, augmentation, and redefinition. The biggest impediment for the introduction of innovation in education is not technological but cultural. The challenge is how to persuade educators and students to risk and try the new to later modify and create new habits. The SAMR model identifies a process for technological change and implementation in two stages. Through redefinition and modification of education and habits, and technology implementation either as enhancement of current technology or simply as its replacement with a better one. Second, Chaffey (2010) RACE framework. This acronym stands for the concepts of race, act, convert and engage. This framework was firstly used for digital marketing. However, it is useful here as it helps to unpack four key phases to promote digitalisation with effective behaviour change (Figure 1).

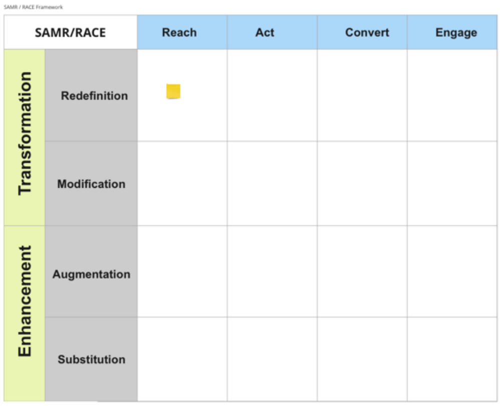

Figure 1. SAMR - RACE Framework (Kramer, 2020) based on (Puentedura, 2010; Chaffey, 2010)

The breakdown of this section is as follows

- 10 minutes: Personal details and SAMR/RACE model. Please select one of 20 boards available. You are welcome to
    - Fill information in the personal details' slots
    - Add your own views with post-it notes
    - Connect post-it notes to create relationships
    - Work with the queries provided
- 20 minutes: Discussion with Miro, Q&A. Based on your post-it notes and
    - Puentedura (2010) SAMR model on the role of technology to support learning,
        - Do you use digital and immersive technologies?
    - What do you use them for?
        - If you do not, do you see a need for them?
        - What would you need for their
            - Implementation
            - Modification of the current system,
            - Augmentation of it
            - Substitution of habits and technology no longer fitting?
    - Chaffey (2010) RACE framework to improve digitalisation,
        - How can we reach educators, practitioners and students to promote change?
        - What activities can promote redefinition of education and practice?
        - What would it take for students and practitioners to change habit and embrace digital transformation?
        - What process would secure their continue engagement in a culture of learning and change?
    - Q&A

Second Hour

Introduction (10 minutes – lead Mauricio, Wendy, Jose Manuel)

Presenters will give a brief introduction to Gravity Sketch as an immersive tool exemplar for VR sketching, ideation, design, and production in this workshop (e.g., menus, NURBS, mesh, sub-D). They will demonstrate how to import both pen and paper sketches and digital images into the VR environment.

Sketching Collaboration (30 minutes – lead Jose Manuel)

Based on selected sketches provided by the audience (e.g., raster, vector), the presenters will show how to bring them into the VR environment for 3D VR development and save them for additive manufacturing. The breakdown of this section is as follows

- Practical demonstration

- Selected sketches 2D, 3D in Gravity Sketch
- Collaborative experience within the immersive VR environment

Discussion (20 minutes – lead Mauricio, Wendy, Jose Manuel)
Presenters will moderate a discussion on the outcomes of the first session and the second session's VR demonstration. Participants are invited to share their views about their VR experience and the new immersive workflows for design and production presented. We welcome their ideas, suggestions, and feedback on the workshop (e.g., table, open questions) and to continue the conversation to form a CoP on this emerging area for design education and research (Figure 2).

SAMR / RACE Framework

Feedback	We welcome your feedback and ideas. Feel free to paste post-it notes below			
What I did like				
What I did learn				
What should we do next?				
What I would like to do next				
Would you like to be in touch for future activities and/or work?				

Figure 2. Participants feedback form

Expected Outcomes
The outcomes of the workshop will be

- To bring into the discussion the challenges of new technology for design education and practice and how to figure them out on a field that generally runs design courses with tight or minimal budgets
- The opportunity to form a community of practice (CoP) that with time can evolve into a culture of learning (CoL) that can facilitate the use and work with new technology for the benefit of its members regardless of location, access, and wealth (Thomas & Brown, 2011).
- Demonstration on VR immersive technology for using
  - Traditional skills with new technology
  - New technology to increase benefit for academia, industry, and final users.
- Demonstration and practice of VR immersive technology for
  - Substituting dated technology
  - Augmenting current practice
  - Modifying design education to improve learning
  - Redefining design education and practice per current co-design collaboration and digitalisation of innovation and production
- To start a cadastral map for the potential implementation of new technology and persuade behavioural change by design

Minimum and Maximum Numbers of Participants
The workshop can run well with as little as 15 and as many as 30 participants. It might run with the attendance of more participants on condition that most of them are either audience or participate through Zoom.

Workshop Benefits for the Participants
The workshop brings to the table the discussion on how technology mediates the generation and diffusion of knowledge and practice in design education and the profession (Tarde, 1903). As a matter of speaking, the

challenge is still whether the tool makes the designer, or the designer makes the tool. With this, the workshop creates a good opportunity to start tracing a cadastral map of how technology is implemented and influence change in different parts of the planet. Also, whether design education and the profession are experiencing a global geographical reversal of fortunes because of diffusion of technology; rather than simply thinking that technology change follows a *haves and have nots* phenomena across the economic divide. The workshop intends to start a conversation on learning beyond technology as just technical skill.

Workshop Relevance to the Track's Aims

The workshop is relevant to Track 07 Sketching and Drawing Education and Knowledge because new immersive technologies present a challenge for traditional education but also opportunities for co-design in flexible and distributed environments, and the realisation of new user experiences, realities and simulation that can streamline workflow and join together process flows (e.g., ideation, design and production) and the void among designers and users with an agile human-centred design approach.

Technical Consideration

The workshop will be delivered through a Zoom session, MIRO, and a VR experience. The latter will be enabled with an immersive experience for the participants if they wear a 6 DoF VR headset and enter the collaborative space in Gravity Sketch app. However, that opportunity will depend on participants' compliance with technical requirement, Gravity Sketch installation and collaborative features prior to the workshop. Alternatively, they can watch the session through Zoom.

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Section 08

Design Learning Environments: Exploring the Role of Physical, Virtual, and Hybrid Spaces for Design Education

Track 08: Design Learning Environments

Katja Thoring, Nicole Lotz and Linda Keane
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Teaching and learning approaches in design and art education can have different characteristics, ranging from traditional ex-cathedra teaching to project-based learning, sometimes even with external clients. Lecturing, self-study, teamwork, practical modelmaking, and remote teaching take turns, which is typical for the design field but can also be seen in other disciplines and K-12 education. The educational practices that arise from these different approaches often have a relation to the spaces and places in which learning takes place. The question arises how the spatial settings of the learning institutions can be designed in order to better facilitate learning.

Compared to other aspects of educational research, such as pedagogy in general, curriculum and syllabus design, educational psychology, and learning theory, the role of the learning space is relatively under-researched. With this track we aimed to explore two different perspectives on the topic: First, to understand the role of the space (physical, virtual, hybrid) in design and art education, and secondly, to investigate how learning spaces can or should be designed to facilitate learning in general. We provided some questions of interest as a starting point:

- How can the design of the physical space facilitate creativity and the design process in general?
- What hybrid or virtual counterparts of physical space can be identified for design learning, and what are related challenges and opportunities?
- What are new trends in learning space design in K-12 education (Kindergarten and Elementary Schools)?
- How does the learning space need to change after Covid-19?

We included 14 research papers and two workshop proposals for the conference program and proceedings that represent a broad range of different perspectives on the topic.

Contributions to Track

Three papers focus on the context of K-12 education: In their paper "Unlocking wellbeing-affordances in elementary schools initiated by a "natural experiment" caused by Covid-19", *Ruth Stevens, Ann Petermans and Jan Vanrie* explore design strategies to design wellbeing related affordances in the post-Covid 19 classroom. *Anne Taylor* presents a collection of case studies of "Architecture for Education" with the aim to inspire designers for creating better learning spaces. Another case study from the K-12 context is presented by *Ge Fu* with the paper "Senseed: A Multisensory Learning Environment for Urban Pre-Schoolers in China".

Several papers introduced new tools and theoretical frameworks for the higher education context: In "A Game Implementation Approach for Design Education Within the Content of Architectural Design Studios" *Duhan Ölmez and Fehmi Doğan* introduce a new video-game-based tool to facilitate architectural design processes. *F. Zeynep Ata and Fehmi Dogan* introduce a conceptual framework for the "Architectural Design Studio as an 'Extended Problem Space'". Finally, this theory-focused session will be concluded by *Yuan Liu, Dina Riccò and Daniela Anna Calabito* who present a framework for an immersive virtual environment to teach basic design.

Several submissions presented theoretical contributions with a strong focus on virtual aspects. *Meng Yue Ding, Yi Ke Hu, Zhi Hao Kang and Yi Jia Feng* ask "Teaching with Virtual Simulation: Is It Helpful?". *Ruth M. Neubauer and Christoph H. Wecht* discuss the "Materiality of Space and Time in the Virtual Design Studio". And in their

paper “Designing Criteria for Developing Educational Multimedia Games” *Chaitanya Solanki and Deepak John Mathew* present a review of theories and guidelines for multimedia learning environments.
The question of how virtual learning spaces were able to replace physical environments during the COVID-19 pandemic was addressed by three contributions: *Andreas Ken Lanig* proposes “the intellectual diet in pastoral spaces of activity in digital design education”. *Alessandro Campanella, Eliana Ferrulli and Silvia Barbero* discuss the advantages of multimodal online learning environments and suggest the need for “Rethinking experiential learning in Design education”. Finally, *Adela Glyn-Davies and Clive Hilton* propose “Utilising Collaborative Online International Learning (COIL) as a Pedagogical Framework for Design Thinking Projects”.

The last session of research papers in this track focuses on hybrid learning spaces. *Shunhua Luo, Jingrui Yang and Chunhong Fan* explore the potentials of “Hybrid Spaces Teaching for Chinese Traditional Costume Craft”. In “Critique Assemblages in Response to Emergency Hybrid Studio Pedagogy” *Christopher Wolford, Yue Zhao, Shantanu Kashyap and Colin M. Gray* report on hybrid critique approaches in the design studio and how these might foster critical reflection.

To complement this cutting-edge research on creative learning environments, two workshops have been invited to deliver hands-on experiences on the topic. “The leftovers of Participation” is run by *Andrea Wilkinson and Steven Lenaers* and will center primarily upon the experience of the participants within different environments. And finally, *Gloria Gomez and Rodney Tamblyn* will conduct an interactive workshop where “Students and Teachers become Co-designers of Learning”. In this workshop participants will have the chance to experience a virtual personal learning environment.

In summary, the selected papers and workshops are presenting varied perspectives into the realm of physical, virtual, and hybrid design learning spaces, targeting both, higher education and K-12 education. The insights to be expected from these presentations promise a glimpse into the spatial aspect of design pedagogy, which is subject to significant disruptions following the COVID-19 pandemic.

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Nicole Lotz is Senior Lecturer in Design at The Open University in the UK. Nicole is interested in design processes, collaboration and engagement across boundaries and at the margins. Her work seeks to offer opportunities for disadvantaged communities to engage and persevere through social and communal creative learning, even in challenging situations.

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Unlocking Wellbeing-Affordances in Elementary Schools

A "Natural Experiment" Initiated and Caused by Covid-19

Ruth Stevens, Ann Petermans and Jan Vanrie
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In 2020-'21 Covid-19 rolled over the school landscape as a pressure wave. Elementary schools had to push through ad hoc changes in their physical structure to succumb to the safety regulations issued after the first lockdown in the Spring of 2020. These physical alterations influenced the organizational structure of schools and the wellbeing of protagonists. Through all the negative, also positive sparks were noticed, as some changes were appraised positively, inveterate ideas were abandoned for an open minded view and teachers at home overthought their functioning and searched for meaning in their profession. This relevant momentum can be viewed as an opportunity to critically question the rather cumbersome design type of elementary schools, and to provide more attuned spatial affordances to teachers and pupils. The aim of our study was thus twofold: first, to get a grip on the values and needs that teachers and pupils had (re)attached to the functioning, and positively appraised changes in the school organization and environment. Second, we aimed to combine the gathered data and explore design strategies to design wellbeing related affordances inspired by the "natural experiment" caused by Covid-19. To conclude, the paper discusses the 'flourishing affordance' in school architecture.

Keywords: architecture; design for wellbeing; psychological needs; programming; learning environments

Introduction

In Flanders, Belgium, currently, there are 2661 elementary schools (Vlaamse Overheid, 2021). The Covid-19 pandemic pushed schools into a "natural experiment" dealing with the sudden crisis situation. From a spatial perspective, the closure (which started in Belgium in March 2020) and the reopening of primary and secondary schools (initiated in Belgium mid May 2020) urged school administrations to push through ad hoc spatial changes to succumb to the safety regulations regarding "social distancing". These changes penetrated onto the levels of the organizational structure (e.g. different opening hours for each grade) also including the pedagogical concept (Tomasik et al., 2021) (e.g. not being allowed to work cross-class) but also affected the protagonists functioning here: pupils and teachers (e.g. Reinius et al., 2021). Both pupils and teachers showed signs of having performed introspections during the lockdown, regarding the values and needs related to their functioning at school. In this paper, we zoom in on the geographical and cultural context of Flanders, and we hypothesise that evaluating the diverse spatial interventions schools implemented from the point of view of the protagonists (i.e., pupils and teachers) will provide insights into the potential of the existing school infrastructure to increase the wellbeing of pupils and teachers. Indeed, in a context where the patrimonial situation of many schools is still rather problematic (Châtel et al., 2011), even small adjustments or improvements in the spatial environment could make a difference.

We opted to use this "natural experiment", and learn what and how spatial alterations were appraised in a particular way. Our research question thus is the following: **what new affordances[1] did the space offer to its users?**

The Current Status of Designing Learning Environments

Designing 'optimal' school environments and spaces for learning is a considerable challenge. On the one hand, there is the aspect of the design of these environments. International researchers investigating learning environments often separated teaching and learning from their spatial setting, or failed to incorporate classroom practice in spatial studies (Gislason, 2010, 2018). On the other hand, while curricula tend to change in line with societal evolutions (Kessels, 2013; Gislason, 2018), the spatial environment in which the courses and teaching methods take part, has, in general, hardly evolved. This is of course in part due to the 'slowness' of the architectural domain in general and school typology in particular. With some notable exceptions, also in Flanders, Belgium, most of the schools are still located in the same type of buildings or have the same interior as during the second part of the 20th century (Châtel et al., 2011; Van Den Driessche, 2009). We notice two gaps in literature that hamper designers to create school environments that focus on wellbeing combined with evolutions in pedagogical organization.

Firstly, in terms of the patrimonial situation of schools in Flanders, the school landscape has known two recent waves of building programmes for school infrastructure at the beginning of the 21st century, via Design-Build-Finance-Maintain (DBFM) projects of the Flemish Government, supervised by the Team Vlaams Bouwmeester (i.e., a governmentally supported team safeguarding the architectural quality of the built environment). This action ought to tackle the non-desirable constellation of school sites today and respond to an extensive demand for extra space. Notwithstanding these initiatives, in the ad hoc, fragmentary alterations that schools undertook over the years in order to answer their local 'most urgent needs' (Châtel et al. 2011; Nusche et al., 2015), interesting opportunities to help resolve particular spatial needs 'are hidden' in the current landscape. While novel projects often integrated particular evolutions and novelties, these were mostly focusing on the level of the architectural masterplan of the school site and surroundings, such as the combination of a school program which non-school programmatic elements (e.g. a nursery), or the more active relation between the school and the fabric it is situated in (Châtel et al., 2011) via the opening-up of parts of the school infrastructure to local residents (e.g. a school's sport facilities), or inserting shared facilities (e.g. a small petting zoo). However to date, a detailed look on the spatial reality of an elementary school tuned to the pedagogical concept, and vice versa, is still missing (Grannäs and Frelin, 2017).

Secondly, it is clear that over the years, studies regarding the physical, social and academic conditions of the school environment have grown steadily (cf. Corral Verduga et al., 2015) but although the built environment in this context can be seen as a didactical agent for positively influencing learning and teaching processes (Gislason, 2010; Daniel et al., 2019; Tapia-Fonllem et al., 2020), there is still too little empirical knowledge to have a solid knowledge base for creating appropriate learning environments that also incorporate the subjective wellbeing of the different protagonists functioning here. More specifically, a lack of empirical data that connects the pedagogy and the actual spatial elements hampers architectural designers to truly integrate wellbeing drivers of pupils and teachers in their design, as they for instance do not know how certain pedagogical strategies can be supported by specific spatial elements. The issue of wellbeing is not only an increasingly frequent topic in educational discussions (cfr. infra), but also in design disciplines. In architecture, this issue has been partially documented, with a focus on spatial aspects that cover objective wellbeing in the environment, such as 'ventilation', 'noise', 'lighting', etc. (e.g. Barrett, 2013, 2015). However, often these issues are studied in isolation, not incorporating the pedagogical approach of a teacher in that particular environment or other elements which might impact of such considerations (e.g. Higgings et al, 2005; Burman, 2018). To develop environments in which learning gain and learning pleasure is promoted, a more systematic view needs to be taken, and one must think in terms of what the environment can offer to fulfil certain needs that allow teachers and pupils to become the best possible version of themselves in the school environment.

An Affordance-Based Approach in Architecture

Becoming the best person one can be, is called 'flourishing', a topic originating in positive psychology (e.g.

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[1] The concept of 'affordance' originates in psychology and stands for how various kinds of environments, ranging from urban spaces to intimate interiors, can appeal to particular users, and why they do so in different ways for different people (Petermans et al., 2020). Users of a particular environment can recognize action possiblities linked to certain needs and goals they have (Stevens et al., 2019b).

Ryan & Deci, 2001). The topic has recently been operationalized in architecture as "Design for Human Flourishing (DfHF)" (Stevens et al., 2019a,b). This approach stands for a search for designing programmatic gestures that allow people to enforce their talents, and fulfil their psychological needs, in order to become the best possible person one can be, or in other words, to flourish. Strategically, a DfHF-approach uses opportunities that are noticed in the social and spatial environment, and is based upon a definition of the target group's psychological needs (Stevens et al., 2019a,b). In other words, DfHF takes an affordance-based approach (see Petermans et al., 2020, p.25), in which psychological needs are translated into designed activities that are thus supported and triggered by the environment. The activities cover various intensity-levels and are shaped together into a so-called 'enriched' program (Stevens et al., 2019a,b), see Figure 1. Based on the enriched program, a spatial reality covering all kinds of architectural elements, is then designed to house the activities. Figure 1 shows how a DfHF-framework in architecture can be composed.

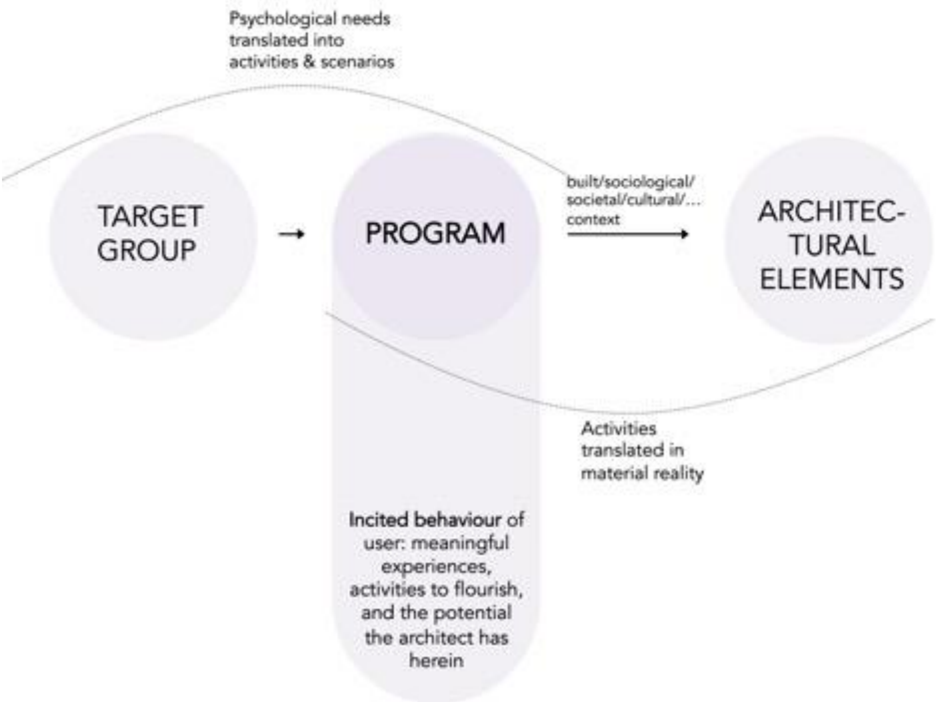


Figure 1. The DfHF-framework in architecture.

As demonstrated in Figure 1, the DfHF framework indicates to first determine the psychological needs of the concerned target group, then translating these into rich activities (i.e., building a program for the site), which leads to designing a space using architectural elements to accommodate the program. Extrapolating the DfHF-framework to the spatial context of school environments, learns that the 'program' or the 'rich activities' are largely determined by the pedagogical concept and didactical methods teachers apply in their educational practices. Regarding the target group, the psychological needs of both pupils and teachers should be taken into account and be balanced out. Thus, in order to create a supportive, flourishing environment, the balanced psychological needs of teachers and pupils should be tuned to pedagogical activities (incorporating the evolutions in the field such as digitalization and the institutionalized character of learning), and can then be facilitated through architectural elements (i.e. elements that make up the exterior and interior of the school building and its surroundings, such as trees, desks, white boards, lounge seats, …).

As the context of school environments poses novel challenges in applying the framework (cfr. supra), in this paper we apply a Research by Design set up to explore possibilities and new affordances the school space can offer to its users based on experiential insights that were gathered during the Covid-19 period. In what follows, we will sketch the set up of the research by design practice, and zoom in on the question of how particular spatial interventions were developed. Then, we will attempt to translate our explorative design research results into design avenues that schools can take to focus on flourishing affordances for pupils and teachers.

Research by Design: A Seminar to Surface Spatial Flourishing Affordances

Context of the Seminar

This Research by Design project was organized within the framework of a master seminar, set up for master students in Architecture and Interior Architecture. A seminar is a one-semester-course, entailing 8 to 9 ECTS, in which master students of the Interior Architecture and Architecture program can enrol. They meet up every Monday and work all day. During these Mondays, the students study a particular topic in the field of human centred design via applying research methods (e.g. qualitative research and literature studies) together with research by design. The topic this academic year related to filtering and designing for positive experiences in elementary school environments, while focusing in particular on one elementary school, located in the east of Flanders. This elementary school was selected as a case study to work on due to the enthusiasm and avidity of the school principle to tackle certain spatial issues, and develop insights into wellbeing. At the end of the course, a master jury was organized in which students presented their research and design results to the tutors and the stakeholders of the concerned case.

Set-Up of the Seminar

The 19 students that enrolled in the seminar were divided into four design groups, each consisting of four or five students. First, students were asked to collect research data of the two protagonist groups of the elementary school: pupils and teachers. For each of these protagonist groups, the students performed a literature review to surface psychological needs and values. As tutors of the seminar, we provided the students with a set of papers (N= approximately 15 per protagonist group) that was composed via a selection on search terms such as ‘psychological needs’, ‘wellbeing’ in journals such as Journal of Educational Psychology, Journal of Happiness Studies, Social and Behavioral Sciences, International Journal of Educational Research and Frontiers in Psychology. Additionally, the students organized qualitative studies (i, ii) to get acquainted with the needs, wishes and experiences that the target group expressed and felt during the current Covid-19 pandemic. To learn from the target group of teachers (i), students prepared a focus group panel discussion in which they posed in-depth questions and presented a number of these, all based on the literature review. That way, they could grasp the intensity levels in which certain needs and values occur, and learn to understand what novel insights teachers developed during the lockdown with regards to how they experience their job, and see themselves functioning as a teacher. For the target group of the pupils (ii), the students prepared a trifold qualitative study in the natural habitat of the pupils, that is, the school site (some results are displayed in Figure 2 below). First, they performed a photo elicitation study (see Warren, 2005), in which pupils were asked to visit their favourite place/space in school, the place they go to when they had a fight with a friend, the place they go to for private conversations, the place in which the pupils feels safe, etc. The pupils who participated had to make a picture of the particular place and add a few words to describe what made them feel that way. Secondly, the students organized a ‘playful interview’, in which they presented a number of pairs of pictures of spatial organizations and interiors of school environments to the pupils, accompanied by specific questions. For instance *“Do you prefer to learn outdoors or indoors?”.* The pupils had to answer the question by selecting their favourite of the pair of pictures. Thereafter, a group discussion was organized in which pupils were asked to describe what the most enjoyable moments are in school, and what they missed during the lockdown and distance-learning –phase. In groups, they had to draw their ideal spatial classroom setting. Thirdly, a group of the design students observed the pupils and the teachers during the ‘playful interview’ and the introduction of the teachers, to grasp in what way the pupils ‘master’ the environment, have their own space, and how the teachers handled and altered the spatial layout and approached their pupils during the playful interview and learning moments.

To conclude this part of the research, the design groups were asked to combine their data and draw up lists of psychological needs and values that the two protagonist groups of teachers and pupils attached to their specific functioning at school. That way, the design students could get a grip on wellbeing drivers and possible barriers for the protagonists of elementary school environments in the Covid-19 era in Flanders, Belgium. Additionally, the design groups performed a spatial analysis of the architectural and environmental reality of the particular school site by drawing interiors, floor plans and site plans, circulation schedules, etc. As the students were not allowed to physically visit the school terrain due to the entangled Covid-19 restrictions in the fall of 2020 in Flanders, the teachers and pupils of the school had made a video of the school surroundings, and sent existing plans and photographs to the students via email. The tutors of the seminar had been able to visit the school terrain at the end of the summer of 2020, and were able to address questions that students had.

Figure 2. An illustration of the data collection – Top left: a photo elicitation of a 'favourite spot' – Top right: a drawing of 'the ideal classroom' – Below: the result of the picture-pair "Do you prefer to learn outdoors or indoors?" with quotes.

A Conflict-and-Synergy Approach to Analyze and Develop Spatial Experiences

At that point, students had learned about the architectural characteristics of the school site, had dived into the general psychological needs of pupils and teachers, and had also gathered insights into the experiences and proper introspections (see Nunan, 1992, Overgaard, 2011) of pupils and teachers during the specific period of Covid-19 relating to their activities at school (e.g. teaching, learning, social connections, etc.). Through the lens of the DfHF-framework, those actions comply with the starting point of a DfHF-design process, covering information on the **target group** (see Figure 1 above).

Here, the typology and particular situation add complexity to the approach due to the multi-stakeholder perspective and the testimonials in which pupils and teachers expressed what they have learned during the Covid-19-period. In an elementary school environment, needs and values of pupils as well as teachers must be balanced in one environment. To do as such, we developed a technique called the "conflict-and-synergy-search". Concretely, the students were asked to envision situations –taking place at certain locations in school- in which needs and values of teachers and pupils could collide. Via the technique of narratives or storytelling (Heylighen, 2005; Stevens & Desmet, 2019), experiential data were included and situations came to life in which teachers and pupils interacted. In these hypothesized interactions, experiences were set out that surfaced what potential conflicts or synergies could be found in the pupil-teachers-relationship in the school's organizational structure. For instance, when a teacher prefers a visual overview of the class and a pupil wishes to work in privacy, or when teachers display a great deal of informative posters on the classroom walls, but pupils feel they cannot concentrate when carrying out a think exercise due to the 'visual noise', there is a potential –spatial- conflict. When teachers prefer flexible set ups of the furniture, and pupils prefer playful learning, possibilities for synergy arise. Below, in Figures 3 and 4 the conflict-synergy analysis of a design group incorporating their literature and qualitative research data, is showcased. In orange, the specific psychological needs of respectively the teachers and the pupils is written, and in between in black, the hypothesized conflict (figure 3) or synergy (Figure 4) situation is explained. For instance in Figure 3: teachers need structure and pupils need flexibility. Here, a potential conflict rises as the needs are operationalized in the following behaviour: pupils do not wish to sit still al day long at school, but teachers need the overview of the class group. Moreover, teachers also wish to teach in a creative manner, that way meeting the a more active posture of the pupils, however they fear to loose a grip on the pupils and miss out on some pupils who need extra guidance and not dare to ask questions.

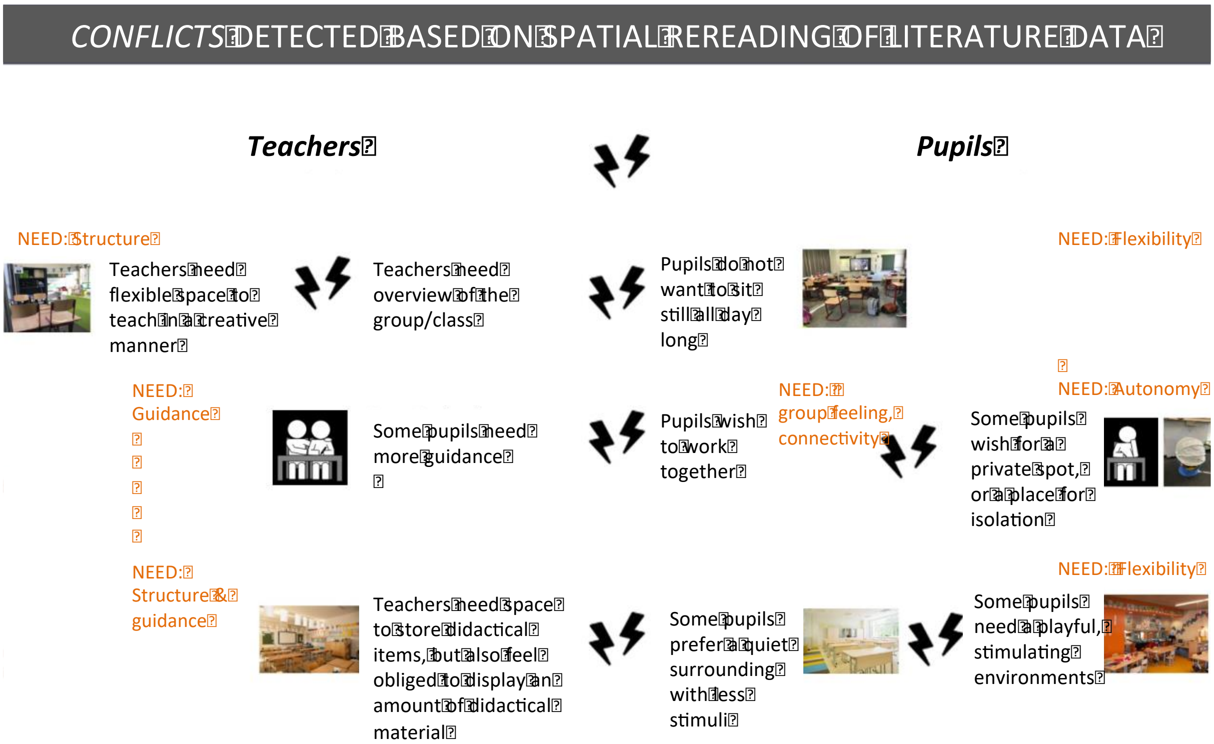


Figure 3. Conflicts between teachers' and pupils' needs and values in certain situations at certain spaces in a school.

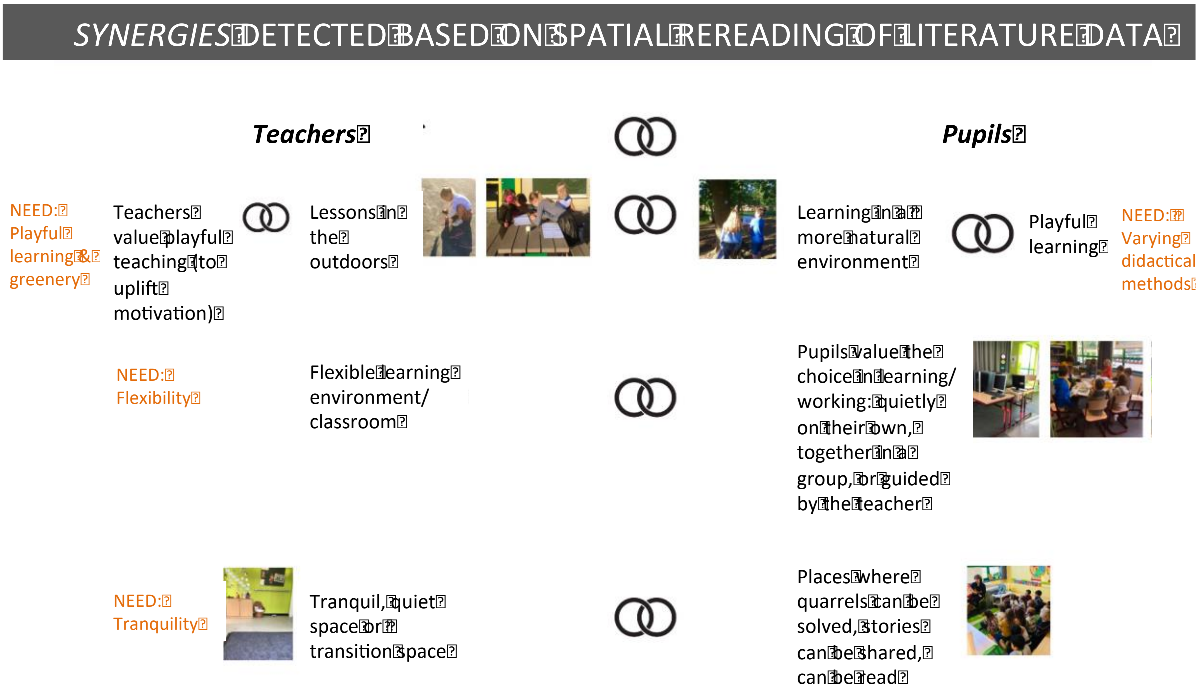


Figure 4. Synergies between teachers' and pupils' needs and values in certain situations at certain spaces in a school.

By screening the spatial environment of a school in this way, a what we label **"experiential passport"** can be developed. This experiential passport links the (universal) needs and the personal values of teachers and pupils to the spatial reality in the environment by an active mapping of the potential conflicts or synergies that can occur when protagonists are present. Thus it brings together three types of information.

Students extrapolated this technique to the particular elementary school that they studied, as visualized in Figures 3 and 4, in which pictures helped to understand where potential conflicts of synergies could occur in the experience of needs. The experiential passport surfaces the potential conflicts and synergies than can occur during certain activities, but can also lead to finding opportunities to obviate conflicts and focus on developing more synergy. For instance, the concerned school had an on-terrain forest, that currently functions solely as a playground during the lunch-break. However, the literature review the students performed on needs and values as well as the in-depth discussions with teachers and school children pointed at the possibility of playful learning and the benefits of the fresh air to a sense of tranquillity for pupils. Moreover, the Covid-19-period has brought more appreciation to spending time outdoors for pupils and has removed certain prejudices teachers might have felt in organizing lessons outdoors. In the novel perspective, for teachers the outdoors implies a more flexible spatial setting, in which set ups can change quickly without obstacles of class furniture being present, blocking the way.

Thus, within the experiential passport, avenues for spatial interventions can be deduced by narrating *how* the protagonists wish to experience their school-time. Moreover, from a spatial lens, conditions can be formulated to intervene in the existing setting to meet the needs and values that the protagonists have.

Exploration of Design Results: The Conflict-and-Synergy Design Technique to Integrate Spatial Learning Affordances

After developing an experiential passport integrating the school environment's spatial reality with the values and needs of protagonists during their daily goings in school, the students were asked to optimize the situations in which synergy was noticed, and obviate the situations in which conflicts or frictions were found. The difficulty here lies in keeping a bird's-eye perspective and a holistic view on the delicate balance between needs and values in the spatial reality, while diving into the detailed level of specifics in the design intervention. As conflicts and synergies are often entangled, there is a causality in trying to optimize synergy while magnifying existing or causing new frictions of conflicts.

For instance, learning in the outdoors can help pupils to have better focus. However, it might cause difficulty for a teacher to keep an overview of the students, and when all teachers carry out the idea of learning outside at the same time, distractions might hamper pupils' focus. Here, we will zoom in on two design results in this respect, to see what parallels we can draw, or what we can learn from these.

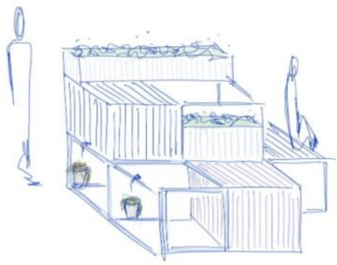
A first interesting design result on the scale level of furniture design is the "Connector" project (see Figure 5), proposed by one of the student design groups. The Connector can be described as a flexible, modular furniture system that facilitates a multitude of actions or activities for pupils and teachers. It consists of a number of flexible cubicles that can be shaped together into furniture ensembles that support teachers in spatially organizing their pedagogical activities indoors and outdoors.

This design groups started to design based on a number of key psychological needs and values that were shared by teachers and pupils, such as competence, connectivity, autonomy, and the need for creativity within pupils.

Figure 5. The Connector in a certain set up.

This design group saw the potential of the natural environment of the particular school and directly linked it to aspects of competence and connectivity. Within their modular furniture system, they designed a modular seating ensemble that can also facilitate different forms of group discussions (e.g. an arena stand of a circular conversation). As the list of possible combinations of the modules is quite infinite, the design group developed a manual based on anticipated synergies and conflicts between certain values and needs, and illustrated these with spatial examples of assembled modules, see Figure 6 below. That way, teachers could search for ideal combinations of the modular system based on their own plan of action, and create a synergetic environment

in which the needs of teachers and pupils could be balanced.
To give an example and linked to the shared need of competence and connectivity, the manual contains the experiential passport of a suggested composition of cubicles that incorporates kitchen and greenery elements, see Figure 6 below. The experiential information learns that creating a greenery module and allowing children to grow herbs or plants together can help them in achieving that "we did it this ourselves"-feeling, and nudge them to work together, promoting connectivity. As for the teachers, such a module can nudge them to work together with colleagues, have pupils build a bigger module and place it in the mail hall, in a way that different classes can each be responsible for the maintenance of some of the greenery cubicles. That way, not only pupils, but also teachers will be nudged to work together. This type of composition hints at potential synergies in creative and flexible learning, and outdoor learning... On the other hand, the manual also hints at possible conflicts, such as an overload of visual and olfactory stimuli that can disturb pupils in their learning, when the module is placed in their direct eyesight or used as a room divider. Reading the manual this way, allows teachers to see the potential of the cubicles in line with their plan of action and anticipate on synergies and be aware of conflicts during the usage.



NEED: Competence

Design proposition: modular seating ensemble

Playful use versus storage

NEED: Structure

- Seating ensemble as a room divider
- Seating ensemble as the area for face-to-face instruction
- Possibility to use in the outdoors
- Overload of visual stimuli
- Versatile use can hamper the structural simplicity

NEED: Connectivity

- Nudges connectivity between pupils from different classes
- Nudges parents to get together while waiting for their children
- Stimulated connectivity between teachers

NEED: Autonomy

- Playful learning
- Nudges pupils to explore features of the assemble

NEED: Competence

- Pupils can 'design' and assemble themselves -> sparks creativity
- Pupils decide where to place the modules
- Integration of kitchen garden and greenery

NEED: Flexibility

- Flexible: arena, waiting area, kitchen garden, ...
- Easy to move between indoors-outdoors
- Mind the size of the host environment (e.g. Classroom vs. Recreational ground)
- Mind weather conditions

Figure 6. Experiential passport of the Connector design.

Another interesting design result is the "Pergola" (see Figure 7). Here, students departed from the strength that lies in the quiet green environment the school was built in. Involving the green surroundings in the actual teaching strategies, could benefit the need for creativity and playful learning of pupils, but can also help to foster relationships between teachers and pupils reciprocally as it offers a multitude of atmospheres. To do as such, the design group developed an ‘add-on-structure’ (see Figure 7 below). First, a greenhouse was designed, to literally connect the building blocks in which the first and second grade are housed. That way, via the greenhouse, teachers of the first and second grade could meet regularly during their classes, and co-working-initiatives could be facilitated. Additionally, a pergola was attached to the enlarged building ensemble in a way that the hard transition from indoors to outdoors could be softened. Moreover, the pergola offered possibilities to rearrange the daily goings in the main building. The two add-ons and the existing buildings are connected in a way that pupils could swarm out within the novel infrastructure in an autonomous manner, but could remain active under the watchful eye of a teacher. The pergola structure is a transitioning space, equipped to facilitate transitioning from recreational playing to playful learning by for instance firstly providing space to store coats and school bags out of sight, to provide enough free space to introduce a novel topic (e.g. learning about clock reading can be accommodated by drawing a large clock on the floor, which can be operated during transitioning moments) and reorganize instruction and work spaces based on the emerging and changeable need for autonomy or for guidance of pupils, etc.

Figure 7. Top left: Aerial image of the school site – top center: existing floor plan. Top right: Altered floor plan with pergola and greenhouse. Large image: 3D render of the altered school environment.

To further detail and ‘enrich’ the program of their add-on structure, the design group developed a number of activity schemes that could inspire teachers to make use of the add-on structures. For each of the activity schemes, the experiential passport (covering the synergy/conflict-status) was also provided, see Figure 8 below.
Here, we see that an experiential passport can also be drawn to communicate a design intervention, and express the benefits (in terms of synergies) and the hazards (in terms of conflicts) of the designed intervention, see Figures 6 and 8 in which renders (of the spatial future reality) help to visualize the synergies and conflicts, together with the needs that are acted upon via the designed intervention. Below, in Figure 8 the shared needs that render opportunities for synergies between teachers and pupils through the pergola-structure, are presented on the left. On the right, the potential conflicts that one should be aware of when using the greenhouse structure are presented.

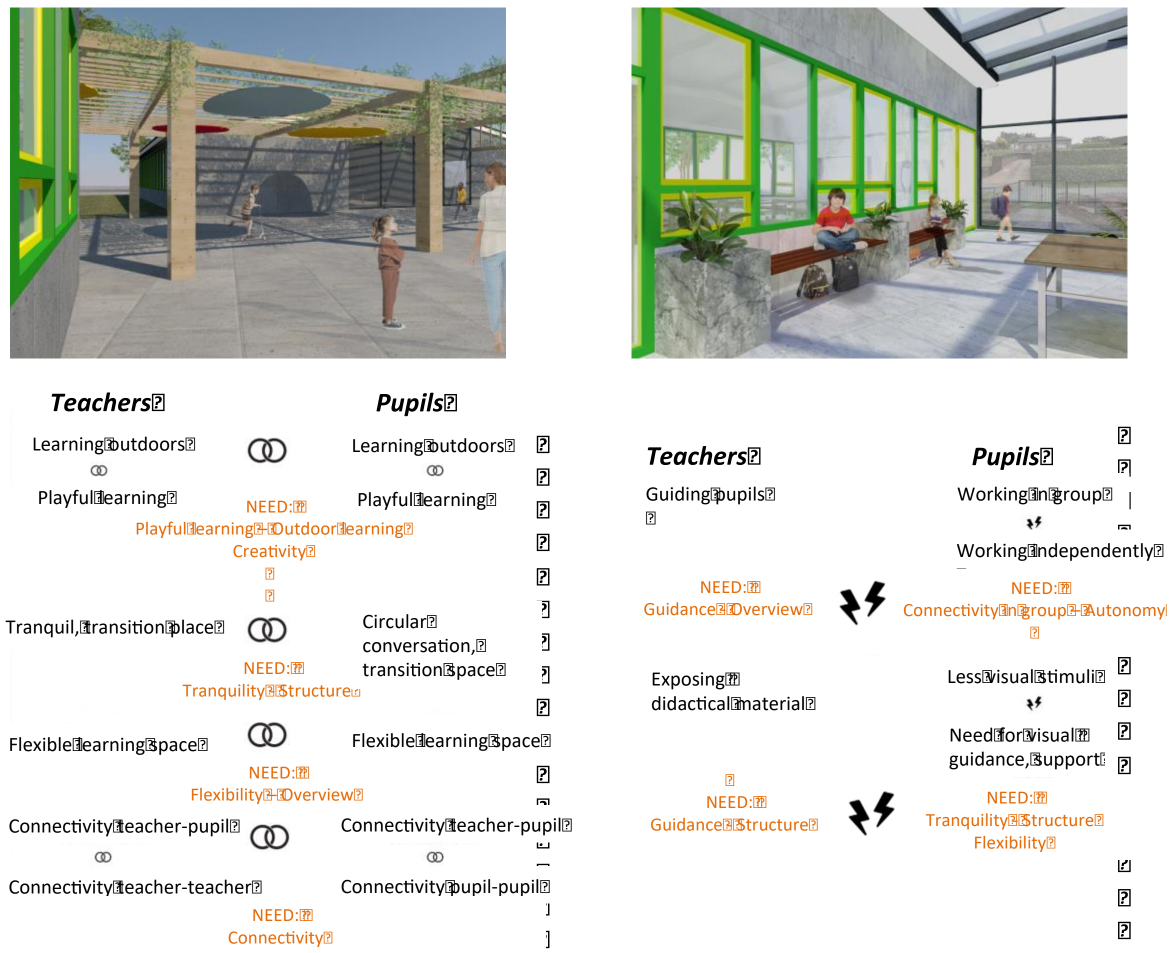


Figure 8. Activities in the pergola and greenhouse structure with their respective experiential passports.

Conclusion: Avenues for Unlocking Learning Affordances

In this paper, we investigated in what way flourishing affordances can be designed in elementary school environments, based on surfaced, positively appraised changes that the Covid-19 natural experiment set in motion in the field of education.

We departed from the Design for Human Flourishing framework (Stevens et al., 2019a,b) and used this model to develop flourishing affordances out of the contemporary needs and values that teachers and pupils attached to their functioning in elementary school environments, while valuing the positively appreciated alterations that occurred after the reopening of elementary schools in Belgium in May 2020. Out of the design results that were presented by the four design groups, we can draw two important conclusions:

Firstly, we developed a technique called the "conflict-synergy-approach" to manage the delicate interactions of psychological needs and values of the protagonists groups in elementary school environments. This technique can be uploaded in the DfHF-framework, as demonstrated in Figure 8 below. By analysing the daily goings in schools via this perspective, synergies and conflicts between the needs and values of protagonists can be deduced, which can be extrapolated to the spatial level. At that moment, a designer can strategize what spatial aspects and architectural elements can be applied to solve conflicts or strengthen synergies.

Secondly, the program of school environments is a fragmented concept containing the didactical activities that teachers undertake, driven by the pedagogical concept of the particular school and undulating on evolutions in the field such as for instance digitalization and in-class versus out-of-class learning. For architects, the programming-phase in their design processes is to date still undervalued and sensed as inefficient (Hassanain & Juaim, 2013; Yu et al., 2005; Bogers et al., 2008). It has recently been brought back to the attention of researchers (Rietveld & Rietveld, 2011; Zwemmer & Otter, 2008, Stevens & Desmet, 2019). Therefore, the creation of an experiential passport can be a key in answering this call to the 'programming- phase' in architectural design. In so doing, it can help handling the first two components of the DfHF-framework, and is essential to be able to initiate the design process of a suitable spatial facilitator of activities. When managing psychological needs and values, and anticipating on possible activities that teachers can undertake, designers can have a head start in developing learning environments that foster wellbeing of pupils and teachers. Via the known architectural elements, potentials in the environment can be unlocked and facilitators can be developed. That way, learning affordances can be designed; see Figure 9.

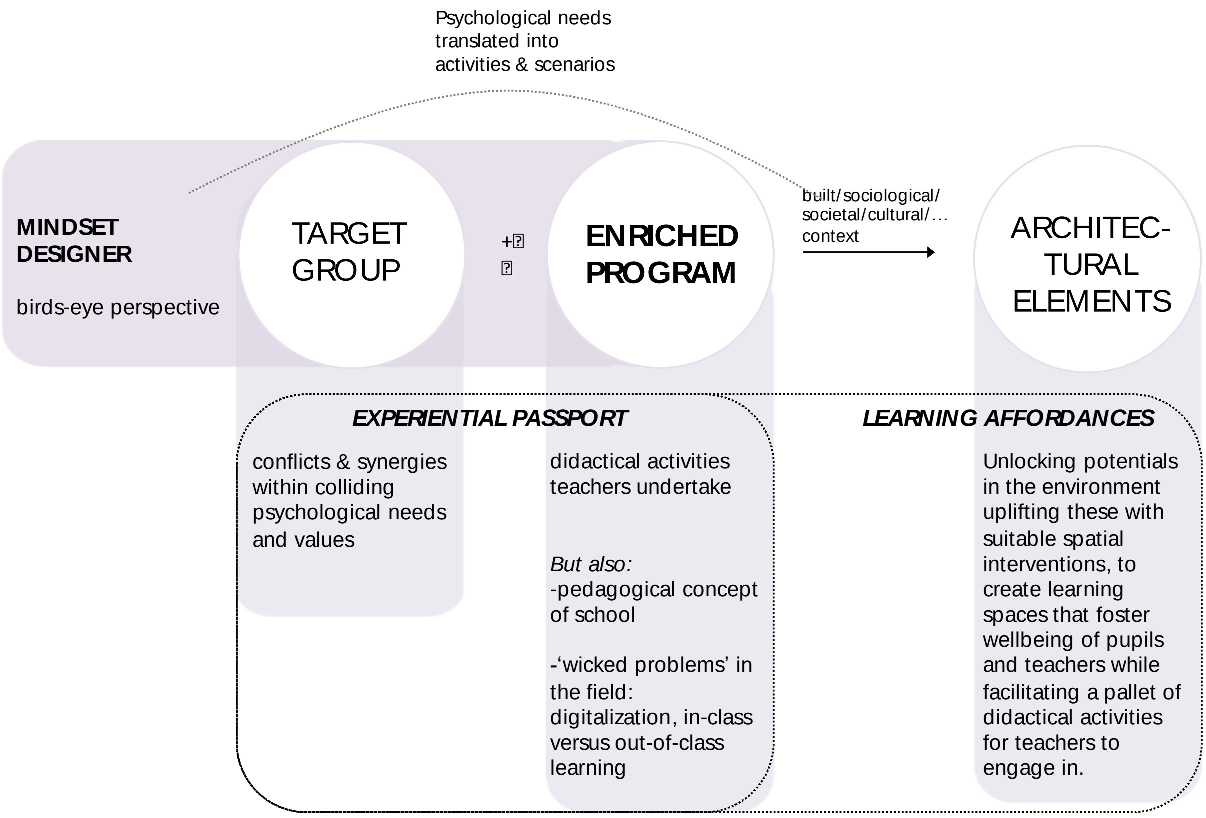


Figure 9. The DfHF-framework translated to the typology of school environments: creating learning affordances.

Discussion, Implications and Further Research Avenues

Now that we have designerly explored flourishing affordances in elementary school environments, or in other words, 'learning affordances' (see Figure 9), we can critically review the results of our analyses and elaborate on the value of our research for theory and practice.

Value for DfHF Theory and Design for Wellbeing

This project allowed us to further dive into the DfHF-framework and test its abilities in practice. In 2016, a case-based study was organized to surface this framework and make explicit certain techniques that architects implicitly use while creating enriched programs (Stevens et al., 2016). There, we took a broad perspective. Via this study, we took an in-depth perspective, and selected a specific typology that is currently undergoing a natural experiment due to the Covid-19 pandemic: elementary school environments. Applying this in-depth perspective allowed to search for deepening in the meaning and significance of the three items of the DfHF-framework (that is, target group, program and architectural elements). In so doing, this particular study adds value to DfHF theory and theory on design for wellbeing.

Value for Architectural Practice

Here, we have learned a novel technique in designing based on psychological needs and values, the "conflict-synergy-approach", that brings a different lens to the design of particular environments in which different target groups interact.
We have also learned about the preconditions that are at play when attempting to apply the DfHF-framework. For instance, psychological needs of a target group might result in balancing out synergy and conflict, which implies applying a holistic view and a bird's-eye perspective. The latter can be framed as a key characteristic of a DfHF-designer, and should be part of his/her mindset when stepping into this process, see Figure 8.
Also, our approach urges for a holistic view in designing school environments or parts of school environments,

in which architects should get acquainted with trends and evolutions in the pedagogical field as well in order to be ready to create interventions in an educational context that are considered as ‘future proof’. Here lies a responsibility for architects in supporting schools in the (architectural) roll-out or translation of their pedagogical concept.

Value for the Design of School Environments

We have mentioned that the spatial reality of many schools in Flanders is still rather problematic (Châtel, 2011). The current trend is to build new, quite large school campuses, but these projects are all part of a long-term plan. There are hardly any strategic and structured short-term solutions for schools to tackle ad hoc space demands or spatial issues. We have now learned that there is a great deal of hidden potential in the current spatial school landscape. By taking a flourishing, wellbeing approach in design, designers are set out to surface these potentials, unlock them designerly, and thereby generating quick-wins for schools. Often, these quick wins can be realized at a low cost.

Critical Reflections and Limitations

It is clear that a number of critical reflections can be made that need to be studied in detail in the future: Firstly, a methodological concern is how to assist designers in applying and integrating field-specific knowledge in their design process. Here, we mentioned the importance of understanding different didactical approaches teachers can take -here applicable in elementary school settings- while grasping important ‘wicked problems’ or novelties in the field, e.g. digitalization. Such aspects or considerations need to be taken into account as they play a major role in the design process when one aims to trigger learning affordances in a particular context. We are confident that designers know how to immerse and retrieve information on the typology or target group, but still, this is an important point of attention that warrants more research.
Regarding the limitations to this study, a first limitation concerns its explorative character. The study was organized in one school environment with a limited number of design students involved. Moreover, the debate on how to measure aspects as wellbeing and flourishing is still in its infancy (Stevens et al., 2019a,b), and has not yet been applied to this particular case. Secondly, it needs to be noted that the results do not pretend to concern ‘fixed’ design methods that can be used to design enriched programs via the DfHF-framework; too little data were collected to generalize. Moreover, generalizing design processes is a questionable goal in itself, since design processes are hardly linear nor rigidly structured in a similar way. This study should therefore be interpreted as an assembly of practical knowledge with regard to creating enriched programs in an elementary school environment, and can be offered to architects to experiment with.

Avenues for Further Research

The existing Flemish school infrastructure is not always compatible with more contemporary didactical techniques and pedagogical evolutions such as digital learning. In that respect, this exploratory research has surfaced the issue of in-class learning versus out-of-class learning. Zooming in on opportunities in the environment to unlock hidden potentials, and developing strategies to activate these as quick-wins, is a goal. More research can be done in developing the “conflict-synergy-approach”, as it shows promising avenues and creative results to develop learning environments and reach a very detailed level in architectural design, especially in the programming-phase. Moreover, recognizing and activating hidden potentials in the environment is an avenue for further research as well, and can form the basis of a tool that schools can apply themselves.

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Architecture for Education

Case Studies to Inspire Designers

Anne P. Taylor
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This paper presents brief case studies from Taylor's 50 years plus of collaborative study, teaching, programming, design, and field work to transform classrooms into studios, playgrounds into learning landscapes, and to encourage sustainable design as a basis for stewardship. The idea is to inspire and motivate designers of learning environments to go beyond predetermined square footage and educational specifications to create schools that are systems for learning based on the developmental needs of students in a body, mind, and creative spirit continuum. Design becomes a fulcrum for interdisciplinary learning. Manifestations, learning cues or prompts, are embedded into the environment itself as teaching tools. A philosophy of "Ecoism" or "Ecosophy" (Næss, 2009) supports care and understanding of oneself and of one's relationship to the environment. Clusters of case studies explore Learning Zones, Reconfiguring the Traditional Classroom, Learning Landscapes, and Sustainability and Culture. These diverse examples offer a starting point to unleash the divergent thinking necessary to design well for the success of future generations.

Keywords: School design, classroom as studio, learning environment, manifestations, ecoism

Introduction

Come with me for a walk on a warm, sunny, sandy beach in Mexico. You will see twelve children who are picking up shells, saving some in their t-shirts and throwing others away. I ask these children, "Why are you saving some and throwing others away?" They reply, "Because they are beautiful and different, and we throw away the ugly ones." I realize in that moment that these young children have an innate power to learn from their environment and to make critical aesthetic judgments about it. Over the years this beach experience has led me to wonder what happens when we subject the creative capacities of our children to the cookie-cutter design and rigid configurations of classrooms where they spend up to eighteen years of their lives. Thus began a lifelong pursuit of research and design of more supportive learning spaces for students P/K – 12+ worldwide (see Figure 1).

In my research and practice as a consultant, I have discovered a paucity of aesthetics in our schools as well as many limitations to the functionality of teacher-centered classrooms (see Figure 2). There are thousands of classrooms waiting to be morphed into design studios and technology labs where students can study independently and pursue their own interests such as robotry, videography, filmmaking, circuitry, graphic design, architecture, engineering, construction, two-and three-dimensional model building, and even musical composition (Creative Learning Systems, 2021). There are acres of fallow land around schools waiting to become nature-jogging trails lined with plants for life zone botany study, gardening or studies of light, shade and shadow (see Figures 3, 4). Above all, I have collaborated with many others through the design process to answer a deep need in our society to teach our students to care for the environment and for each other. Architects as well as educators must appeal to the developmental needs of the client—the whole child—across body, mind and spirit.

Figure 1. Revelatory shelling beach walk in Mexico 1969: Never underestimate the ability of children to make their own critical aesthetic judgments about their environment. (Source: sagacious1 2020)

Figure 2. Visual cacophony. One of our visiting architecture students taught fourth graders in this messy classroom. Chaos and clutter impede embedded or figure ground discrimination in learning how to read. (Source: Taylor 1980)

Figure 3. A familiar sight: dirt and chain-link. Teacher Eeva Reeder once told me: You can't learn in ugly! (Source: Taylor 1990)

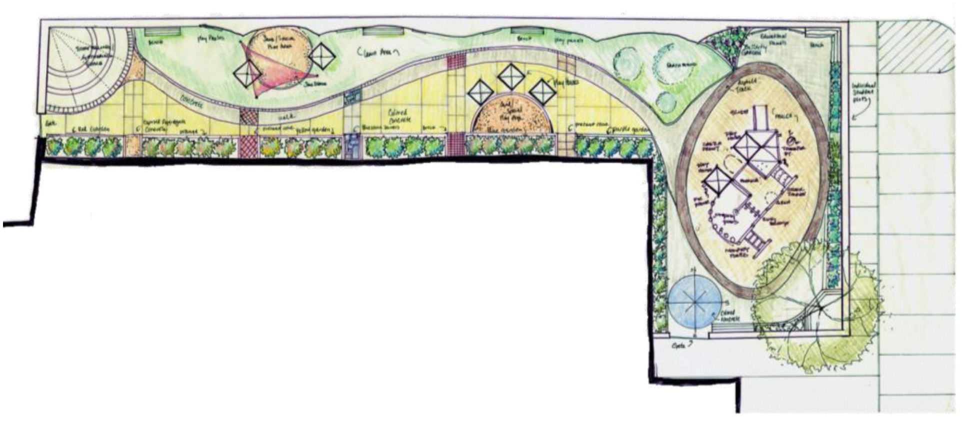


Figure 4. Pre-K Learning Garden, Cheektowaga, NY. This conceptual drawing from CannonDesign is in direct contrast to the barren desert playground shown in Figure 3. Each classroom opens to the learning garden maintained by students. (Source: Kelly Hayes McAlonie, FAIA, MRAIC, LEED AP & Joy Marie Kuebler, RLA, ASLA, CannonDesign 2006)

Architectural Manifestations

My work as teacher and consultant addresses qualitative and quantitative research and development of selected learning environments in an attempt to offer new models of programming, design, and building of contemporary schools. Concepts, if built into the physical learning environment of schools, act as cues or “manifestations” from which students can transform things into thoughts or ideas usually only found in textbooks. When students become sensitive to the specific nuances of a place, we refer to their awareness as “the knowing eye.” They learn to visually “read” their surroundings for knowledge and understanding, as designers do.

Figure 5. Manifestation. ¡Explora! Children’s Museum, Albuquerque, NM. Concept of Fibonacci numbers is incorporated into shelf-like protrusions on the museum exterior. (Source: Mahlman Studio Architecture and Paul Tatter, former Associate Director, ¡Explora! 2003)

The physical environment of any school is a “silent curriculum” or teaching tool for concepts across disciplines. The environment is actually a three-dimensional textbook (see Figure 5). Meaning lies in student interaction with rich multisensory stimuli. Manifestations can be “found” objects as sources of study. Even a crack in the sidewalk is a microhabitat that can be investigated for plant and insect life. Manifestations are also generated from curricular concepts and standards. A hinge on a classroom door acts as a fulcrum (physics) and allows the door to swing 90 to 180 degrees (geometry concepts). All building systems including corridors/pathways, flooring, HVAC, electrical, windows and more can be prompts or cues for learning interdisciplinary concepts. Similarly, outdoor playgrounds can be transformed into learning landscapes with serenity gardens, fishponds, bird feeders, orchards, wetlands, seating, pathways, and so much more. Ecologically responsive “green” school design provides working examples of systems thinking, cycles, and sustainability (see Figure 6).

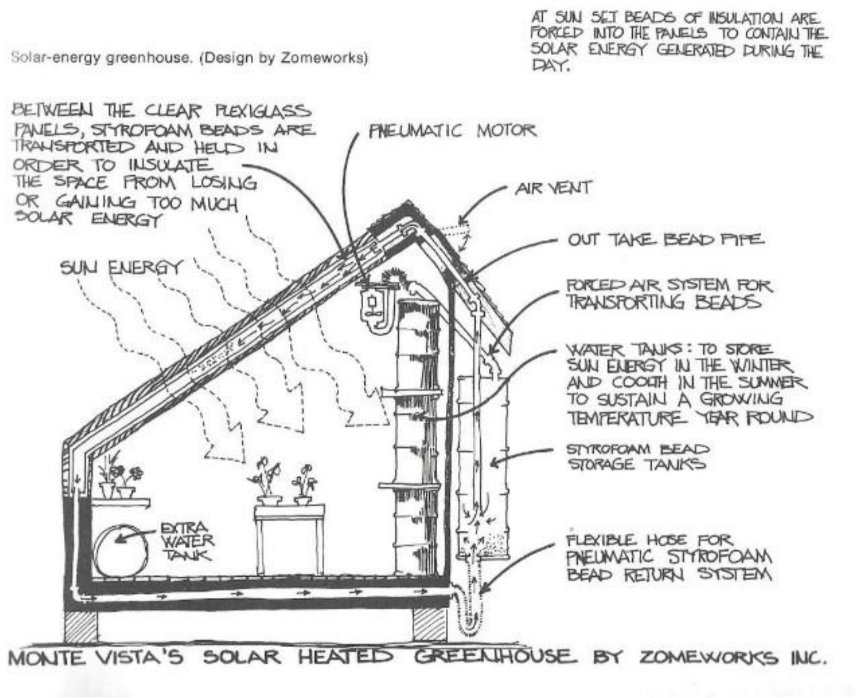


Figure 6. Solar Greenhouse Manifestation at Monte Vista Elementary School teaches concepts of botany, the scientific method, mechanical systems, alternative energy, and survivor skills of sustaining life outside the self. (Source: Zoneworks. drawing by George Vlastos 1978)

Ecoism or Ecosophy

Norwegian philosopher and professor Arne Næss coined the term ecosophy to describe a philosophy of ecological harmony or equilibrium that values not only issues of sustainability but also well-being and diversity of life. Many others have elaborated on the concept of a new holistic field beyond ecology that explores the complexity of the relationship between humans and their environment.

I have always encouraged my architecture students to develop and investigate their own design philosophies to inform their future work. We discuss what is real, true, good and beautiful. As part of that search for guiding meaning, ecoism or ecosophy plays an important role in forming belief systems for sustainable design. In terms of ethics, education ultimately should create caretakers of the Earth and culture and inspire kinship with all things on the planet. Architecture should give back to the Earth rather than deplete it. Beauty lies in relationships and stewardship, and beautiful design is responsive to and enhances the environment. Ecologically responsive design reinforces the order in the universe. People are a part of, not apart from, the environment.

These philosophies inform the following case studies. I examine carefully provisioned zones for learning, ideas for reconfiguration of the traditional classroom, examples of playgrounds transformed into learning landscapes, and designs that inspire stewardship and connection. The case studies are not exhaustive, of course, but the hope is that readers will expand their own versions of the knowing eye to see the limitless potential in contemporary school design.

Case Cluster One: Learning Zones

Learning zones are spaces where diverse learning experiences can occur based on different subject matter disciplines, themes, or ways of learning (multiple intelligences). Students move though the spaces rather than remaining confined in rigid classroom configurations with desks in rows and the teacher as focus. Often an open central gathering space provides space for children to come together. Choice and student empowerment are supported by learning zones. The locus of imagination remains in the child's mind. Children determine how to use the space versus predetermined goals of the teacher. The key design take-away is that users flow through the space. Traffic systems are designed to be fluhttps://doi.org/10.21606/drs_lxd2021. The early childhood environment is not necessarily literal but can be provisioned with objects to be manipulated and arranged by learners themselves.

Instructional Environments for Young Children

A pilot study, followed by experimental and replication studies I conducted at Arizona State University, led to a prototype design based on observations that the children were using multisensory cues to explore and learn from the environment (Taylor, 1971).

These and other studies rely on a theoretical basis combining research on cognition and concept development (Piaget & Inholder, 1969); curriculum development embedded in the environmental stimuli (Bruner, 1976); importance of environment in shaping artistic abilities for production and appreciation (Eisner, 1994); and from Woodruff's (1967) work on the significance of objects that surround an individual, how events occur in which objects take part, and that knowledge is about the real world.

The instructional environments created for the prototype study included concepts or manifestations embedded in the environmental designs for four distinct multisensory environments (see Figure 7):

- A soft environment or zone with pastel colors offering a place to relax, muted sound, psychomotor skill development and concepts of soft texture.
- A geometric environment with primary colors with geometric shapes and three-dimensional forms (math cues), level changes, some of the six basic machines (physics), and encouraging large muscle development and imagination.
- A hard-edge black and white mirrored environment on which to draw, study oneself from multiple angles, and explore self-concepts, role-playing and dress-up reflecting multiple cultures. Students also explore science concepts of reflection, refraction, optical illusions, and infinite space.
- An organic environment with round areas (tables, fountain) for hands on experiences in science, math and art concepts with natural materials, sand and water.

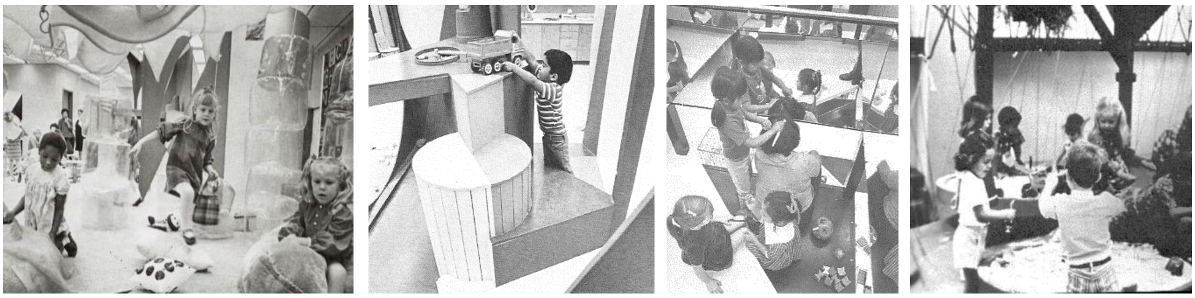


Figure 7. a-d from left to right: a. Soft Environment - soft elements of design (Photo by Charles Conley 1970); b. Geometric Environment - mathematical cues and forms (Photo by Charles Conley 1970); c. Mirrored Environment - fosters awareness (Photo by Larry Light 1970); d. Sand and Water Play - what sinks or floats (Photos by Anne Taylor 1970).

Monte Vista Classroom Remodel

I was the lead researcher working with George Vlastos and volunteers for this Southwest Cooperative Educational Laboratory (SWCEL) project at the Monte Vista School in Albuquerque, NM, which had been built by WPA labor during the depression. Two adjacent classrooms were joined to create a multilevel open classroom with activity areas around the perimeter designed for diverse student experiences. High ceilings allowed development of two levels, as depicted in plan view (see Figure 8). On the upper level, a soft quiet area and library encouraged a sense of calm. Zones included a soft forum, music area, mirrored area, sewing and weaving, communications, weather station, and a student study loft. Ground level featured a large open area with perimeter activity centers including a science and math area, light table, soft implied stage and seating with role-play space, listening center, art area, and numerous places for storage for both children and adults. Desks were replaced with individual, portable fishing tackle boxes for student supplies. A previously neglected and unused outdoor space adjacent to the south side of the school was expanded with a deck, playground, a graffiti wall, and a solar greenhouse.

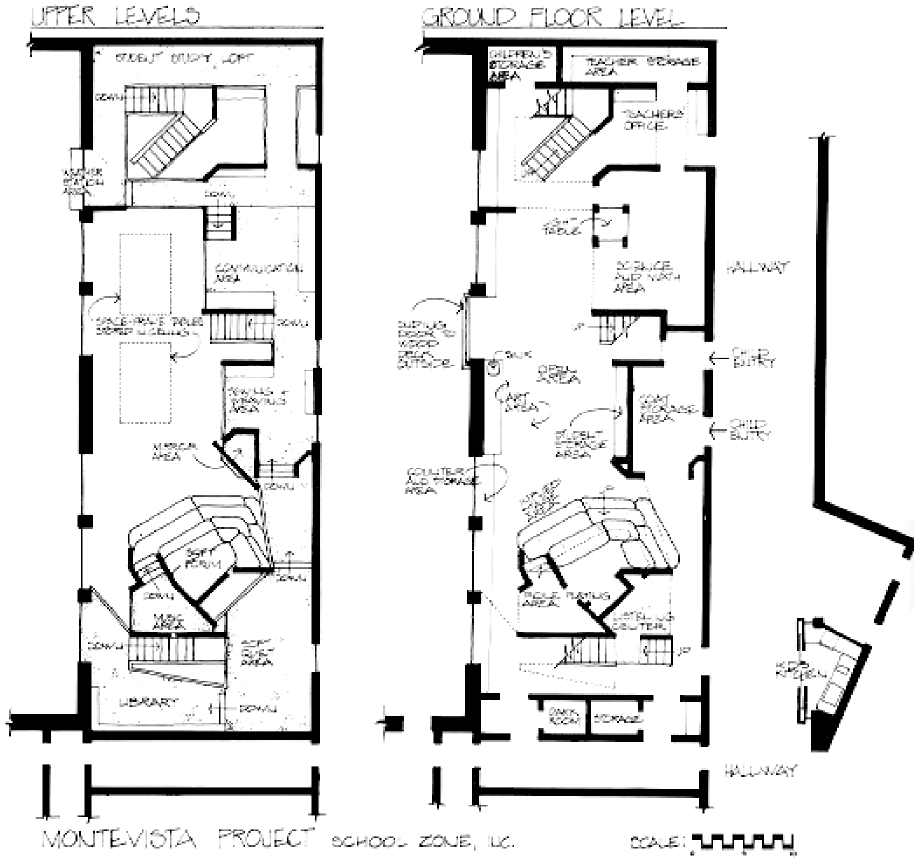


Figure 8. Monte Vista Elementary School plan view. Note levels and zones for diverse activities, space frame table on ceiling using block and tackle pulley system (physics), and both student and teacher workspaces and storage. (Source: George Vlastos 1976)

Head Start Classroom of the Future

With a grant from the federal Health and Human Services Department, Architect George Vlastos and I designed and constructed another early childhood learning environment for use at Isleta Pueblo, New Mexico, and later at the University of New Mexico. The Taylor/Vlastos Head Start prototype combined the concept of learning zones with the idea of deployability and flexibility (see Figure 9). Fold-out tables housed in trylon columns could be deployed to transform spaces into learning zones. The zones could be easily transported and set up in different classrooms for continuity of learning through many Headstart locations. Metaphoric names for the zones were:

- The Nest—a nonliteral multisensory soft environment positioned to be the heart or center of the room from which all events emanated and returned. This idea was derived from the sacred nature of the Native American plaza.
- The Frame—a spatial relationship zone
- The Hearth—a nutrition and cooking environment with an induction cooktop
- The Design Studio—An art and design zone with drop-down light tables
- Media Center—with computer, drop-down keyboard with headphones and a DVD player
- Construction Zone—a building system zone (collapsible and portable)
- The Showcase—a mirrored zone for drawing and creative drama
- The Museum—book storage, manipulatives and art gallery
- Trash Management System—a learning tool for sorting, classifying and recycling

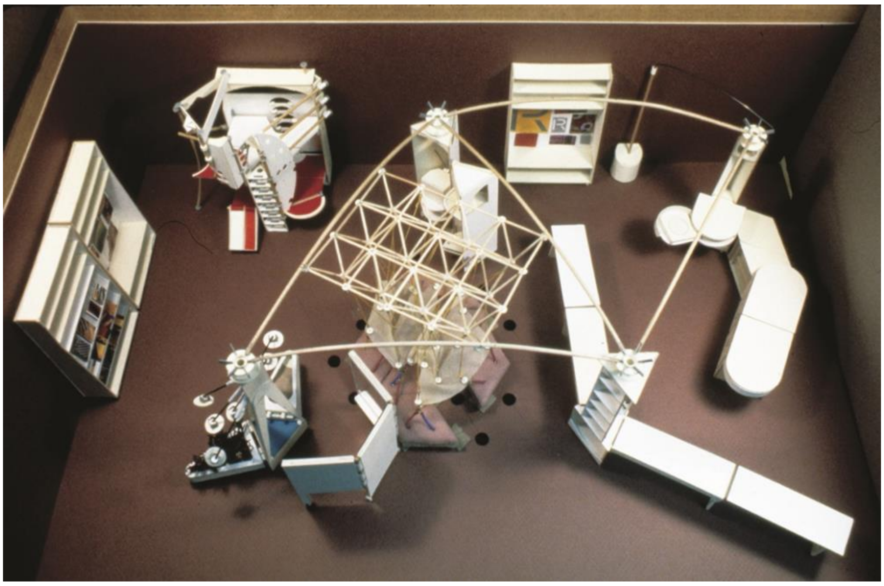


Figure 9. Taylor/Vlastos Head Start Model. Design for deployable and flexible learning zones housed in pylons. (Source: Taylor 1980)

Case Cluster Two: Reconfiguring the Traditional Classroom

Much of my work as a consultant involves working with existing classroom spaces and making them more habitable for learners. These efforts can and often do require student and community input and actual work on the environments they envision. The goal is to move away from the desks-in-rows, double-loaded corridor factory model to a more informed, rich physical learning environment and studio.

Conceptual floor plan for Mark Twain Elementary School

At Mark Twain Elementary, I collaborated with local AIA architects to teach the Architecture and Children Program in public schools. Teachers encountered the limitations of the typical classroom when it comes to workshop and design learning. In this plan (see Figure 10), a conventional classroom is conceived as a lab/workshop/studio with individual workstations, large group space, open circulation, task lighting and significant storage. Key ideas include standing work areas (fewer chairs equals less clutter), bright color schemes to identify work areas, storage bins on shelves, a meet/build makerspace, and tables away from walls to allow use from both sides.

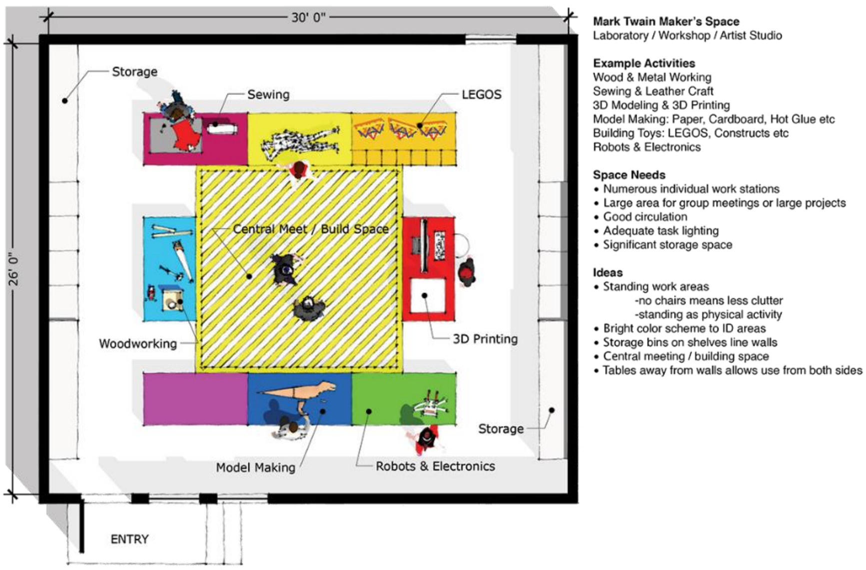


Figure 10. Re envisioning the traditional classroom space. Conceptual drawing by Architect Steve Mattern to illustrate the potential of a makerspace at Mark Twain Elementary School, Albuquerque, NM. (Source: Mattern 2019)

Integrated Studio Design Model

We developed this conceptual plan drawing to depict what the ideal integrated design studio for any age learner might look like as compared to the typical classroom (see Figure 11). An adjacent makerspace and access to the outdoors allow for integrated learning and a softening of boundaries between inside and outside. Note the interior with drop-down tables, walls to sketch on, supplies accessible to all, a gallery for presentation, and plenty of natural light. Wide doors open to an outdoor courtyard, shade structure, and learning studio for landscape design instruction and growing vegetables.

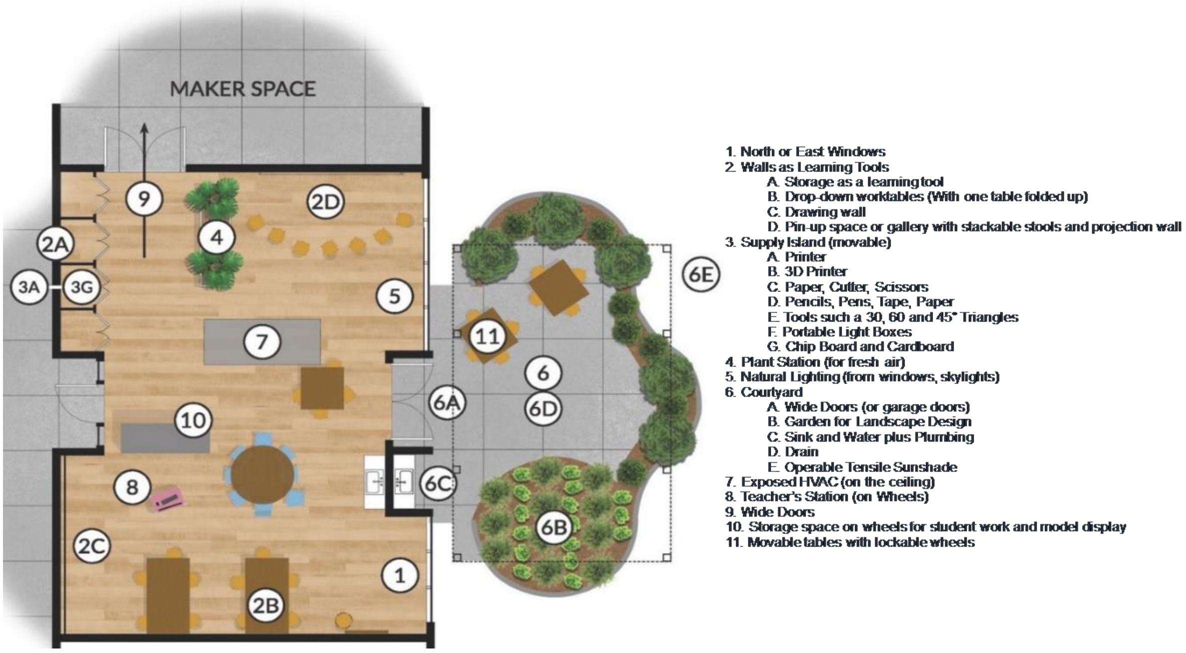


Figure 11. Remodelled Classroom as Studio for all students. Taylor collaborated with Arlo Braun, architect, and Camilla Kennedy, graphic artist, to design this plan view to suggest ease of flow between indoor and outdoor spaces for learning. (Source: Braun/Kennedy 2020)

School as Children's Museum

Children's museums with their emphasis on active participation and the quality and variety of their displays can be strong models for the learning spaces of the future. While working on schools with HOK architects in Alaska, George Vlastos and I were asked to design with the local AIA a museum exhibition of Architecture and Design for children. The highly manipulative exhibit taught not only elements of architecture but also included signage scaled to children, and nerf balls positioned to reveal what it is like to be inside certain architectural spaces: domes, vaults, pyramids, arches and more. Tensile structures were manipulative (see Figures 12, 13, 14).

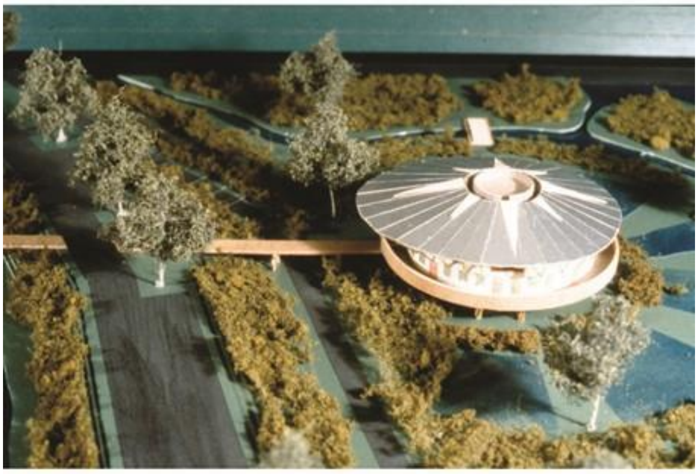
Figures 12, 13, 14. Museum quality. Views from the Taylor/Vlastos Phantasmagorical exhibit in Alaska. Children actively engage in the environment, learning concepts as they would in a children's museum with hands-on experiences, child scale, and high-quality signage and display. (Source: Photographs © Paul Warchol 1985)

Case Cluster Three: Learning Landscapes

Our school playgrounds are often barren and wasted places devoid of interest. The learning landscape transforms these neglected areas into multi-use places for experiences across body, mind, and spirit. Site analysis and developing the new landscapes also are excellent projects for student involvement and for gaining knowledge of their school life zone

Stockton Farm

Some learning landscapes can take the form of agricultural and farm study campuses. In this sense, the entire school setting acts as one large operational manifestation for learning. At a student programming and design session with 100 students in Stockton, California, we learned that the teenagers were adamant, “Don’t give us another high school!” These three concept drawings by architect Steven Bingler at Concordia LLC (see Figures 15, 16, 17) are the result of students’ visions for a working farm and environmental study area. The concepts respond to the students’ cry: Make our education real!



Figures 15, 16, 17. Conceptual images of a working farm and environmental study center on the San Joaquin Delta as high school for Stockton, CA. Top: a barn as learning environments. Middle: Aerial view. Bottom: School as farm. During the antecedent planning process students insisted: Make our education real! (Source: Concordia LLC - Wolff, Lang & Christopher 1994)

All Indian Pueblo Council School in Santa Fe, New Mexico

As part of programming, my colleagues and I developed a “day-in-the-life” scenario to support the Pueblo vision and master plan for a new boarding school. In this narrative, we followed a student through his experiences at the school as he moved through the campus site, which is informed by the Pueblo connection to the land, the sacred mountains, the sun and the seasons. The learning landscape shown here (see Figure 18) supports ties to community by incorporating field learning relevant to Pueblo life and culture.

Figure 18. Pueblo vision. Santa Fe Indian School grounds and sketches. Learning landscape design with cultural and practical significance for New Mexico Pueblos. (Source: Van H. Gilbert Architect and Flintco Construction Solutions. Sketches by Kent Blair 2004)

The Playscape

I include this playscape as an example of my long-time experiences as a professor of young designers who have special insight for what children might need in an outdoor learning environment. Alex Maloy, freshman architecture student at the Rensselaer Polytechnic Institute, was asked by his professor to design an outdoor early childhood classroom. Maloy’s research showed that many children do not spend enough time outside. His answer to this need was a protected structure designed from concrete with plenty of foliage, personal spaces, and some interactive group spaces (see Figures 19, 20). It is a protective space in which to climb, play, have treasure hunts, have fun with friends, be close to nature, and breathe fresh air.

Figures 19, 20. Getting outdoors. Two views of architecture student Alex Maloy's playscape for young children. (Source: Alex Maloy, Architecture Student, Rensselaer Polytechnic Institute, Class of 2025, 2020)

Case Cluster Four: Sustainability and Stewardship

The final group of case studies shows how physical learning environments can serve as working models that teach principles of sustainability, support culture through design, and highlight interconnectedness.

The University of New Mexico School of Architecture and Planning

This design is replete with salient manifestations from which architecture students can learn how a sustainable building should be designed and constructed, from massing, use of daylight, water, materials, and exposed mechanical and structural elements (see Figures 21, 22).

Figures 21, 22. George Pearl Hall, School of Architecture and Planning, University of New Mexico. Antoine Predock, FAIA and Jon Anderson, FAIA. Sustainable concepts enable students to learn from the building itself. ((source: Photographs by Kirk Gittings 1999)

Pueblo of Isleta Head Start and Child Care Center

This facility is a journey into Isleta Pueblo's myths and traditions. A circular multipurpose space has a dome skylight, cardinal directions embedded in the ceiling skylights, and cultural pathways in the floor (see Figure 23). The spiritual and uplifting design reveals an understanding and appreciation for interrelationships between terrestrial, celestial, cosmic, and human worlds.

Figure 23. A Native American Head Start School at Isleta Pueblo, New Mexico. Janet Carpio designed this project as her master's thesis, researching Pueblo history to establish cultural precedent for the school. Pictured is the circular multipurpose space with natural light from a dome skylight. (Source: Carpio, Photograph by Kirk Gittings 2004)

Bi-National Border Academy

To conclude, I have selected this design thesis from Antonio Aranda III, a postgraduate student of mine from the School of Architecture and Planning at the University of New Mexico (see Figure 24). This culturally sensitive design would link two border towns of Columbus, NM, and Palomas, Mexico, through a mirrored campus. The school would be open to students from both countries. Environmentally responsive elements are a wind farm, orchards, gardens, retaining ponds and much more. Breaking down the boundaries that keep us apart will result in designs that celebrate our similarities while creating a new whole that is greater than the sum of its parts.

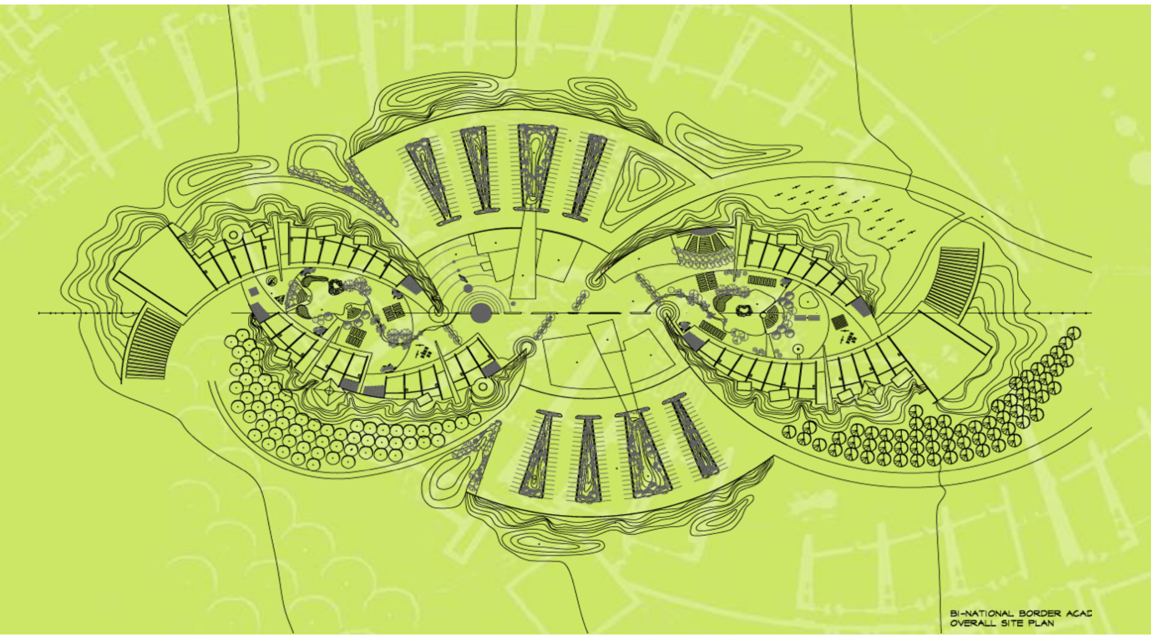


Figure 24. Bi-National Border Academy site plan view. An uplifting design solution from UNM graduate student Antonio Aranda III, who used his own background of living in the New Mexico/Mexico border town of Columbus to imagine a cooperative and hopeful alternative to the idea of a border wall. (Source: Aranda 2007)

Discussion

The following is a short discussion on programming of schools, with a few starting points for approaching the design of contemporary learning environments and generating ideas that serve the developmental needs of clients, our children P/K through 12+.

- Study the developmental psychology and stages of development of the client in the areas of body (multisensory and health), mind (knowledge and concept formation) and spirit (creativity and aesthetics) as the organizers for design thinking and translate them into habitability levels of design elements (Taylor, 2009, p. 134). (How does your design support the whole child?)
- Brainstorm how to manifest or embed, where possible, educational concepts or standards from science, technology, engineering, art, language, math and history into the architecture of a school (such as east-facing windows for tracking the sun's movements).
- How might designers incorporate the philosophy of ecosophy or ecoism as the basis for sustainable design decisions for students, teachers and community? What other philosophies underpin your design work?

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Senseed: A Multisensory Learning Environment

For Urban Pre-Schoolers in China to Learn About Plant Seeds

Ge Fu
https://doi.org/10.21606/drs_lxd2021.03.172

A consequence of rapid urbanisation is the ever-limited availability of green space in cities, limiting children's access to nature and associated learning opportunities. To address this issue, the present paper describes the design of a learning environment called **Senseed**. The proposed project will introduce urban children aged 3-6 years to sensory games designed to increase their interaction with China's natural environment, thus enhancing their interest in and understanding of nature. The study combines interviews, a questionnaire, and case studies to identify environmental education issues for pre-school learners, employing exhibition settings as a healthy and engaging multidisciplinary approach to pre-schoolers' needs. Based on the theme of seed propagation, **Senseed** encourages pre-schoolers to play visual, auditory, tactile, and olfactory games, which are respectively assigned to four separate rooms. Unlike traditional displays, **Senseed**'s four rooms introduce natural elements of seed propagation—such as wind and sunlight—into these games. Children are encouraged to collect seeds and nurture and observe them at home to cultivate understanding and build emotional connections.

Keywords: environmental education; interactive experience; multi-sensory environment; pre-school education

Introduction

Nature deficit disorder (Louv, 2008) is a social phenomenon in which children become disconnected from nature because of fewer opportunities for outdoor activities or exposure to wildlife. According to the Research Report on Chinese Children's Intimacy with Nature in Cities in 2013, 12.4% of a sample of over 1,300 children showed a tendency to be nature-deficient.[1] This disorder has the following negative effects:

- little respect for nature (indifference, aversion, lack of empathy for plants and animals);
- ignorance of nature (lack of knowledge about food sources, no recognition of local plants);
- limited sensory development;
- reduced creativity and imagination;
- shorter attention span;
- poor physical condition (myopia, obesity); and
- psychological problems (depression, autism).

Numerous studies have confirmed this disconnect and associated problems (e.g., Kuh et al., 2013; Dyment & Bell, 2006; Fjørtoft, 2004; Pellegrini, 2005; Taylor et al., 2001; Wells, 2000). A survey conducted by the author in three kindergartens in Beijing in 2014—including New Beginnings and Creative Bird—confirmed that students lacked general knowledge of natural environments. Of 12 common plants and insects, only ladybugs, dragonflies, and weeping willows were correctly identified by all 130 children. The reasons for Nature Deficit

[1] https://sh.qq.com/a/20130516/006696.htm

Disorder can be summarised as follows:

- little access to natural landscapes;
- overexposure to electronic devices;
- neglect of environmental education because other lessons are prioritised in early kindergarten.[2]

According to the 2020 Report on The State of Greening in China, China's 14.8 square metres of green space per capita[3] is worse than the lowest number of 19.69 square metres worldwide as specified in the Annual Report on Remote Sensing Monitoring of Global Eco-environment 2020.[4] The use of electronic devices both in school and on weekends is in the top three most time-consuming activities. [5]The Research Report on Chinese Children's Intimacy with Nature in Cities shows that 48.5% of Chinese children spend less than three hours a week outdoors, and it recommends that a primary school child should spend more than seven hours a week outdoors for extended periods of time. An over-emphasis on skills training has contributed to the neglect of other aspects of children's overall development. According to the Report of Chinese Children's Development (2019) - Situation of Children's Life Outside School, most of the children's time outside school is spent on homework, with an average of 87.85 minutes.[6]

The tangible benefits of exposure to natural environments for children's comprehensive development have been extensively validated in relation to physical activities (Bell et al., 2008; Fjortoft, 2004; Lovell, 2009), mental and emotional health (Faber et al., 2001; Roe, 2009), motor development (Fjortoft, 2004; Scholz & Krombholz, 2007), and creativity (Lester, 2007; Nicholson, 1971; Louv, 2008). Additionally, children can develop their environmental knowledge through contact with natural settings (Milton et al., 1995; Pilgrim et al., 2007), as well as an affective connection to nature (Bixler et al., 2002; Thompson et al., 2008).

In terms of environmental education across age groups, younger children (up to 11 years old) tend to exhibit a stronger connection to nature, with more substantial positive short-term impacts than among older children (see Liefländer et al., 2013; Wells & Lekies, 2006). Wilson (1996) and Tilbury (1994) assert even more explicitly that environmental education should begin at the pre-school level or earlier. In light of children's limited access to the natural environment in urban China and the fact that environmental education for children is somewhat neglected in practice, existing evidence of the wide-ranging benefits of environmental education for pre-schoolers should therefore be given greater emphasis.

According to Gu et al. (2020), environmental education for children can be facilitated both by increasing their exposure to natural elements in their physical environment and by adding nature-based lessons or activities to school curricula. Most of the existing international literature focuses on outdoor activities and nature-based curricula, while discussions of introducing natural elements tend to focus on schools and indoor activities in nature conservation institutions (Gu et al., 2020; Hu & Xu, 2006; Ballantyne & Packer, 2002; Fjørtoft, 2001; Bailie, 2012). Notably, nature-related museums and exhibitions remain relatively scarce (Ardoin & Bowers, 2020). Informal learning spaces for environmental education tend to be monotonous and dominated by traditional parks, zoos, botanical gardens, and related exhibitions (such as nature-specific museums), which have not been widely researched in relation to the needs of pre-school children (Bates, 2018; Piscitelli & Anderson, 2000; Dunn, 2012; Kirk, 2013).

Otto and Pensini (2017) argued that direct contact through natural environmental education can improve environmental knowledge and connection to nature. Similarly, Gill (2014) highlighted the importance of more open, self-initiated, and playful experiences in this regard. In short, it seems important to investigate how nature-themed museums and exhibitions can be optimised to make them more interesting for preschool children and contribute more to their health and well-being. That is the focus of the present research.

The paper describes **Senseed**, an indoor educational and entertainment environment emphasising multi-

[2] Cheng. (2014). Analyzing the Phenomena of Turning Early Childhood Education into Primary School in the Multi-disciplinary View. *Educational Research, 35*(9), 69–76.

[3] http://paper.people.com.cn/rmrb/html/2021-03/13/nw.D110000renmrb_20210313_1-15.htm

[4] https://new.qq.com/rain/a/20201205A0B85100

[5] http://baby.sina.com.cn/news/2019-08-21/doc-ihytcern2227915.shtml

[6] https://www.thepaper.cn/newsDetail_forward_4255667

sensory play with real plant seeds, along with subsequent plant cultivation and development. **Senseed's** displays incorporate natural elements such as wind and sunlight and encourage interaction with real natural flora rather than depending unduly on digital media. **Senseed**'s design includes four distinct spaces, along with tools, play experiences, and a visual identity that links families, schools, and communities through environmental education. It is hoped that the **Senseed** concept can help optimise the future development of environmental education products, spaces, and services for pre-school children.

The rest of the paper is organised as follows. Building on Piaget's theory of children's cognitive development and the concept of *cognitive-emotional parallelism*, the next section conceptualises environmental education for pre-schoolers in terms of the affective, cognitive, and behavioural requirements for designing more effective learning settings. The paper goes on to analyse relevant display methods, game activities, and exhibitions, and then discusses contemporary environmental education issues in relation to pre-schoolers. Building on the conceptual framework and associated analysis, the section after details the design of **Senseed**, and the final one discusses its prospective application and areas for future development.

Cognitive, Affective and Behavioural Traits of Preschool Children in the Context of Environmental Education

In China, the term "pre-school" refers to children aged inclusively between three and six years who have not yet entered primary school. Liefländer et al. (2013) criticised the neglect of environmental education for children and the failure to improve their sense of connectedness to nature. Rather than merely teaching environmental knowledge, Nisbet et al. (2009) argued that this connection to nature should encompass cognitive, affective, and behavioural or experiential aspects. Accordingly, the present study analyses the characteristics of environmental education for pre-school children from those three perspectives and concludes on the six dimensions that are important to a targeted and beneficial environmental education for pre-school children.

Cognitive Traits

Naturalist intelligence is the eighth intelligence in Howard Gardner's (1995) theory of multiple intelligences (MI), and its existence is supported by neurological evidence (Checkley, 1997). It is clear that the ability to categorise objects objectively, including objects in the natural world, is an important skill for human development. Both Meyer (1997) and Nolen (2003) have noted that attachment to nature can be developed through education designed specifically to shape naturalist intelligence.

The cognitive characteristics of pre-schoolers are predominantly grounded in their perceptual-motor experiences (Piaget, 1970), and subsequent research confirms that environmental education with adequate sensory supports can help children learn better (Boss, 1999; Bredekamp & Copple, 1997; Kahn, 1997; Kahn & Kellert, 2002; White & Stoecklin, 2008). An example is using, reducing, and rebuilding new stores of sticks or shells in creative play and observing nature while collecting materials from one's natural surroundings (Beery & Jørgensen, 2016). Direct sensory exploration of real natural elements—through sight, sound, touch, smell, taste, and bodily movement—can render experiences more meaningful for children (James & Bixler, 2008), thus creating an affective bond with nature and cultivating their interest in ecological behaviours (Monroe, 2012).

Volpe and Gori (2019) underlined the need for primary education to target the right senses; for example, touch is more useful than vision for perceiving texture. In general, as appropriate sensory signals can help children learn specific concepts, a flexible multisensory approach beyond the current visual hegemony in education facilitates personalised learning. Therefore, the use and selection of digital media needs to take into account sensory learning of specific concepts, and this approach is central to the Senseed project.

Because of young children's short attention span and the rhythm of natural cycles, some self-exploratory activities need more time to reveal the joy of natural environments as compared to the more immediate appeal of digital games and media. For that reason, direct and varied feedback is important when designing nature-based educational spaces and experiences. In science museums, for example, there is evidence that diverse sensory modalities enhance young children's science learning (Anderson & Lucas, 1997).

Affective Traits

Developing a positive attitude to nature is crucial for pre-schoolers' overall sense of connection with their environment, and that positivity can be promoted by cultivating their environmental knowledge. According to Piaget, children's cognition works in parallel with their emotions. That is, their emotional response to something emerges and evolves during contact through continuous education. When introducing young

children to the world of nature, Milbrath (1994, p. 278) and Liefländer et al. (2013) suggested integrating cognitive and affective responses.
Indeed, according to Wilson (1996) and Carson (1956), feelings are more important than facts. Wilson (1993) believed that humans are born with an inherent emotional bond with life and lifelike forms—a phenomenon known as biophilia (Barbiero & Berto, 2018). This is distinct from natural intelligence, manifesting instead as an ability to process environmental information and output environmental knowledge (Checkley, 1997). However, the intrinsic human inclination towards biophilia can be seen as the ultimate starting point for developing a child's naturalist intelligence (Barbiero & Berto, 2018). Gardner (1999) also acknowledged that a certain degree of natural intelligence capacity is developed when biophilic preferences are expressed. Zhang et al. (2013) found empirical support for these theoretical findings when they surveyed 1,119 children aged 9–10 years in 15 urban schools in China. Specifically, they found a significant positive correlation between children's exposure to nature and their biophilic traits. It follows that creating positive emotional experiences when designing informal spaces for environmental education can encourage children to explore nature in great depth. By learning more about nature, pre-schoolers can in turn cultivate their value judgments of the natural world and develop a positive attitude towards it.

Behavioural Traits

Children's daily routines characteristically include play (Watts et al., 2014; Canadian Association of Occupational Therapists, 1996; Couch et al., 1998; Rodger, 2010), which serves both as a means of developing positive emotions and as a learning process (Piaget, 1951). For that reason, the design of environmental education and nature-based educational spaces must incorporate the fundamentals of play behaviours.
The various types of play behaviour can be assigned to four distinct categories: constructive, representational, social, and active play (Johnson et al., 1987). Different types of play can help develop different abilities. For example, Dansky and Silverman (1975) found that children think more creatively in experiments where the rules of the game are not provided, and the tools supplied can be played with freely in the given scenario. In that experiment, children who were allowed to play freely with common objects were better able to think of different uses for the same object after ten minutes than those who could only imitate how the objects were used by adults and those who could only colour with crayons. Nicholson's (1972) theory of loose parts holds that, in any given environment, inventiveness, creativity, and the possibility of discovery are directly proportional to the number and range of variables in that environment. Manipulative or constructive play with objects is very similar to the type of free play referred to above, as children can explore infinite possibilities for playing with objects in their own preferred ways, and this discovery-based activity tends to be highly creative. According to Singer and Singer (1985), pretend play can help develop children's adaptability and flexibility. In addition, the psychological need to interact with their peers becomes stronger as children get older. Children as young as two years show some willingness to play with their peers, and between the ages of three and five, they are already learning to share and understand the social principle of fair play (He & Jin, 2006). Piaget (1962) confirmed that social play, especially cooperative play, allows children to overcome their self-centredness, satisfying their need to interact with others while also learning to think from the other's perspective and to understand the idea of roles, laying the foundations for positive interpersonal relationships (Brewer, 1998).
Finally, as well as promoting the growth and development of bones and muscles (Huang, 1989), it has been further theorised that physical play promotes prosocial behaviour in children, making them more compassionate, willing to help others, and to share, cooperate, and donate in the future (Quan, 2012).
Given previous theories on the cognitive, affective and behavioural characteristics of preschool children, the author summarised the following six dimensions that can be targeted further to provide interesting, effective, and beneficial environmental education for preschool children:

- the use of all five senses in children's learning and exploration;
- direct contact with real natural objects;
- varied ways of exploration;
- collaboration with peers;
- information and entertainment;
- immediate feedback.

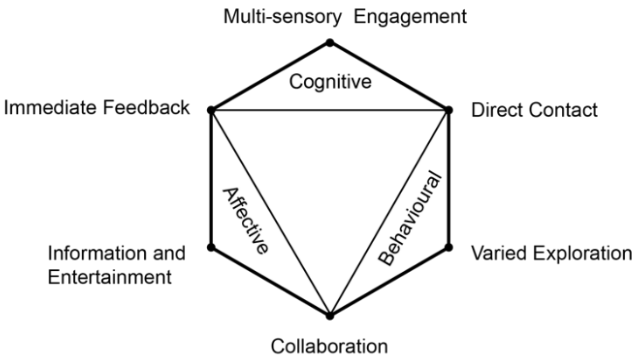


Figure 1. Six dimensions of environmental education for pre-schoolers in exhibition settings.

Types of Display and Activities in Contemporary Children's Environmental Education Spaces

In shaping urban children's attachment to nature, educational spaces such as natural history museums, nature-related science museums, and art exhibitions targeting families, kindergarteners, and the general public are important audience-specific platforms. According to the 2012 Blue Book on Outdoor Activities for Urban Children in China, parents exert the strongest positive influence (46%) on their children's outdoor activities. In contrast, teachers' positive influence was surprisingly low (3.3%). Most children were found to have little access to nature: 71% reported that walking and strolling in open spaces in their neighbourhoods accounted for most of their daily outdoor activity, and 14.8% were primarily exposed to nature indirectly through structured weekend visits to zoos, botanical gardens, forest parks, and museums.[7]

This section examines the display and game methods in children's environmental education spaces in relation to the six dimensions mentioned in the previous section. The cases are mainly selected from natural science museums and natural history museums in Shanghai, China and the surrounding cities with developed educational resources, but also include exhibits from other types of institutions related to environmental education, such as art museums and children's museums (Andre et al., 2017). In order to analyse more comprehensively the current trends and issues in environmental education spaces for children, some Chinese cases have obvious limitations, and in these instances, representative advanced cases from overseas are selected.

Display Approaches

Figure 2. Natural History Museum, Zhejiang

Figure 3. National Wetland Museum, Zhejiang

- *Static Objects or Artifact Models*. Specimens and objects that afford little interaction have been identified as a major problem in science museums' efforts to disseminate scientific knowledge to the general public in China (Dong et al., 2010). For example, both the Natural History Museum and the National Wetland Museum in Zhejiang place relatively large collections of specimens on static display in reconstructed scenes of wildlife (Figures 2 and 3). While the American Museum of Natural History's addition of sounds and smells to simulate the life of prehistoric plants and animals (Figure 4) is

[7] http://www.ci123.com/article.php/43691

considered a breakthrough beyond traditional exhibition practice, displays remain passive, with limited interactive value.

Figure 4. American Museum of Natural History, New York, USA. ©C. Chesek

Figure 5. Manchester Museum, UK. ©Elaine Bates

The Manchester Museum has transformed the specimen display in the Nature Discovery gallery into a familiar scene for children by creating a storybook made of cut-out papers (Figure 5) outside the specimen stand. This encourages parents to guide their children and read with them, using the exhibit to trigger interaction (Bates, 2018).

- *Multimedia Exhibitions*. Increasingly, multimedia installations facilitate child-exhibit interactions in a playful way by using mobile computing, wireless technologies, sensors, sound, and visual tracking (Xu, 2005). In the Funky Forest of the Art Garden exhibition at Singapore Art Museum, for example, children can move physical logs to redirect waterfall flows to provide water to plants that are projected on the wall, which attracts more creatures to inhabit the forest. This interactive hands-on approach and sophisticated visual effects embody the play-related characteristics that children so enjoy and meet the cognitive, behavioural, and other psychological needs of childhood development (Figure 6).

Figure 6. Funky Forests, Singapore Art Museum, Singapore. ©Design IO LLC

Although exhibitions of this kind are designed to supplement the limited interactivity of static displays, the ultimate purpose of getting close to nature is not well-served by an over-reliance on technology. Although allowing them to enter a room with immersive video games is an effective way of getting children to put down their iPads, the version of nature that these children encounter is still a product of virtual technology and cannot ultimately heal the nature deficit.

Game Types

- *Sports Equipment*. Large-scale sports equipment inside or outside the natural displays typically uses exaggerated plant and animal forms to attract children. In Figure 6, for example, vines and mushrooms are transformed into climbing playgrounds to capture children's playful behaviour, using physical activities to encourage them to run and chase.

Although these exhibits eliminate the use of technological supports to engender intense sensory stimulation, the children are again exposed to artificially processed natural elements rather than to natural objects per se. This again differs somewhat from children's activities in real natural environments and does not help them understand real wildlife.

Figure 7. Natural History Museum in Zhejiang China

- *Role Play*. This is one of the favourite activities of pre-school children. For example, children disguised as bees and ladybirds can burrow into flowers to learn about their structure and the process of pollination.
- *Construction Play*. At present, most venues and educational spaces outside China utilise hands-on exhibits such as “measuring the size of a butterfly's wings” or “feeling how many bones are in an elephant's trunk.” However, this highly task-oriented form of learning leaves little scope to freely explore construction play, which is not often seen in natural museums.

The National Building Museum in Washington, D.C. offers children a more engaging combination of construction play and sensory experience. This is an effective way of encouraging active and creative thinking, and deepens children’s understanding of educational objects through fine hand movements and tactile and visual perception. As shown in Figure 8, children can build their own skyscrapers from different building parts. Through manipulation, they can use their imagination while learning about building structures.

Figure 8. National Building Museum in Washington, D.C., USA. © Walesonline

Issues with Children's Contemporary Environmental Education in China

Among young children, hands-on manipulation, sensory engagement, and self-initiated exploration are crucial for learning (Wilson, 1996). However, the author found few exhibits or activities targeting pre-schoolers at the China Wetland Museum and Zhejiang Natural History Museum. Such museums typically exhibit specimens or, at the other extreme, rely heavily on digital media to simulate nature, using interactive images to entertain children. While this kind of indirect and vicarious contact may compensate for children’s lack of opportunities to engage with and explore natural landscapes (Kellert, 2005; Bates, 2018), such experiences cannot adequately convey the reality of those landscapes or the opportunities they afford for spontaneous—as opposed to pre-designed—exploration (Sobel, 2008).

After focusing on the public exhibition environment in former section, this one will look at the common approaches to environmental education at home and school (Table 2), and include their disadvantages and advantages in an attempt to understand the panorama of contemporary environmental education for children in China.

According to the six dimensions that characterise the environmental education of pre-school children in the second section, there are several approaches in each category—public spaces, kindergartens and homes—that seem to contribute to the development of pre-school children's learning about the natural world, as they form a relatively complete hexagon (Table 1 and 2). Respectively, outdoor activities represented by camps and so on meet children’s social needs and engage them in a sensory process; raising and cultivation activities like domestic pets, plants and kindergarten nature corners promote direct contact and emotional bonds with the natural world; and construction games of exhibitions allow a varied exploration that enables immediate feedback. When these radar diagrams are overlapped, as in Figure 9, the shortcomings of these methods are still obvious, but these could be alleviated by incorporating the others’ positives. Therefore, this elucidates crucial perspectives for designing a targeted environment of environmental education for children aged 3-6 years.

Table 1. Advantages and disadvantages of environmental education in China (public spaces)

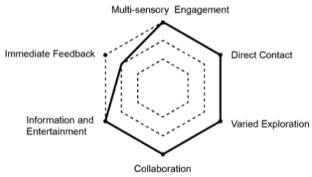
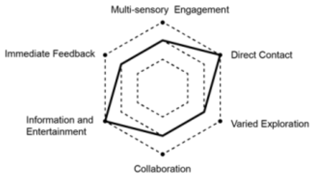
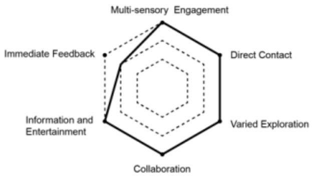
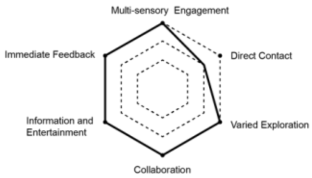
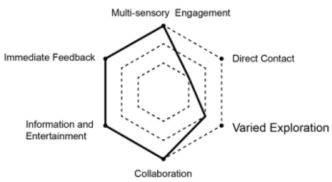
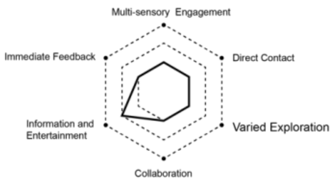
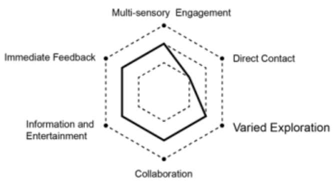
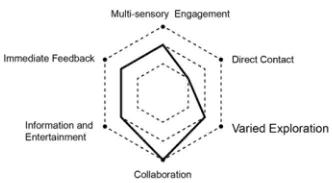
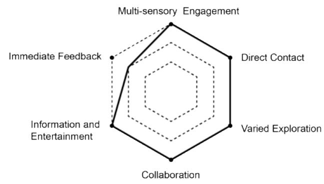
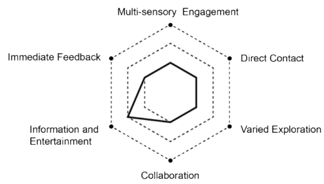
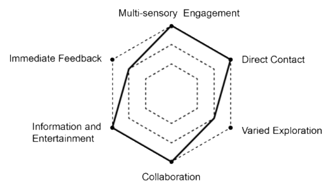
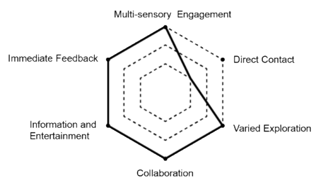
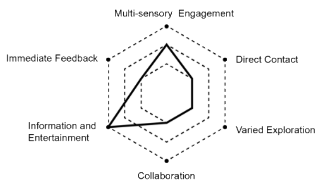
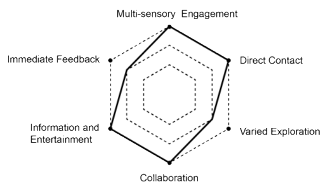
Locations	*Activities*	*Objects*	*Games*	*Pros and cons*
Public spaces	Parks and green spaces	Natural elements	Multisensory/ social/constructive	
	Zoos and aquariums	Natural elements	Vison-based	
	Camps/nature schools	Natural elements	Multisensory/ representational/ active and physical/ social/constructive	
	Exhibitions - construction play	Natural elements/ cartoonish images or objects	Multisensory/ representational/ social/constructive	
	Exhibitions – multimedia	Images/videos/ cartoonish images or objects	Vison/tactile/active and physical/ constructive	
	Exhibitions - static objects or artefact models	Natural elements	Vison-based	
	Exhibitions - sports equipment	Cartoonish images or objects	Vison/tactile/active and physical	
	Exhibitions - role play	Cartoonish images or objects	Representational/ social	

Table 2. Advantages and disadvantages of environmental education in China (kindergartens and homes)

Locations	*Activities*	*Objects*	*Games*	*Disadvantages*
Kindergartens	Outdoor activities	Natural elements	Multisensory/ representational/ active and physical/ social/constructive	
	Educational cards and physical books	Images	Vison-based	
	Observational corners	Natural elements	*Multisensory/ representational/* social/constructive	
Homes	Toys	Cartoonish images	Multisensory/ representational/ social/constructive	
	Television programmes	Cartoonish images/videos	Vison-based	
	Plants and pets	Natural elements	Multisensory/ representational/ active and physical/ social/constructive.	

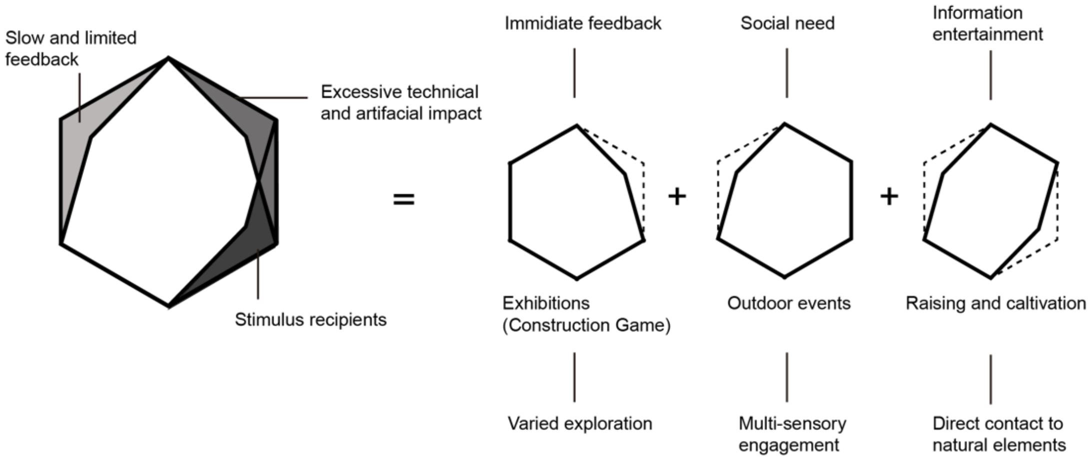


Figure 9. Overlapping radar maps to form a better environment education for children

The Design of Senseed

As a conceptual and experimental concept of environmental education for pre-schools, **Senseed** is designed to supplement a natural, fun, and educative space when the wildlife outside has a long life cycle and slow feedback for pre-school learners. Compared with animals or other natural objects, plants are common, safe and easy for children to start with. This section describes the project's design in greater detail, focusing on features taken from the six dimensions listed above.

Direct Contact with Natural Elements

Senseed utilises real seeds as the medium for a nature-based experience, encouraging children to learn about seed dispersal by playing visual, auditory, tactile, and olfactory games in each of the four rooms. The visual and auditory rooms, respectively, introduce wind and sunlight. In addition, light sensors, high speed cameras, projections displayed on the ground, infrared sensors, and odour generators are employed to support the necessary science objectives. Utilising natural dynamics, **Senseed** intends to recreate and stress how plants reproduce and alleviate the problem of environmental education spaces in China through the targeted use of digital technology.

Figure 10. Visual room

Figure 11. Auditory room

Figure 12. Olfactory room *Figure 13. Tactile room*

Senseed's branding and visual identity system (Figure 14) also foregrounds seeds. The real grass planted on the logo and other signage throughout the museum means that these change with the seasons. Children can observe and touch them, evoking the changing of the seasons and how this affects the natural environment.

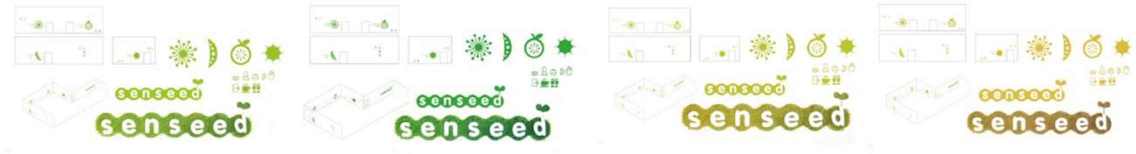


Figure 14. Branding and visual identity system

Multisensory Play

Unlike traditional natural displays, Senseed is based primarily on multisensory play that is complemented by multimedia technology but not contingent upon it. Figures 15,16,17 and 18 how children are encouraged to interact in the visual, auditory, tactile, and olfactory rooms.

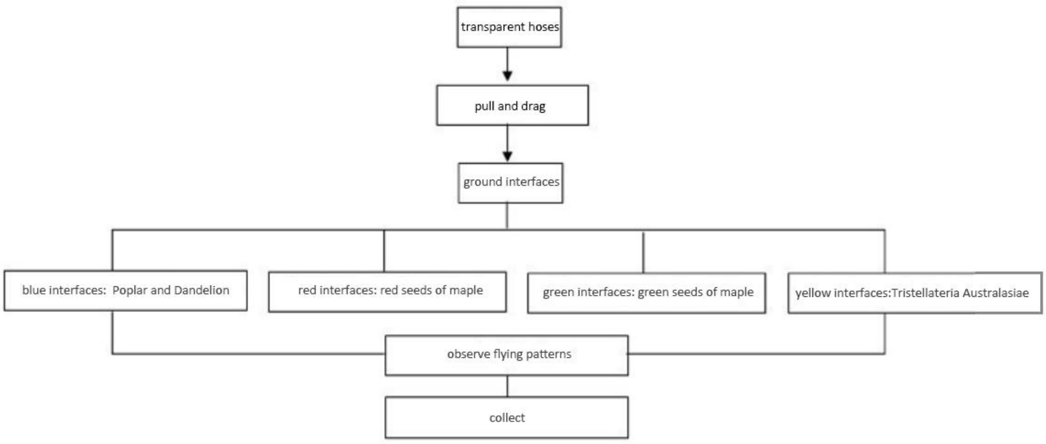


Figure 15. Visual room interactions

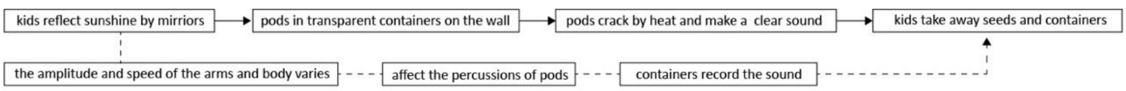


Figure 16. Auditory room interactions

Figure 17. Tactile room interactions

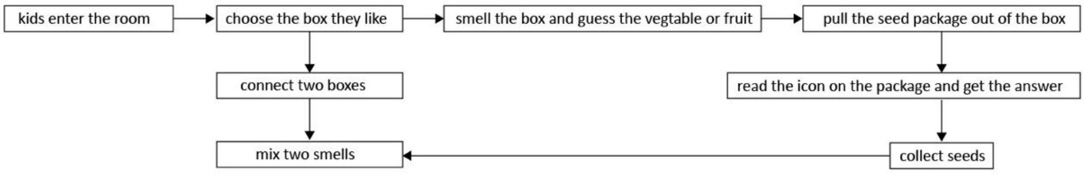


Figure 18. Olfactory room interactions

Drawing on established research on children's play behaviours, Senseed combines the five senses with games that are suitable for pre-school children, mainly involving manipulative/object play, physical activities, and social games. While some guidance is provided, the distinct absence of fixed rules encourages children to freely explore possibilities for displaying props, seeds, and spaces, thus empowering them to acquire information in their preferred way. By combining different types of play, this format encourages the development of observation, exploration, teamwork, and sensory and physical capabilities.

Varied Ways to Explore

- *Variable Forms of Spatial Organisation.* Blowing dandelions is one of the great joys of childhood play, and incorporating familiar activities into the experience helps children become more involved in new activities (Allen, 2004; Kellert, 2005). Accordingly, the common dandelion was chosen as the main interactive seed in the visual room, along with the willow, maple, and star fruit vines, which also reproduce through wind transmission. As shown in Figure 19, each has a different flight pattern by virtue of their differing construction.

Figure 19. Dandelion seeds, Poplar seeds, Tristellateria Australasiae, and Maple seeds

When the transparent hose is connected to the ground interface, the ventilation system is activated and randomly generates air currents to simulate different wind directions and speeds. These expel the seeds in different ways from the corresponding coloured interface, creating a familiar musical fountain-like effect for children. The children can adjust the wind trajectory from the tubes by connecting different interfaces and creating new flight paths to see the seeds fly in different states and create new forms of spatial organisation and display effects (Figure 20).

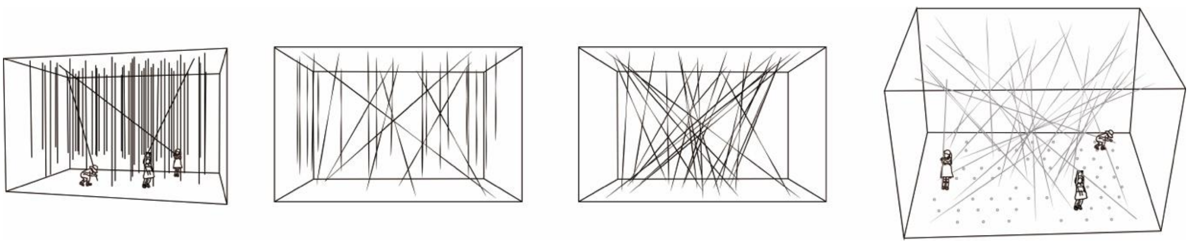


Figure 20. Different seed flight paths configured by the children

- *Diversity and Openness of Play Behaviour*. In a traditional exhibition, visitors must usually follow specified operational requirements for interaction. By dispensing with such restrictions, **Senseed** greatly increases the children's level of participation and self-generated initiative.

The auditory room chooses pod plants (yellow beans, black beans, red beans, peas, and others) using ballistic transmission as content for the experience. These pod plants exploit sunlight to crack their tightened skins and eject their seeds into the distance to grow. The cracking can be induced by light and heat and usually makes a clearly audible sound when it occurs.
As children are familiar with reflection games using mirrors, they are encouraged to reflect the sunlight from the roof to illuminate the pods on the walls, heating them up to eject the seeds. During this process, the amplitude and speed of the arms and body can be varied to create different percussions, resulting in different rhythms of blasting and different trajectories of sunlight reflection (see Figure 21).

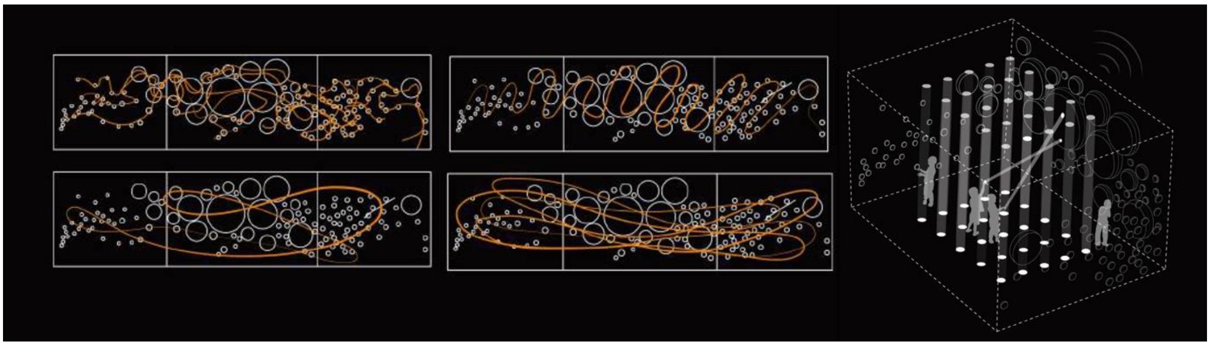


Figure 21. Different movements of light on the wall reflected by mirror and sunlight from the ceiling

Taking into account safety and hygienic issues, the sensations of smell and taste are designed as an integrated whole. The olfactory room offers opportunities to engage with sour, sweet, bitter, and salty tastes and smells, basing the content on foods with distinctive qualities such as lemon, apple, bitter gourd, chilli, and asparagus. When the author experimented with the prototype for the smell boxes, children were observed putting different boxes together to combine the smells (Figure 22). This self-motivated innovation is a positive validation of the approach, as mixing smells in this way represents a new form of olfactory interaction.

Figure 22. Prototype of smell boxes

The box, which combines both scent-releasing and mixing functions, releases the scent stored in the basic memory when infrared sensors detect a child approaching. This allows the child to take away the seed package that emits their preferred scent by selecting the appropriate box. The plant icons and corresponding scents help develop the child's general knowledge of fruits and vegetables. Breaking away from the traditional model of first providing standard answers, children are instead allowed to actively explore in order to find the answers themselves.

Collaboration

Rather than a single interactive act, smelling boxes in the olfactory room become more like a cooperative game, which extends the fun. The tactile room also supports co-operative gameplay. Here, the seed types are the Spiny Cocklebur and the Bidens Pilosa, which rely on animal furs to travel great distances. Soft, spherical booths encase these seeds, changing the width of the path in space as they move rhythmically between larger and smaller spherical booths. As the paths change in size, the child's position changes in relation to the display. For example, if a pathway that two children can cross together becomes a pathway that only one person can pass through sideways, the child must change their interaction behaviour from an easy “run” to a hard “squeeze” (Figure 23) as the location and amount of seeds sticking to the child also change.

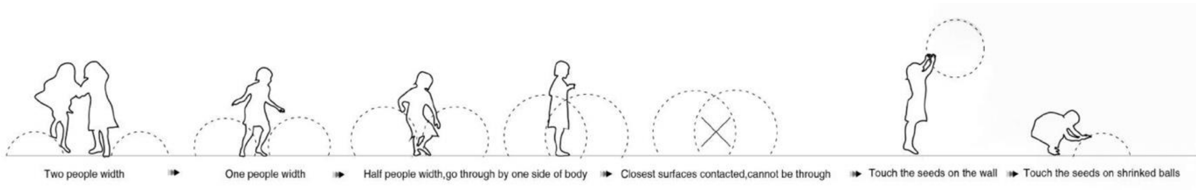


Figure 23. Paths change in size

The Bond of Emotion and Knowledge

In **Senseed**, the four rooms correspond to the four modes of dispersal, and children can collect their favourite seeds to take back to their school or home to cultivate. This encourages them to take proactive ownership of the cultivation process, facilitating engagement both during and after the visit. One of the tools used to extend the experience of the venue is the playbook, which contains information about the different modes of plant dispersal in each of the four rooms and features special tricks that allow children to relive the games they played at the venue. For example, in the chapter on the visual room, children can press the plastic bubble wrap on the pages to create air flows that keep the dandelion seeds flying. In the chapter on the auditory room, the collected pods can be stored until the child interacts with the mirrors to eject the seeds from their pods. Using the collected Spiny Cocklebur and Bidens Pilosa seeds, children can experiment with different textures of fabric to see which will capture the most seeds (see Figure 24).

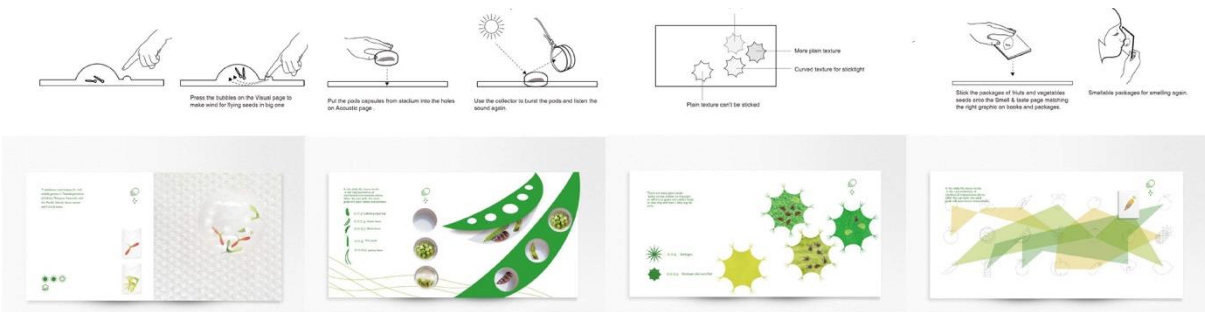


Figure 24. Visual, auditory, tactile, and olfactory pages of the playbook

By following the steps in the interactive playbook, children learn to nurture and care for the plants and develop an understanding of the light, water, and soil needed for different plants to grow, along with a sense of pride and ownership that further deepens their connection and interaction with nature.

Conclusion

As mentioned at the outset, nature deficit disorder is threatening urban children's connection with nature in China, risking degradation of the senses, mental illness, physical weakness, and ignorance and indifference regarding wildlife. Natural history and natural science museums and exhibitions are important venues for bringing pre-school children into indirect contact with the natural world, but these currently depend on high-tech replicas and monotonous displays, interaction, and games. The aim of the present study is to boost children's knowledge and enjoyment of nature by introducing natural elements into exhibition spaces in various ways that will encourage age-appropriate multisensory activities. By enabling children to collect seeds to grow at home, it is hoped that **Senseed** will enrich the design of displays and interactive games in exhibition settings.

This paper still has some limitations. Firstly, research on the environmental education in contemporary China still relies mainly on desktop research and official reports, with limitations in terms of sample size and type of data obtained from primary interviews and field research, which to some extent affects the analysis of issue

from a more localized point of view. For further application of the conceptual design, these solutions also need more prototype work to test the possibility of meeting the characteristics of Chinese students in the future.
Secondly, although **Senseed** questions the current dependency on technology to engage children with over-edit nature images as a potential problem for an objective understanding of nature, it does not completely dismiss the role of technology in nature-related display settings. The utilization of natural force to enhance preschoolers' perceptions of how seeds spread in natural world provides a new approach to the use of technology in environmental education, but a systematic investigation on the invisibility of technology (Hill & Bannon,2006), namely the balance between technological magic and the perception of wildlife to achieve certain educational function, could enrich the subject in the future.
Finally, **Senseed** seems to extend the impact of urban environmental education through tools from the venue to homes and schools (such as the play book and plant seeds that can be taken away after a visit), which also pushes to a higher level of discussion on how public venues can strengthen the systemic links between the various platforms in environmental education like families and schools.

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A Game Implementation Approach for Design Education

Within the Content of Architectural Design Studios

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This paper proposes a new implementation of video games to be used as an architectural design education tool within design studios. There are studies which include video games in design education, however, they include video games either as mere representational media, or simplified design environments, or as just visualization tools. Video games' structures provide a ground for designing with constraints to find solutions to ill-defined design problems with a trial-and-error process. As an addition to traditional master and apprentice model of learning in the studio, video games can reduce the workload of the tutors and allow them to focus on design itself rather than focusing on hard constraints. Video games provide a highly immersive, fast, and accurate feedback to students to improve their designing skills, allow them to generate a design library and provide a platform to gain know-how in terms of solving design problems. Our contemporary architectural design education can benefit from the proposed implementation method with the video games in the market.

Keywords: video games, design education, design with constraints, design studio, problem-solving

Introduction

We are faced with wide range of problems in our lives and different types of problems require different solutions. While well-defined problems can easily be solved with the help of systematic approaches, ill-defined problems can be solved by non-routine strategies (Simon, 1973), and often require a different type of knowing , i.e., designerly way of knowing (Cross, 1982). Solving an ill-defined problem requires a person to undertake extensive cognitive processes to be able to come up with a solution in the first place, and enough experience to see the errors in the solution. This design solution must fulfil some requirements within certain constraints.
Design education, even if there is no agreed system as of now, is primarily based on learning by doing (Casakin & Goldschmidt, 1999; Lawson & Dorst, 2009a; Schön, 1992). Students often are exposed to new materials, conditions, elements, functions, organizational schemes, contextual relations, and various analyses throughout their design education. Tutors evaluate students' projects based on the outcomes of the design studios. These outcomes include architectural value, contextual relations, as well as the fit of the students' projects to the constraints and rules tutors gave during the problem introduction (Webster, 2021). While this method is highly subjective (Rapoport, 1984), it is still not clear which and what kind of instructions and tools are more effective in learning how to design. A search for a tool to teach how to design is still a valid question in the field.
Design process is eventually an exploration among alternatives which are best satisfying each set of constraints (Gross, 1978). In architectural design education, studios are in the core of the training. Within the content of the studios, students are introduced to a series of problems to be solved within a design project. During the process, master and apprentice relation takes place, students develop their projects with critiques and panel reviews with their tutors to satisfy different constraints predefined by their instructors (Lawson, 2019).
As much as design courses are vague in terms of objectives and methodologies, there are platforms where design action occurs, and the objectives are clearer. Playing a game requ significant amount of cognitive process. Players are expected to come up with solutions to different problems. Each game has specified rules, mechanics, and goals. All these elements are also the features of an ill- or well-defined problem. Unlike in real

life, these strict elements of video games allow players to get to know the limitations of the game and provide them with a ground to understand the solution space after they gain experience with the game elements. Constraints and to-the-point and instant feedback of the games allow players to explore the potential solutions to specific problems (Sanina et al., 2020).
When investigated, contemporary video games include a tutorial at the beginning of the games. Even if the tutorial contents change, their goal is to teach the necessary elements of the games to the player. These elements are most of the time the game mechanics, however, often they also introduce significant features of the game such as constraints, parameters, game environment, and intractable elements. This information about game elements allows players to fully understand the game environment and mechanics. Through these tutorial, players gain full control over their creative process in the virtual game environments with their self-learning actions (Toh & Kirschner, 2020). Due to strictly coded background of the games, every move and action has a counter action. Therefore, players are fully immersed with the environment, and ready to learn by doing. This feature of the games allows contemporary games to be used in different disciplines to train novices.

Problem Definition

In the literature, many studies (such as Almeida & Simoes, 2019; Haahtela et al., 2015; Jayakanthan, 2002) indicate video games are used as tools to teach specific topics in every level of education. While their application in elementary and high school education is more common than their use in higher education, some studies also include video games in the higher education as well. Studies based on video games (Parsons et al., 2019; Sun & Gao, 2016; Vidergor, 2021) are often used as tools to make education entertaining for small kids in their teaching environments. In higher education, the reason to use games is to create a safe simulating environment for non-experienced professionals. There is no categorization and utilization technique for the video games to be classified within such use. In a significant number of studies (e.g. Marlow, 2009; Örnek, 2013), games are being used as environments to design, interact, fulfil a quest, increase hand-eye coordination, presentation environment. However, there is no use of game environment to be used as a tool to teach designing with a set of specific constraint.

Scope, Aim, and Methodology

Within the scope of this research, studies which investigate the use of games in education will be critically reviewed to introduce a pedagogical framework for design learning. As a methodology, we are following an argumentative method to construct the framework and to introduce a new implementation.
There are different ways to use games in the curriculum for educational purposes. While some of the studies are using games as a tool to introduce new concepts, some are using them just for presentation purposes, others to investigate the effects of video games in the process of learning. In other disciplines games are already being used as learning tools and this paper will revisit these to understand how different professional practices and their education systems incorporate them within their curricula. Later, methodological differences in games will be studied further to demonstrate the current state of the art.
After the review, the way instructors utilize these games in their teaching environment will be categorized. The main aim here is to understand what games could be used in what manner for ill-defined design problems and propose a brief framework for design learning.

Design and Design Education

As it has been put before, here the problem is more about the requirements, and provisions to see the fit between them (Alexander, 1964; Archer, 1979). Disciplines which have “design” in their cores deal with ill-defined problems. Even though it is not an easy task to define exactly what is ill-defined problem, Simon (1973) explains what makes a problem ill- or well- defined in reference to whether the problem space, or the solution space, or the operators to be used to go from the problem space to the solution space is underspecified. For well-defined and ill-defined problems, initial state, goal state, and operations differ drastically. Games proposes a highly well-defined environment, where the rules and movements are strictly organized with a well-thought pattern like in the game of chess (Simon, 1973).
Even though design problems are ill-defined, a design problem comes with rules and certain constraints which can be discarded, modified, added during the process, or evaluated at the end. When one undertakes design tasks, constraints emerge at different phases of the design problem. Some are stated at the very beginning of the design brief, some constraints emerge in relation to a particular design solution during the design action. Rather than seeing these constraints as limitations or blockages for free-will, they form the vague boundaries

for the solution space, in a multi-dimensional manner. They can also extend the solution space as well (Gross, 1985). Apparently, designers generate solutions by activating different constraints and associate them with their previous experiences. Design ability includes implementation of the new design solution to new constraints (Chan, 1990). Recent studies based on this assumption also indicates that designers who are led by visual constraints approach to design action in a different manner than those who were not exposed to any constraint (Ashrafganjouei & Gero, 2020). Another unique aspect of design action is the way designers generate new task goals and redefine the constraints along with it (Akin, 1978). Designers, even if the specific constraint was not put at the early stage of design process, can propose a new constraint, or edit it with their expertise in the field. However, this process requires a wide range of domain knowledge for the designer, as well as a know-how to handle it.

It is not an easy task to educate designers. While design students are required to improve their technical skills such as representing ideas, new methods, CAD use, they are also expected to learn profession related knowledge (Lawson & Dorst, 2009b). Learning how to design is also a skill which students are expected to learn, improve, and demonstrate. Acquiring expertise in design education is only achievable through practice (Lawson, 2019). Due to architectural design education's "learn by doing" approach, students are set in a simulated real-life like projects, where they undertake an architectural design project. This system has various shortcomings in terms of mimicking the practice. Even a well-defined problem in architectural terms can be a brand-new problem for students. While professionals easily solve such a problem, students need to generate enough design skill and experience to cope with the slightest problem in their design education (Goldschmidt, 2001).

In architectural design courses, students often use their tutors' experiences to create the control mechanism for the design decisions. Here, tutors have various roles, they become the client, the consultant, project team member, instructor. One of the major roles of instructors is to understand the student's evolution in expertise level and force them to undertake even more challenging tasks. While this is not an easy task to properly satisfy, tutors are often involved with the projects more than students are able to. Studies indicate tutors have more to say for a student's project than student has during the design crit and panel review (Khaidzir, 2007). Through a long and extensive trial-and-error phase, students rely on their instructors' previous experiences, skills on transferring knowledge, and representational language (Oxman, 2001).

Games in Education

Nowadays, game industry is one of the most profitable entertainment industry in the world (Statista, 2018). Serious gaming redefines the purpose for which the games are used for. This implementation of games creates an alternative as an educational or psychotherapeutic tool (Lievense et al., 2020). Gamification is another way of using the games for specific learning outcomes. It entails the use of game environments and outcomes for specific pre-defined aims in non-game contexts (Abou-Shouk & Soliman, 2021; Whittaker et al., 2021). Gamification, serious gaming, and use of games for different purposes are more and more used in education (Dicheva & Dichev, 2015). In learning, video games are used extensively in the higher levels for the last few years for purposes ranging from representation to designing due to their user-friendly interfaces, three-dimensional capabilities, and transferring knowledge for a profession-specific topic (Almeida & Simoes, 2019; Kharvari & Hohl, 2019). However, there is still ongoing research to explore the possible uses of games in different training and education fields (Gunter et al., 2006, 2008). In a broad sense, games allow players to monitor and have control on their progress through instant and efficient feedback process of the games. Players also develop motor, cognitive and space-related skills while playing games for educational purposes, rather than solely for entertainment. Another important aspect is to illustrate the conditions and rules, where it is hard to imitate in real life environments (Simkova, 2014).

Throughout the years, serious games were categorized in different manners. Main categories can be named as public policy, strategic communication, defense, education, healthcare according to a study by Zyda (2005). Another categorization includes more genre such as military games, government games, educational games, corporate games, healthcare games, political games, religious games, art games, advertising games, cultural games (Alvarez & Michaud, 2008; Chen & Ringel, 2005). Categorizations can be extended for marketing, genre, audience focuses (Bergeron, 2006; Despont, 2008; Miguel Encarnação, 2009). However, within the content of this paper, only educational games are reviewed.

Training for different purposes is one of the major aims of gamification for serious gaming. Examples can be found easily in the medical field, military use, and skill-based practices. Educational paradigms for gamification in higher education can be put as interface design for disabled people, transferring academic knowledge, and gaining professional expertise (Jayakanthan, 2002). In war games, military strategies can be learned and

practiced through gaming (Smith, 2010). Here the games are mostly used for their simulating features for battlefield, where military actions can be understood in action and strategies can be implemented. The game mechanics and goals immerse the players, so that they can learn the very core outcome of military use. Another satisfactory field is the medical use of gamification. Researchers state that serious games have a wide range of potentials for educating surgeons. Technology based education in surgical games create the cognitive and perceptual models for the trainees. Not only knowledge-based games, but application based, hands-on games to undertake the action of games with the help of virtual reality systems are the safest ways to train surgeons to demonstrate in real-life examples (Baby et al., 2016). History teaching is also possible through satisfactory serious game design for historical objective, which develops enthusiasm, motivates and engages students, reduces monotonous learning methods, helps students to focus, gain self-esteem, and improve the memorization of the historical content (Zirawaga et al., 2017). In engineering, serious gaming supports learning course materials and effect student's perception of course content positively (Bodnar et al., 2016). Not only students learning capabilities, but transfer of academic knowledge to the industry seems to be maximized with the help of games in the academic curriculum in higher education (Deshpande & Huang, 2011). Mayo (2007) states that educational benefits of video games in science and engineering fields are scalability of the audience, being available any time for students, compelling nature, improving learning abilities, and being better than a lecture. Research indicates improvements of learning outcomes are typically 30% and more when gamification applies to engineering education.
Games are also used in design education. A study conducted by Radford (2000) created a game-like environment where students interact with historical structures to learn about shape grammar and come up with ideas in the game environment itself. Further research used this learning outcome in an interactive manner, where creational objectives were also introduced to novice designers. Students' understanding of spatial relationships and formal decisions were taken into consideration within the game environment through automated scripts. However, it was used only as a design grading element rather than providing a feedback during the design action (Sandstrom & Park, 2019). Another study used a gaming platform to design in a collaborative manner within its environment, however researchers and participants struggled with the technicality of the game, even though at the end the collaborative design environment was set, it was harder to design than with the traditional methods (Warmerdam et al., 2007). In landscape design education, games are used as a representational tool (Örnek, 2013) as well as a platform to teach technical, material, historical, sustainable approaches (Marlow, 2009). In a study, a massive-multiplayer role-playing game was used as a representational shared online medium for students to showcase their works to their tutors in the final reviews (Abdellatif & Calderon, 2007). Another prototype was for everyone to learn the basic architectural workflow for housing projects. The tool was generated to maintain a design environment and provided the player with the tools to design (Otten, 2014) with no further implementation of trial-error based reasoning and learning. Application of serious gaming in design education also includes the shift of game purpose into a virtual studio, where students and tutors come together to work on individual or group projects (Moloney, 2001; Moloney & Amor, 2003) . However, within such case, game environment is nothing more than a collaborative communication platform. Another game prototype was generated to create spaces out of blocks to enhance students' creativity towards spatial creations (Sanchez, 2015). No constraint definition, feedback process or design satisfactory criteria were applied in the content of the game, therefore the prototype was used only as a platform to create a virtual replication of the design, like a computer-aided design software.

Critical Review Outcomes

Games, when they are considered in a serious gaming context during education, proves to have multi-dimensional advantages. Apart from being only entertaining and immersive, in most of the professional fields, games introduce real-life like scenarios to juniors and provide them with technical and cognitive skills they will need further in their professional lives. One of the major things in all these fields is that the game environments are not only to maintain a platform to simulate professional practices, but they also have the feedback mechanisms, where actual expertise is acquired through strictly defined problems and satisfactory objective oriented solutions. These mechanics in the games serve as not only constraints but also as tools to play around and better realize the solution space in the well-defined problem systems in specific professional fields. Especially the strict and various constraints in games can create a manageable design environment for players.

However, design fields when compared to others, include gamification and serious gaming into their curriculums in a different manner. While other fields use the immersive environment to maintain the feedback process and fitness of the design decisions with regard to design constraints, games in design education are used primarily for representational reasons, collaborative environments, and as tools to support the design action's technical side. No design cognition challenge or no feedback process is considered with the games and the educational objectives with which a learner could set design constraints, modify them, and when necessary, drop them with instant feedback from the game environment.

A New Implementation of Games for Design Education

In non-design fields, games' advanced feedback mechanisms are being used to create an immersive and real-life like environments for players and students. However, in design field this feedback process of game algorithms is usually not introduced. The potential in games to support instant feedback in reaction to a certain move is not explored in the literature. Games consists of many algorithms and background calculations to provide working game mechanics. Every game and scenario have a goal, where they are highly well defined. For design education, games with ill-defined problem-solving game mechanics can be used to make students to explore the potentials of the game's first. Within the infrastructure of the game the hidden algorithms can easily track students' actions, and decisions which can be easily calculated and reflected back to them to allow them to generate a new solution or adjust their current design solution. Not only to provide feedback and evaluate, but the video game also can act as an artificial tutor to teach students about constraints, support their prioritization skills in professional manners, as well as manipulate the current constraints and set up new constraints.

In design education, tutors constantly evaluate students' projects and provide regular feedback. They try to find out the problems, errors in design, and provide suggestions for their design or rational for their design decisions. Due to students' lack of experience in design, some of the basic design decisions are hard to grasp. Right at this point, full potential of games can be used. Games can support the design learning experience by using finite elements in infinite combinations, where students can try to solve problems, fail, and try it again until they acquire the experience to cope with the technical difficulties. Tutor's role here changes. Rather than trying to find the errors in design, and failed design decisions, hard built constraints can be left to strict algorithms to check in students' designs. At that point, tutors can start dealing with the intricacies of design itself, student's approach to design problem, unique ideas, design concepts, which are the soft constraints, therefore reduce the tutor's workload.

The proposed new implementation is a hybrid system to design courses, where traditional method is coupled with contemporary serious gaming in a designerly way. However, it is important to select the game best suitable for this manner. Most of the games in the market are based on simulation and management games. These games provide an environment where players oversee a specific facility (such as a hospital, prison, colony, spaceship, airport, collage, hotel, etc.) and their actions are affecting the occupants of the game environment. Players are expected to design a working program with certain specifications. In this manner, what players (students in educational settings) must do is to maintain a working scheme throughout the game with dynamic and changing demands based on the simulation algorithms. To give an example, a game called *Prison Architect* is a simulation game where players create prisons for specific needs (see Figure 1). Architectural elements such as foundations, walls, furnishings, plumbing and electrical systems, zones such as kitchen, cell, armory, staff room, garden, interrogation rooms, showers and many others are present. Players start with certain specifications for a design project, such as fifty prisoner inhabitants, with a cafeteria for eighty people, a staff room, two offices, and a garden, with service spaces enough to facilitate them. A certain amount of funds is given to players to come up with a design. What is important here is, players must be aware of their actions before prisoners arrive to the prison. Players must understand the program and place each zone with certain requirements in a meaningful order. Possible consequences can be generated by the game algorithm to provide feedback during the design process. For example, if the player puts a cell close to one of the major exits, during the free hour (where prisoners can move as they want), prisoners will most likely start escaping the prison. Therefore, player can adjust the design in accordance with this specific situation. Another consequence for the design can be, if the square meter for the cafeteria is not adequate, and if the prisoners sit too close to each other, they get psychologically stressed and start a rebellion, where staff members are in danger and a lock down must be announced.

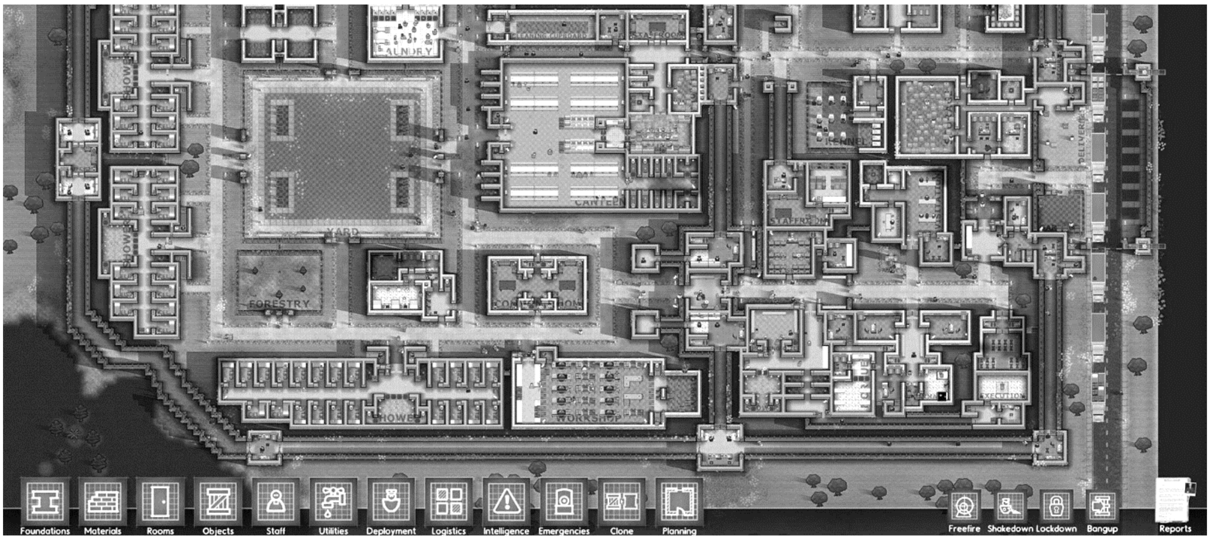

Figure 1. Prison Architect, In Game Heads-up Display (Fernan, 2019)

Another example for a simulation game can be *Project: Highrise* which has a side-view section like game environment to create a resemblance with architectural notations (see Figure 2). In the game, players oversee balancing the supply and demand chain in a high-rise project. The game elements include a wide range of functions which are represented with different styles, and attributes that both adds up to the workload and the infrastructural needs for the whole building. Main constraint in the game is to follow the uses of the spaces and re-arrange the spaces' uses as well as add new offices, accommodation units, shafts etc. accordingly. Even if the game proposes a simple challenge, to understand the vertical relations and some of the main constraints in terms of structural, plumbing, electrical, and mechanical systems can be learned through the game challenges, as well as manipulating the existing spaces for the demands of the occupants.

Figure 2. Project Highrise Game Environment (Gault, 2016)

These kinds of situations in game environments can make the player (student) generate an experience for the designed spaces and foresee the consequences of their actions, which can lead them to make more appropriate decisions along an automated, fast, and rigid trial-and-error based design process.

Conclusion

Today, design education is based on models created in Bauhaus and partially a continuation of Ecole des Beaux Art with some minor contemporary additions. This study proposes that adding video games in the design studio might foster checking the objectives with constraints and providing instant feedback. In the last decade, gamification and serious gaming are introduced in education to teach certain skills and knowledge to novices. In this study, the use of games in different learning disciplines are reviewed. After stating the main difference between different disciplines' approaches to gamification, it is seen that the use of games in design education is rudimentary. A new approach to use video games in design courses within a hybrid system of traditional design crit system is proposed. The new hybrid system allows the course instructors to deal with the design idea related items, rather than the organizational problems of the projects, while game itself can create a self-learning environment for such outcomes. One of the major focuses of the proposed methodology is to allow students to overcome the lack of design skill in early phases of their design education. Providing a meaningful platform for an automated trial-and-error based system for students can enhance their abilities to understand

the consequences of their design decisions, which corresponds to the design experience.
For further studies, this new approach must be tested with a group of novice designers. An experimental study based on the outcome assumptions will provide a deeper understanding and foresight for the idea of implementation of serious gaming and gamification concepts in design education's core.

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Architectural Design Studio as an 'Extended Problem Space'

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Drawing on the foundational theory of Zone of Proximal Development, this paper approaches dominant architectural design studio pedagogies critically and explores how the concept of 'extended problem space' can help develop better pedagogies for design learning. A conceptual framework is introduced through a theoretical understanding of architectural design studios' multi-layered environmental sphere of cognitive systems based on previous research on studio education. The formation of the framework is inspired by an earlier study carried out in knowledge production and transmission processes in a research laboratory that considers the human and non-human components of the laboratory within an evolutionary mechanism. Cognitive components of architectural design studios, hence, are described through the social, cultural, material, and temporal dimensions within an understanding of embodied, distributed, enculturated, situated, and extended cognition. Next step of this conceptual study is to explore architectural design studios' cognitive systems empirically to investigate dynamics among cognitive components in different settings.

Keywords: situated cognition; extended cognition; learning environment; design studio; problem space

Introduction

Recent research on learning has increasingly focused on the role of the environment in its most comprehensive understanding of learning processes and is clustered mainly under the concept of situatedness (see Lave&Wenger, 1991; Greeno, 1998; Wenger, 1998; Newstetter, Nersessian &, Kurz-Milcke, 2002; Henning, 2004; Engeström, 1991; 2014; Greeno & Engeström, 2014). The literature on situated learning reveals positive and negative impacts of social, cultural, material, and temporal dimensions (hereafter will be referred to as "multi-layered") in professional learning environments on cognitive processes (e.g. Herrington, 2005; Yeoman&Wilson, 2019; Franca&DeLuca, 2019). The motivation of these studies is to develop pedagogies that conceptualize the environment as a scaffold for learning. Vygotsky's seminal study on learning and development (Vygotsky, 1978) is the foundation of these studies (see Engeström, 1991; 2014; Sawyer, 2014; Reiser& Tabak, 2014). Vygotsky's theory reformulated learning as more than an individual mental activity. The theory approaches learning processes from an environmental perspective that focuses on the scaffolding impact of the physical, social and cultural environments in learners' cognitive processes of internalization of the knowledge.

In this study, the focus is on the environmental dynamics within the architectural design studio (hereafter will also be referred to as "design studio" or "studio") which is the core learning environment of architectural design education (hereafter will be also referred to as "design education"). Design studio is not just a physical environment; it embodies the studio culture, curriculum, social relations, and many other aspects of design learning albeit mostly implicitly. It has been one of the exemplary learning environments for professional education as Schön (1987) proposed in his theory of 'reflective practice'. It is both a formal and an informal learning environment that engagement with the place is considerably higher compared to classrooms. Such engagement has a higher impact (negative and positive) on learning. While Schön (1981; 1987) mostly focused on its positive impacts, many scholars criticize that there are problems in design studio learning because of high subjectivity, individuality, weak collaboration, hierarchy, excessive focus on crafting, or weakness in theoretical development (see Rapoport, 1984; Dutton, 1987; Webster, 2005; 2008; Tzonis, 2014; Frascara,

2020; Meyer&Norman, 2020).
Research on studio conducted from a cognitive perspective mostly investigates different methods for design learning in the studio like the use of computation or crafting in designing (see Oxman, 2008; Koronis et al., 2021), or focuses on specific dimensions of the studio environment such as physical space, tutor-student communication, studio culture, or collaboration (see Thoring et al., 2018; Davidovitch&Casakin, 2015; Goldschmidt et al., 2010; Oh, et al., 2013; Ward,1990; Ketizmen Onal & Turgut, 2017; Vyas, 2012). Yet, as studies of situated learning suggests studio's multi-layered dimensions have a holistic impact on the learning processes. Hence, the aim of this conceptual study is to propose a theoretical framework to conceptualize design learning pedagogy taking into consideration the multiple layers of design studio.
In this study, the studio environment is defined as an 'extended problem space' following Nersessian's (2005) conception of research laboratory's knowledge production and transmission. Newell and Simon (1971) introduced the concept of 'problem space' to study problem-solving. The concept was further expanded in Nersessian (2005) in her studies of laboratory settings. In this paper, we elaborate on Nersessian's definition together with Vygotsky's theory of learning to conceptualize a framework that might respond to some of the issues highlighted by recent research in design learning. Accordingly, the 'extended problem space' concept in this paper is defined as an abstract multi-layered environment of all human, non-human, and conceptual components that take part in design learning, as well as the interaction among them. Thus, 'extended problem space' includes at least learners, tutors, visiting professionals, representational tools, representational materials, terminology, physical space of the studio hall, architectural space in the real world, the curriculum, the library, and the studio traditions like design jury and one-to-one tutor critiques.
This paper begins with the "Theoretical Perspective" section that gives a summary of the environmental perspectives in learning starting from Vygotsky's approach to an overview of current research. This is followed by "Design Studio Learning Framework" section introducing a design learning pedagogy concept that proposes parameters for design learning process supported by multi-layered contexts. Use of the framework is illustrated in a visual diagram as a model for future studies to explore the dynamics of cognitive components empirically in different settings. Finally, in the "Discussion" section, existing studio pedagogies are critically examined through a holistic environmental perspective and prospective future studies based on the proposed framework are discussed.

Theoretical Perspective

The literature on situated learning mostly criticizes the poor qualities of formal learning places and curriculums (see Freire, 1968; Lave & Wenger, 1991; Greeno, 1998). The underlying cause of this poverty seems to be the positivist tendencies that approach learning as a merely mental activity (see Schön, 1987). Situated learning researchers, on the contrary, consider learning as an embodied and socially constructed process. Their proposal is based on the efficient involvement of the multi-layered environment into learning processes. They mostly draw on the foundational theory of Vygotsky (1978), and especially the concept of Zone of Proximal Development. Despite being focused on development in childhood, the theory is interpreted as a helpful guide in understanding the human faculty of learning in general. It emphasizes the critical role of human interactivity with the environment in learning processes. In this theory, language use and tool use are suggested as the main instruments of human development as they regulate and enhance the interaction with the environment (Vygotsky, 1978). In the situated learning literature, the environment is proposed as a scaffold in the learning processes (Brown et al., 1989).
The main focus of situated learning literature is the social-cultural relations among the learners' and teachers' community, as seen in studies of Freire (1968), Lave and Wenger (1991), and Brown and colleagues (1989). All have explored how environment, especially the social context, can influence learning processes positively. Freire's (1968) 'culture circles' was a proposal of equal and free dialogue groups that a social environment facilitates. Later, Lave & Wenger's (1991) theory of 'legitimate peripheral participation' has been a framework for master apprenticeship setting that novice ones gradually become involved in the practice and in time become professionals. Similarly, Brown and colleagues (1989) proposed the concept of 'cognitive apprenticeship' in which they build on the traditional master apprenticeship setting as the starting point for a multi-layered pedagogy. They highlighted the significance of 'authentic activities' in learning processes, which they explained as learning activities that are situated within "coherent, meaningful and purposeful activities" like the activities of practice in the real world (Brown et al, 1989, p.34).
Schön's theory of 'reflective practice' has been influential in higher education. Schön criticizes the weaknesses of impoverished positivist education in professional education (Schön, 1987). As he emphasizes, the result of such an educational setting is "the crisis of confidence in professional knowledge" (p.3). He proposes

architectural design studio as a model for professional education. His ideas on studio education influenced many educators to adopt studio setting in educational processes (see Wacks, 2001; Shaffer, 2003; 2004; Reimer&Douglas, 2003; Griffiths, 2020).

Another stream of research was by Engeström and his colleagues; they build on Vygotsky's philosophy to frame the Activity Theory. They define the activity system as including at least "the object, subject, mediating artifacts (signs and tools), rules, community, and division of labor" (1999, p.9). Their studies are more related to collective activity rather than individual activity and based on the cultural-historical school of Russian psychology (Engeström et al., 1999). Engeström and colleagues' studies (1991; 1995; 1999; 2000) focus on the collectivity of the activity considering the value of criticism, change, and novelty in organizations. They criticize Lave and Wenger's 'legitimate peripheral participation' as it misses an important aspect in communities of practice: "questioning of authority, criticism, innovation, initiation of change" (p.12). The master-dominancy and closedness of the practice were indeed the main weakness of master apprenticeship settings. Yet, as Lave and Wenger (1991) argued, the communities of practices are powerful enculturation mediums for novice ones, whereas formal learning communities usually lack in providing that engagement and just promote individual activity.

As Nersessian (2008) explains the situatedness and distributedness of cognition emerge and evolve in a system, not merely in the mind or in the world since every mental activity in fact interacts with "other material and informational systems (including other humans)" (p.117). There is a continuous and dynamic connection between human brains, bodies, and multi-layered environments in any cognitive process that forms interlocking 'systems' (see Sprevak, 2020). Clark's (2008) concept of 'cognitive niche construction' is a valuable viewpoint in exploring human development in practice in everyday settings within the influence of the culture it embodies. Cognitive niche construction is defined as the "process" by which humans "transform problem spaces" through constructing their own environments that facilitate their activities (p.62). This process is a long-term one that is developed within the evolution of the specific social, cultural, and material contexts (Clark, 2008). The environment accordingly becomes the 'cultural cognitive niche' with its cognitive offloading mechanism in which a novice learns to carry out the activities (Clark, 2008). Clark's example is a bartender who learns how to prepare the drinks according to the order of orders with the help of the diverse shapes of the glasses. In this example the material environment support novices to learn practices through the already structured setting that evolved in long terms of practice.

The environmental perspective of learning that involves the interaction with the material environment increased after the 1990s (see Clark, 1996; 2001; Hutchins, 1995; Hutchins&Klausen, 1996). Thought experiments of Clark's hypothesis of extended mind have usually been technological artifacts that people use or can possibly use in the future as an extension of body and mind (see Clark, 1996; 2001; 2008; 2012). Hutchins's study (1995) on pilot training on plane cockpits was about the use of material environment functions developed through technology as a cognitive offloading mechanism. In Hutchins's study (1995), tasks in the cockpit are distributed among the equipment and people. For novice ones, the cockpit is a classroom where learning happens within shared activities; these activities are important components of "learning a complex job like flying an airplane" (Hutchins, 1995, p.13).

When viewed from an individual's perspective, there seem to be two dimensions that should be considered in processes of engagement with the environment: expansion and implicitness. The first dimension is the expansion of cognition as Clark defines. Clark (2008) explains the embodiment in the world as a process of gradually creating a broader and fluent existence within the 'extrabodily world'. This embodiment leads an individual to define the body as 'transparent equipment' (see Clark, 2008 in reference to Heidegger, 1927/1961). Accordingly, the more an individual becomes fluent within the environment, the more h(er/is) mind 'expands' to the environment (Clark, 2008). This paper interprets this 'expansion' to the multi-layered environment as learning.

The mechanism of engagement with the environment in cognitive processes are also explained with 'internal' and 'external' representations. Nersessian (2008) proposed that "coupled cognitive system" consisting of a "relationship between the internal and external worlds" constitutes the basis of representational components of cognition in general (p.115-116). An architect's sketching process is not a process of reflecting the ideas in mind, but it is a process of supporting design thinking process, just like using a pen and paper for mathematical calculations.

The second dimension of engagement with the environment is the implicitness of the engagement. Research on human perception and learning shows that interaction with the environment is primarily through implicit and automatic processes (see: Lewicki, 1986; Reber, 1989). These studies support that implicit and explicit learning processes are intertwined, so the implicitness of the processes is not distinguishable from the explicit ones (Reber, 1989). Indeed, enculturation of the environment is a way of transforming human cognition both explicitly and implicitly, as seen in both Clark's 'cognitive niche construction' and Hutchin's plane cockpit. Interested in both perspectives (from humans' and from environment's), this paper uses Newstetter, Nersessian, and colleagues' study (2002) as a model for interpreting the role of the environment in design learning processes. Their study compares distinct characteristics in a research laboratory and an undergraduate course classroom. Research laboratory is evaluated as an environment of in-vivo activities. It involves interacting human and non-human components (Newstetter et al., 2002). The study shows that such an environment of in-vivo activities is more effective in learning rather than learning in a classroom environment (Newstetter et al., 2002). Accordingly, they argue that for better learning processes, the knowledge production processes in laboratory should interact with the classroom knowledge production processes (Newstetter et al., 2002). Nersessian's (2005) succeeding publication proposed that laboratory environment is a dynamic and 'extended problem space' "with permeable boundaries" as an "evolving distributed cognitive system" (see "cognitive system" in Hutchins, 1995) within its social, cultural, and material environment (p.15). Her definition highlights the distributed nature of problem-solving (see Newstetter, Nersessian, and Kurz-Milcke, 2002; Nessisian, 2005; Nersessian, 2006; Kurz-Milcke, E. & Nersessian, N. J. & Newstetter, W., 2003). Newell and Simon's (1971) concept of 'problem space', in fact, was criticized by scholars and several proposals were given to expand it (see Greeno, 1998; Kirsch, 2007). The proposals by situated cognition researchers were potentially richer characterization of 'problem space' that considers the role of the environment. Nersessian's (2005) definition is based on those. It includes all "resources for problem-solving" which are "people, technology, techniques, knowledge resources (e.g., articles, books, artifacts, the internet), problems, and relationships" (Nersessian, 2005, p.20). From the situative perspective, every problem depends on the conditions of the environment it is in, and each is solved through reasoning using material and cultural resources in the environment (Kirsch, 2007). Hence the so-called problem depends on the "discourse" of the activity; therefore, it is "socially structured" (Kirsch, 2007, p.266).

When interpreted from the perspective of the theory of Zone of Proximal Development, the multi-layered learning environment is in fact the 'extended problem space' for design learning processes in the studio. The environment is both the reflection of how the education is intended to take place and the reflection of how learning processes are performed. Learning environments are socially, materially, and culturally structured and thus have the potential to scaffold learning like it is in the research laboratory study of Nersessian, or not support an efficient learning process like it is in classroom learning settings. Schön's (1987) proposal of architectural design studio as an exemplary learning environment for professional education was also partly for its potential in scaffolding novice ones, due to its rich communicative setting. Indeed, studio environment is potentially an efficient place for design learning if the limiting characteristics of the studio culture are understood and mitigated.

The following section is a proposal of a monitoring tool that considers diverse components involved in the cognitive systems within the 'extended problem space' of studio. The proposed theoretical framework is a model which involves dynamics of the cognitive components in different studio settings. The function of the framework is modeling the scaffolding role of the multi-layered environment of studio. The main target of this model is to compare different settings in future studies to reach which patterns of multi-layered environment serve better for architectural design studio education.

Design Studio Learning Framework

If learning is an internal cognitive construction with internal and external processes, designing is, in the reverse direction, an external construction with internal and external processes. This requires effective use of 'coupled representations' that Nersessian (2008) mentions, such as design thinking processes with the use of modeling and sketching. In other words, the design learning process is already a process that progresses in interaction with the environment. And the environment can be both facilitator and inhibitor in these processes. The conceptual model proposed here considers the impacts of the studio environment on design learning and suggests parameters to monitor and evaluate its role in scaffolding within an understanding of embodied, distributed, enculturated, situated, and extended cognition.

Design is a human act of situated 'material creation'. Designers do not just deal with the 'human-made world', but with the totality of everyday life. (S)he also deals with human experiences, psychological processes, social interactions, or interactions with nature. Gero and Kulinski (2000) define 'situated design' as "a conversational activity between the designer and the physical expression (representation) of his/her design ideas" (p.213). This perspective is limited because it does not include the main environmental sphere introduced with the situatedness and the designer's dynamic complex interaction with its environment. Chiu (2003), elaborated on Gero and Kulinski's model by adding two levels. In the "micro-level", the model includes (a) exploring and thinking on precedents, (b) thinking on the design problem and its environmental circumstances, (c) space of working and working tools. The "macro-level" involves (d) communicating to the group of people at the workplace and (e) interaction with the culture. Gero and Kannengiesser's (2003) study proposed a wider conception that focuses on the environment. They introduced three environmental types comprising (a) the 'external world', (b) the 'interpreted world', and (c) the "expected world". This advanced model tends to divide the 'world' into two in terms of "external" and "interpreted". Hence, the body and the adopted tools can either be included in the interpreted world or the external world. However, as Clark (2008) underlines, cognition within the "extrabodily world" is enabled through considering the body as "transparent equipment". We can interpret these 'extrabodily' tools as part of our cognitive 'fluency' as long as we adopt them as if they are 'extensions of our body'. Polanyi (1967) supports this idea arguing that "whenever we use certain things for attending from them to other things, in the way in which we always use our own body, these things change their appearance" (p. 16). He continues, "they appear to us now in terms of the entities to which we are attending from them, just as we feel our own body in terms of the things outside to which we are attending from our body" (p. 16). Accordingly, the 'tool' we are "attending from" becomes the "transparent equipment", whether it is the corporeal body or a tool. Furthermore, all social, cultural, and material interactions became "transparent equipment" when we are "attending from" them. So, expanding the cognitive system into the social, cultural, and material environment results in gaining the mentioned fluency in designing processes. This model considers the use of the environment in design learning as potential 'transparent equipment' of learners, which, then, could be conceptualized as an 'extended problem space'. Hence, change in the studio environment is crucial. The change in the cognitive systems of studio is considered based on two main pillars comprising (1) cognitive expansion of the learners through implicit and explicit learning processes and (2) evolution of the environment (including artifacts) due to interaction among human and non-human agencies.

Cognitive Expansion

Design studio is the medium of designing in interaction with the cognitive systems in the environment. The focused cognitive processes are mainly 'outside' the cognitive components which mean the focus is on the interactions/relationships of these components. All interactions/relationships conducted by learners and tutors are potential ‘transparent equipment’s for them. In order to become 'transparent equipment', learners’ internalization of design learning is achieved through developing certain skills to an advanced level and appropriation of the design 'body of knowledge' within a critical stance.

The skills and the design knowledge are implicitly or explicitly acquired by a learner through the scaffolding of the environment. This scaffold is modeled as a network of cognitive components that embodies the abstract concept of ‘extended problem space’. The cognitive components are envisaged as comprising at least learners, tutors, visiting professionals, representational tools, representational materials, terminology, physical space of the studio hall, architectural space in the real world, internet, and the library (see Figure 1). The outsider cognitive components of the studio environment are what the studio environment cannot transform single-handedly. These outsiders are at least architectural space in the real world, internet, terminology, and library. The insider cognitive components of the studio environment are what the studio environment can transform. These insiders are at least tutors, learners, representational tools, materials, and design representations (external representations). As a result, studio pedagogies are seen as regulators of the interactions among insiders in the studio.

As seen in Figure 1, there are two types of relationships among these cognitive components. One is through material interaction, and the other is through social interaction. Material interaction is physical/perceptual; hence it is embodied; social interaction is communicative. Dynamics within the cognitive systems of studio are reflections of the cognitive expansion. Positive effects of these dynamics on design production are the indicators of efficient learning processes in the studio environment. For example, communication between two students in the studio about their design schemes can help both develop their knowledge; or a student can experience characteristics of a material in a building material library that can help h(er/im) to increase awareness for most suitable ways to use this material in design or learning to use a parametric 3d modeling software with the help of a friend can help a student develop skills of computational design.

In fact, the quality of the relationship is the driving force of learning more than the existence of the interaction among agents in the design studio. Hence, this conceptual model seeks qualitative aspects of the structured relationships in different studio settings. In-depth interviews with learners and tutors are necessary tools to develop an understanding of quality in these relationships. The environment of the virtual studio, on the other hand, is considered to be a perfect medium to quantitatively analyze these relationships.

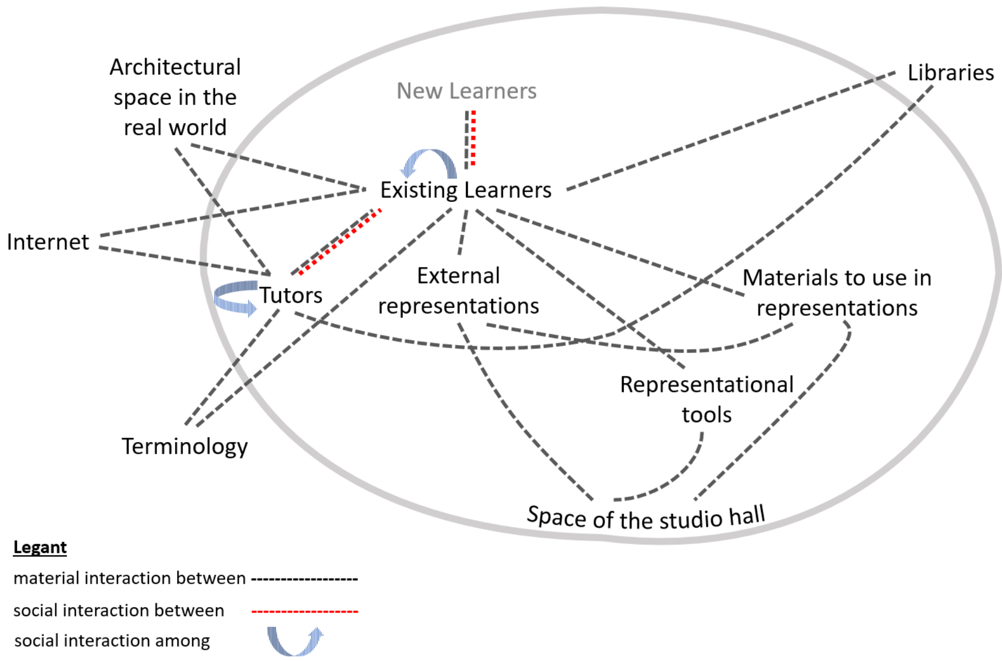

Figure 1. Cognitive components of the studio and the network of relationships

Evolutionary Aspects

The interrelations of the cognitive components are considered as the most important factors in the evolution of the cognitive components and the environment. The other dimension that influences this evolution is the temporal context. That is, the studio traditions such as design jury, weekly one-to-one critiques with tutors, duration of courses, or design projects are accepted as evolutionary actors in the studio. They shape the characteristics of the relationships between cognitive components, and they are drivers of when and how the evolution of the systems happens.

Depending on the curriculum, a studio can be either an ongoing medium for designing processes that new learners can get involved from time to time or an episodic medium for learners of specific time periods (like semester-based studios). In any case, studio's cognitive systems are always in an evolutionary process either in an implicit or in an explicit way. In this model, the evolution of the systems is considered on three levels, comprising (1) the microevolution of the design representations, (2) the evolution of learners throughout design learning processes, and (3) macroevolution of the studio settings.

The microevolution of the design representations is a visually observable process. The development of design can be observed through representative objects that we consider as part of coupled representations in design thinking processes. These objects mostly trigger the following steps taken in the design thinking process. They are both like frozen pictures of the process and they can become standalone artifacts. They represent the fastest level of evolution in the studio.

The evolution of learners throughout design learning processes is the most important aspect of evolution in the studio. It reflects how effective the studio environment is in the learning processes and it is the mainline this model will focus on. The analysis of the microevolution of the design representations will enrich the understanding of this process.

The macroevolution of the studio settings is what the model will monitor in different studio settings in comparison. The analysis of the evolution of learners throughout design learning processes will enrich the understanding of this process. The analysis of this macroevolution of the studio settings will help us to understand possible directions that the material, social, cultural, and temporal environment influence studio learning processes.

Discussion

Studio setting is a more lively environment compared to classroom setting; but we believe that common studio pedagogies are usually difficult to adapt, especially for new learners. The difficulty of crafting, use of terminology, individuality, hierarchy, design juries, or high subjectivity of design are among challenges for the novices in studio.

Seeing the design studio as an 'extended problem space', on the other hand, offers an alternative. It changes both the description of the design problem and differentiates the structure of problem-solving processes. Accordingly, the problem is no longer just the student's individual problem, but the whole group of students' communal problem. The design problem becomes a problem solved together with peers and instructors in the studio, interacting with the physical, social, and cultural environment. We believe that current studio pedagogies cannot consider different layers of the studio from a holistic perspective within a critical stance. When examined from such a holistic perspective, the proposed model can evaluate, for example, the effects of 'hidden curriculum' (see Dutton, 1987) on learning processes by associating it with the physical environment of the studio, communication styles among students, or the use of representation tools.

Questioning Studio Pedagogies

After Schön (1987), the studio pedagogy is further scrutinized (see Lawson & Dorst, 2013), but in many architecture schools around the world, the accustomed studio framework has stayed essentially unchanged for decades. Problems related to the studio pedagogies have been discussed through the concept of 'hidden curriculum' (see Dutton, 1987), power relations (see Webster, 2005; Webster, 2008), master-apprenticeship hierarchy (see Rapoport, 1984), or weakness in design theory (see Meyer&Norman, 2020). Yet, we believe that the problems are intertwined among the cognitive components. For example, the desk crit and design jury with the grading system support the dominance of the studio tutor as the 'master', whose wisdom cannot be questioned (see Rapoport, 1984). Yet, it is known that the studio tutor and students' one-to-one relationships do not demonstrate an ideal symmetrical structure, as evidenced in Schön's (1987) Petra-Quist and Judith-Northover dialogues. Judith-Northover dialogues show that the student is disturbed by the dominance of the tutor; she does not want to accept him as a 'master'; and there is no communication between them that will benefit from the experience of the tutor (Schön, 1987). On the other hand, Quist and Johanna's communication shows that these dialogues can be constructive.

As Dutton (1987) emphasizes, collaboration in the studio is usually weak which is in contrast to the laboratory setting studied by Newstetter and Nersessian. The design is accomplished individually and is mostly isolated from peers. Of course, this is rooted not just in the grading system, but also in the individualist lifestyle in everyday socio-cultural life emphasized by the design world. Still, learning processes are negatively affected by this individualism (Dutton, 1987), and such individual learning processes increase resistance to the benefits of situated learning, just like it is in real-world practice.

Petra, Johanna, or Judith's design learning processes could have been considered by Schön (1987) through their 'embodiment and situativity'. Hence their relationships with each other and with others (formal and informal), their reactions to studio rituals (through their artifacts, thoughts, or speeches), the representational tools they use in the design process could have been deconstructed within these human and non-human components' interrelations. This could have helped reach different layers and reveal the existence of different dynamics. With this belief, the future step of the study is to evaluate various studio setting (including real-world studios and virtual studios) within the proposed conceptual model to reach a holistic understanding of studio environment through its cognitive systems. Before starting to explore studio environment, focus group studies are planned to be conducted with studio tutors from different backgrounds and different pedagogical approaches. As a start, a series of pilot design workshops will be conducted to develop data collection instruments in real-world and virtual world settings. Accordingly, a mixed-method study that will include both virtual studio settings' quantitative analysis and qualitative analysis of various studio settings will be designed.

Conclusion

What we know about studio's interwoven social, cultural, material, and temporal aspects and their effects on design learning processes is limited. It is known that the studio environment is usually rich and dynamic but also individualistic and competitive. The use of cognitive artifacts in the studio is usually limited to pre-defined designing activities with specified tools and is dependent on students' individual talent. Since the focus of the design learning research has often been on designing activities, there is not enough insight about the impacts of studio's physical, social, and cultural aspects on designing and learning. Yet, it is seen that students' engagement with the studio's multi-layered environment as an extension of the 'problem-solving processes' is usually limited. Although there are possibilities that a studio can be more integrated into students' design learning processes, the common pedagogical approaches make studio more like a space of transition. When design education researchers begin to understand the architectural design studio as an 'extended problem space', it can be possible to understand the strengths and weaknesses of existing pedagogies. Design education researchers then need to rethink the design tasks being given, the design tools being proposed, the studio processes being planned, and grading methods employed.

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Immersive Learning

From Basic Design for Communication Design: A Theoretical Framework

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In this paper we discuss the two changes that basic design education faced: one is the teaching need of transformation from visual to multisensory and synaesthetic communication; the other is the use of virtual environments to teach design. As an answer to the trend of constructivist learning, also in order to fulfil the need for multisensory training, the discussion of an innovative learning environment for basic design education has become essential. The problems remain, as virtual technology has limitations regarding visualizing abstract concepts. This research aims to build an immersive virtual environment to teach basic design, along with the value of subjective immersive experience for design learning in general. The study presented in this paper proposes a theoretical framework, starting with the redefinition of the concepts of "immersion" and "presence" from a cognitive perspective (Scuri, 2017). The main research method is based on two groups of case studies; through literature review and secondary research, this work categorizes the factors of presence into a three-dimensional framework, also defining the four typologies of immersion and two in-class educational models. The paper presents the results of the research at the first phase, aimed at bridging the gap between design learning and virtual spaces. Through the framework addressed, we are able to frame an actual design tool with the help of online platforms and tools.

Keywords: Immersive learning; Innovative teaching; Basic design; Synaesthesia; Virtual learning environment;

Introduction: The Transformation of Basic Design

The relationship between design education and virtual technology could develop a new integrated system. Design education has always been recognized, and is still always recognized, as highly creative and participatory. The benefits of virtual technology, with immersive simulations and flexibility of virtual dialogue, remain some of the key benefits for interactive and/or by remote didactic. In the twenty-first century, more sensory-involved technologies needed to be addressed by designers who are better equipped, leading to innovation in educational tools and methods.

Basic design, usually referring to the training of abstract design fundamentals (Neves & Duarte, 2015), is both the starting point and the main research objective, not only as it is a fundamental means to teach design capability, but also since it deals with abstract design principles, which leads to broader teaching and learning discussion based on cognitive immersion.

In this section, we discuss the two changes that basic design education faced: one is the teaching need of transformation from visual to multisensory and synaesthetic communication; the other is the use of virtual environments to teach design. Therefore, we are able to hypothesize the concept of immersion (usually provided by virtual learning environments) as an innovative teaching method for design.

The Transformation from Visual to Synaesthetic Communication

Multisensory learning methods, which usually engage the coordination between visual, auditory, kinesthetic, and tactile inputs, appear to achieve a better teaching effect (Chandrasekaran, 2017; Shams & Seitz, 2008). The importance of multisensory integration, which appears both on the expression and cognitive recognition,

meets the educational needs of designers and leads to more comprehensive design products (Chandrasekaran, 2017). The significance of multisensory input is not only that it better develops students' sensory abilities, but also that it allows one to obtain a logical path of synaesthetic translation (Riccò, 2016).
Basic design has made attempts to innovate within-discipline learning, and is constantly innovating its education model. In this context, applying a synaesthetic approach - that is, considering the interactions and links between information from different sensory registers - can be of support to train students not only in visual observation, but in induced perceptual changes from sensations of other modalities.
At the Politecnico di Milano, synaesthetic workshops for visual, audible and taste are studied as components for basic design learning (Anceschi & Riccò, 2000; Riccò, Belluscio & Guerini, 2003; Liu, Calabi & Riccò, 2018). The urgent needs for multisensory and synaesthetic training in design opens the door for the engagement of virtual technology, which involves various amounts of sensory stimuli and the ability of scene simulation. Possible sensory interactions (especially within an virtual environment) seems to be the enter point for innovating design learning, such as engage multiple sensory within an comprehensive environment, to expand the contents and forms of traditional learning activities. The examples can be various, among the recent experiences conducted in basic design in the Italian context, of particular interest the interactive basic design by Cristina Chiappini[1] and the basic design procedures by Lorenzo Bravi[2] which apply programming languages.

Virtual Technologies in Design Learning

As stated above, it is not novel to consider design learning with virtual and digital technology, yet previous efforts should not be ignored. A relevant number of studies understand virtual technology as the new teaching and learning tool for design (Neves & Duarte, 2015; Neves et al., 2016; Calabi, Mottura, Sacco & Vigano', 2003; Liu, 2020). In 2016, Neves and Duarte used VR-based tools to enhance the effectiveness of basic design learning. Students studied and tested basic design topics, demonstrating that virtual tools were effective both for the discussion of the exercise and for exploring abstract structures (Neves, Duarte, Dias & Saraiva, 2017).
In juxtaposition to the common cognition, virtual technology can be effective in both graphic and interior design, rather than being limited to disciplines with high three-dimensional demand such as architecture and product design. Dalgarno and Lee's (2010) research addresses a wide range of learning effectiveness to promote spatial knowledge representation, including experiential learning, contextual learning and collaborative learning. The sense of presence provided by immersive VR assists with spatial visualization to enhance learning outcomes. The simulation of scenes or spatial environments could also be beneficial for problem-based learning, as it could immerse the students in a real design problem. It matters little whether the design problem is concrete or abstract; what remains important is to incorporate the principles under the creative process (Neves, Duarte, Dias & Saraiva, 2017).
It makes sense to discuss basic design education within an VR-based environment, as those technologies have potential to benefit the learning activity by engaging students in perceptual actions and concrete approaches towards abstract objects. New ways of in-class interaction are available, and students may explore design disciplines in a highly interactive and immersive environment. The virtual learning environment (VLE) shows great potential for virtual simulations within architecture and medicine, as well as great potential in art exhibitions. Compared with web-based learning, the possibility of virtual interactivity and a deeper feeling of presence is fundamental when it comes to virtual dialogue.
To sum up, the benefits of teaching basic design with virtual technology include:

- promoting the understanding of abstract knowledge, which remains essential for teaching design principles;
- enhancing the learning outcome by further involving the students thanks to the feeling of presence implicit in VR technology;
- compatibility with innovative teaching methods;
- promoting virtual environments both for in-class interactions and social dialogue.

Immersion as a Subjective Mental Description for Design Learning

It is fundamental to discuss the concept of immersion as the starting point of this research. In 1997, Slater and Wilbur defined the term immersion as "the extent to which the actual system delivers a surrounding

[1] See: https://cristinachiappini.com/category/interactive-basic-design/.

[2] See: https://www.lorenzobravi.com/ftp/basic-iuav/IUAV-reference.pdf.

environment, one which shuts out sensations from the real world". Witmer and Singer later (1998) raise objections to immersion identified as an objective description of VE technology. In short, other factors such as attention, focus, involvement, and engrossment may affect the level of presence from a subjective level. They argue immersion as a "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences". The engagement of immersion (usually through VR tools) has opened a new path for design didactic rather than the old way of learning (de Freitas et al., 2009), yet further efforts should be put into the identification specifically under the subjective perspective.

For design learning, the concept of immersion can be understood from two perspectives. One is to understand immersion as a subjective mental description (Scuri, 2015). Physical immersion is achievable through the characteristics of virtual reality, while mental immersion is a main task of communicative media. The other is from the educational perspective, to understand immersion as an innovative teaching method, that has already been discussed through the studies of medical treatment, military and safety training. Its main approach is not limited to the simulation of a real scene and virtual narrative; instead, it compliments new teaching methods, including experimental learning (De Freitas & Neumann, 2009; Beckem, 2012), conceptual thinking, and multi-perspective information transformation (Scoresby & Shelton, 2011). New educational methods and tools make efforts to consider a multisensory environment rather than individual sensory channels like visual or audible (Haverkamp, 2012).

Therefore, to define the concept of Immersion and Perception for design (Calabi, Chiodo & Scuri, 2015) the definitions of related concepts (immersion and presence) will function as the framework to help with the further analysis through case studies.

Method

Based on related secondary research and literature review, the aim is to develop our own definition of the degree of immersion necessary to understand achieving immersion with cognitive-related factors. In total 94 definitions addressed from 27 related references are analyzed; the list is attached as reference.

Based on the literature, we understand the "degree of immersion" as：

THE DEGREE OF IMMERSION is a mental description of how much people receive cognitive and perceptual transfer of consciousness. This could be enhanced by:

- the addition of sensory modalities including visual, audible and tactile.
- the narrative, which depends on the teaching context to influence emotion.
- full immersion in virtual learning, equal to "mental presence".

The realization of presence, understood as a mental tool to achieve immersion, also requires further definition, especially from the perspective of sensory engagement. We found Heeter's (1992) work most reliable to define the factors, since it is highly referenced within studies of psychology and presence. We visualized the framework into a 3D model, and further explains every factor under the sections of personal, social and environmental.

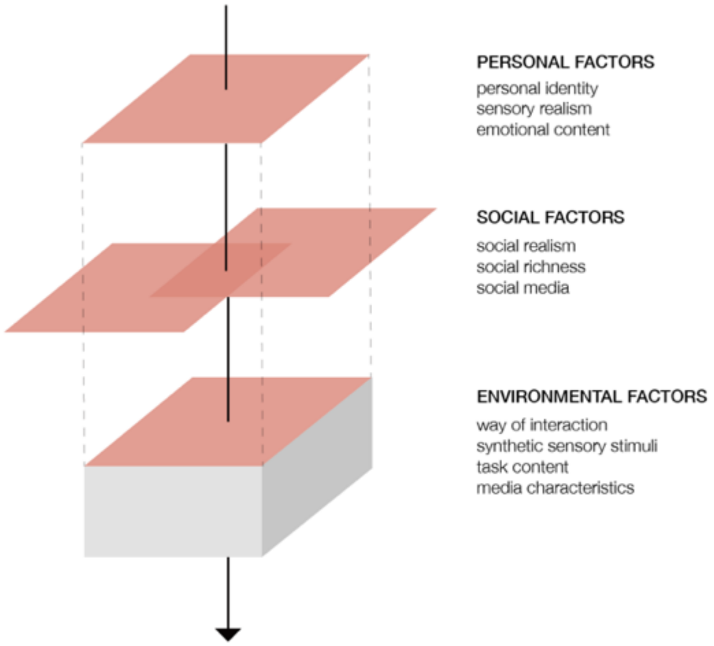

Figure 1. The 3D framework of factors of presence.

Personal factors

a) Personal identity: self-representation within a VLE, such as having a virtual body or entering the virtual world in a perceptual position. There are several evaluations to achieve certain personal identity, including: the sense of being there; the memory of "visiting" a place; and the emotional effect among activity and response to other participants' actions.
b) Sensory realism: the representations of reality in a perceptual system. The so-called reality here is not the fidelity of visual and sound quality, but whether one responds as if sensory data are real. Spatialized sound and kinesthetic references have positive effects on sensory realism.
c) Emotional content: the evocation of emotional factors such as fear, joy, stress etc. Positive factors such as enjoyment increase personal motivation and engagement in learning activities.

Social factors

a) Social realism: The extent to which other players react to participants. Having multiple participants (real or synthetic) appears to enhance the feeling of "being there", under the premise that their existence is natural and will not destroy the current context.
b) Social richness: the extent of daily social simulations within a VLE, including chatting, responding and co-working. Co-working positively affects socialized virtual environments, and it is preferred for educational applications.
c) Social media: the engagement of instant social medias, such as remote control, online communication and remote cooperation.

Environmental factors

a) Way of interaction: The way of interactions between participant and VLEs, including kinesthetic (tactile and proprioceptive sensations), voice control and behavior-response correlations. Natural feedback will enhance the self-identification of participants. The immediacy of control and feedback of participants' mental state appears to be important.
b) Synthetic sensory stimuli: the extent of sensory information which simulates the real world. The real-world refers to complex, perceivable elements, including the proportion of visual and audible predicates, tactile elements, olfactory elements and the fidelity of picture. They usually do not appear in isolation but interplay in a synaesthetic way. The overall combination of sensory stimulation should be focused on design needs, not the realism of actual visual and audible quality.
c) Task content: the task-driven activity been defined towards the learning purpose, normally related to "plot"

line (presenting an alternate self-contained world separate from the real world), storytelling and interactivity.
d) Media characteristic: the media form and content engaged within VLE, such as scene simulation, real-time creation and after-course evaluation.

Case Study 1: Immersive Exhibitions and Interactive Museums

The relationship between design education and virtual technology could develop a new integrated system. Design education has always been recognized, and is still always recognized, as highly creative and participatory. The benefits of virtual technology, with immersive simulations and flexibility of virtual dialogue, remain some of the key benefits for interactive and/or by remote didactic. In the twenty-first century, more sensory-involved technologies needed to be addressed by designers who are better equipped, leading to innovation in educational tools and methods.
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Case selecting and analysis method

The first group of case studies aims to take a look at existing approaches which aim to achieve "presence" through human senses and interactions within the virtual spatial environment. By analyzing immersive exhibitions, we aim to verify the groups of factors necessary to achieve presence, along with the different degrees of immersion. All the cases selected are based on a physical attainable environment, which differs from the virtual immersive environment of online courses and the exclusive use of virtual equipment.
Also, we review the factors of presence previously defined within these case studies; they are shortened as:
- Personal factors: personal identity; sensory realism; emotional content;
- Social factors: social realism; social richness; social media;
- Environmental factors: way of interaction; synthetic sensory stimuli; task content; media characteristic;

We organized the case studies into the following list; most of them are shown in the web-based platform.

Table 1. The list of selected case studies

• Research Group	• Related Project Name	• Research Group	• Related Project Name
• **IKEA**	• IKEA Blue City Dream Room	• Crystal Bridges Museum	• Ideum with Crystal Bridges Museum of American Art
• **Maotik & Fraction**	• DROMOS	• Cleveland Museum of Art	• Cleveland Museum of Art
• **Vedo**	• Vedo	• M9 Museo	• M9 Museo
• **Taste of Sound AB**	• Taste of Sound	• College Football Museum	• Obscure digital
• **Teamlab**	• Teamlab Restaurant	• Uffizi Virtual Experience	• Uffizi
• **Inside magritte**	• Inside magritte	• Museo storico dell'età veneta	• Museo storico dell'età veneta
• **HealthySim;**	• Group of	• Sarah	• Dun Huang

George's University Hospital; Van Gogh show; PARIS || Atelier des Lumières; DREAMED JAPAN	Studies: None-Interactive Immersive Exhibition	Kenderdine	Virtual Exhibition
• **The Cooper Hewitt Smithsonian Design Museum**	• WALLPAPER	• Tetrachromia	• Bird Vision
• **Sonos Studio SXSW**	• Playground	• Piet Mondrian Universale	• Piet Mondrian Universale
• **Ideum with National Cowgirl Museum and Hall of Fame**	• Western Design Room	• Anna Muksunova; Vadim Goncharov; Igor Yakovenko;	• Subtle States
• **San Francisco Digital Art**	• San Francisco Digital Art	• Dotdotdot	• VENCHI
• **MGM Cotai plaza**	• You Are Art	• Belle & Wissell	• Space Needle Skypad

Discussion: Typologies of Immersion within Immersive Experience

In general, we can recognize three types of interactions: "passive", "interactive" and "contributive". These categories illustrate the basic relationship between the human and synthetic environment: from a passive acceptance of structured information to a contributive approach that generates a new flow of information. This classification is further addressed and refined through the case studies.
Within this analysis, the identified four types of immersive environments are: passive sensory immersion; exploration-based immersion; knowledge-based immersion; user-contributed immersion. We selected 24 case studies under the categories identified to verify the degree of immersion.

Table 2. Types of immersion and the related case studies

• Type of immersion	• List of case study
• **Passive sensory immersion**	• Dromos; Vedo; Inside Magritte; Ikea blue city dream room; Teamlab restaurant; Taste of sound; Group of study: None-interactive immersion;
• **Exploration-based immersion**	• Wallpaper; Playground; Cleveland Museum of Art; Western design room; Crystal Bridges Museum; San Francisco Digital Art;
• **Knowledge-based immersion**	• College football museum; UFFIZI; Museo storico dell'età veneta; Dun Huang virtual exhibition; M9 Museo; Piet Mondrian Universale; Bird Vision;
• **User-contributed immersion**	• Venchi; Space Needle Skypad; You are art; Subtle states;

The factors of presence within are revised in the following table. Among them, passive immersion contains the fewest immersive elements, especially within personal and social factors. Personal identity does not appear in both passive sensory immersion and exploration-based immersion, nor does the social richness and social media function appear much within passive sensory immersion. Knowledge-based immersion and user-contributed immersion include all types of factors and verify through different needs. Based on the definition of “degree of immersion”, we compare the factors related to sensory modalities and narrative components, including “sensory realism”, “emotional content” and “synthetic sensory stimuli”. By analyzing the effects and proportion of immersion, we therefore hypothesize that passive sensory immersion has the highest immersive experience paradoxically, while user-contributed immersion has the lowest level of immersion. As the most comprehensive environment involves all kinds of activities, knowledge-based immersion and exploration-based immersion are difficult to distinguish; we therefore place them in a parallel position. Their levels of immersion depend on several aspects, including: the natural response of human-computer interaction; the agreement between sensory design and the theme of activity; and the design of the task and the skill of narrative.

Table 3. The table shows the “factors of presence” existing within four types of immersion

Type of immersion	Factors of presence									
	Personal factors			Social factors			Environmental factors			
	personal identity	sensory realism	emotional content	social realism	social richness	social media	way of interaction	synthetic sensory stimuli	task content	media characteristics
Passive sensory immersion		✓	✓	✓			✓	✓		
Exploration-based immersion		✓	✓	✓	✓	✓	✓	✓	✓	✓
Knowledge-based immersion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
User-contributed immersion	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

We further explain every type of immersion and their features and usability.

Case selecting and analysis method

The passive sensory immersion emphasizes the passive reception of sensory simulation. Participants within the virtual environment have a lower degree of manipulation, but a higher level of passive receiving. Most of the exhibitions use passive sensory immersion to provide an emotional “tour” and a unique sensory experience.
In this kind of immersive experience, social interactions are very limited, and we understand them as not essential to achieve immersion. Both direct and indirect (not with body movement but physical tools) interactions are designed to fulfill specific goals. There are two patterns to enjoy the sensory performance: audible-visual passive receiving and partly interactive props engagement. The second pattern could provide some tactile supplements and simulate a more realistic environment that is similar to real life.
It is possible to identify three specific objectives which passive sensory immersion aims to reach:
1. to create a specific feeling or atmosphere.
2. to support a virtual narrative and convey information (differing from traditional learning materials such as a desktop).
3. to optimize synaesthetic experience, such as sound to taste and visual to taste.

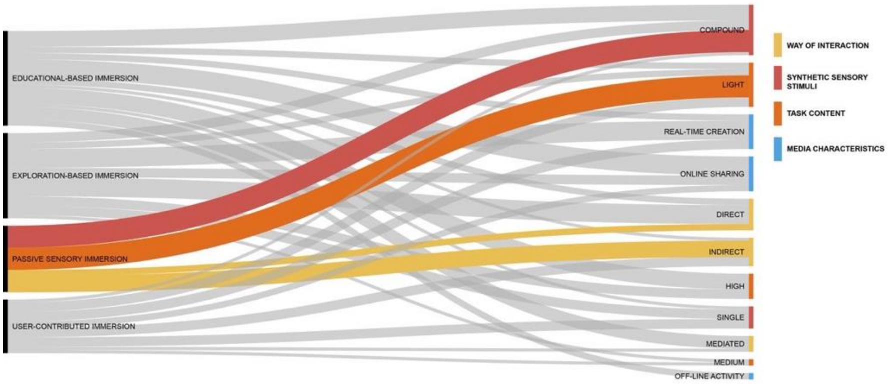

Figure 2. Relations between passive sensory immersion and the factors of presence (take environmental factors as an example)

Exploration-based immersion

Exploration-based immersion sees frequent use within art and design museums. It has been revitalized within interactive exhibitions. Through a certain level of interaction, some museums aim to simply provide a delightful experience or convey light messages. Within these studies, the message given is not rigid; rather, the vague content aims to create certain cognitive involvement. Participants can also achieve immersion through physical interaction. What makes exploration-based immersion special is the way in which it achieves immersion through interactive activities, which is significantly different from passive sensory immersion.
Social factors are at the center of exploration-based immersive environments. Multiple visitors are encouraged to participate since co-working and social communication are important to art creation. Compared with passive interaction, the ways in which participants communicate and explore content are much more enriched. The size of the physical environment (space) is "narrowed" compared with large open spaces, partly because some activities involving educational tasks needs visitors to focus, which means distracting elements require reduction.

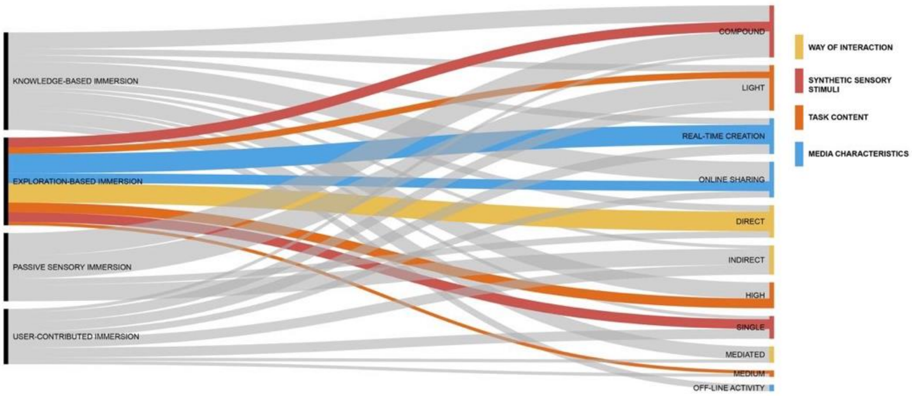

Figure 3. Relations between exploration-based immersion and the factors of presence (take environmental factors as an example)

Knowledge-based immersion

Knowledge-based immersion refers to an immersive experience that is framed by clear themes and aims to transfer information and knowledge. The expression "knowledge-based" can also be conveyed as "education-based" or "information-based". Most case studies have a clear identification of educational themes supported by a wealth of immersive tools and interactive methods. Personal identity appears in knowledge-based immersion in the form of both first-person and third-person perspectives.
This kind of immersion encourages comprehensive social environments wherein participants can interact and co-work within the same space. Moreover, since the dissemination of knowledge requires media assistance, venue resources are also fully utilized. Socialization has reached the highest level, as the open place supports almost every kind of social communication. As to the way of interaction, it is preferrable to call participants "players", as playful content seems to optimize the experience. The designers use bodily interactions to both

enhance immersion and fulfill specific tasks.

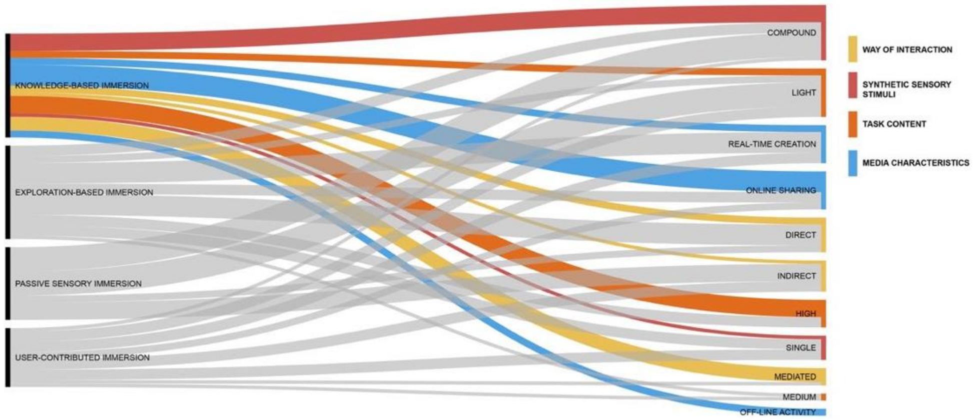

Figure 4. Relations between knowledge-based immersion and the factors of presence (take environmental factors as an example)

User-contributed immersion

Within user-contributed immersion, information is constituted by users, and the display engaged is only for organizing, analyzing or displaying. The performance of participants reaches the highest level among the four types of immersion, since user behavior is the main component, and real-time response is key to supporting this kind of activity.

Mediated and indirect interactions are preferred within user-contributed immersion. Real-time response is the key to directly involving participants by having them form the experience in near totality. Concerning the media characteristics, real-time media translation creates conversation between content and participant. User-contributed content includes subjective expression, tasting, body movement and virtual personal data.

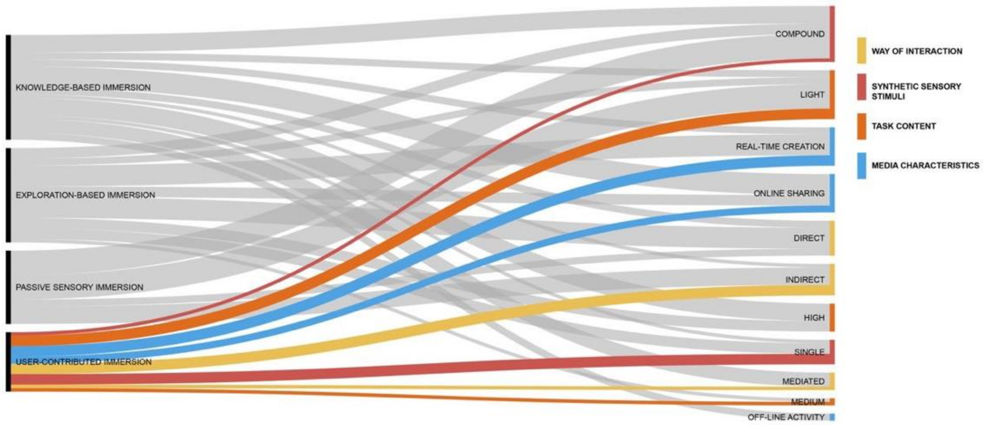

Figure 5. Relations between user-contributed immersion and the factors of presence (take environmental factors as an example)

Case Study 2: Educational Activities Within VLEs

Case selecting and analysis method

Case selecting

After identifying the typology within immersive environments, we further study associated educational practices that benefit from immersive learning. What differs from the case study 1 is our attention towards the course structure and task. We focus on analyzing the formulation of applicable tasks and three ways of interacting (Moore, 1989) as a means to provide support for course design. The field of selection contains desk research from scientific databases including Google Scholar, Semantic Scholar, Scopus and Web of Science from 2009-2020 (last 10 years); video/image materials; and personal interviews.

To conduct a more systematic and scientific research, we go through a careful case selection process starting from identifying the keywords through databases. We define the main keywords as “immersive learning environment” and “education”; however the keyword “immersive learning environment” is quite general and it contains other technologies such as VR, AR, and online learning projects. We therefore replace the keyword with “CAVE” (Cave Automatic Virtual Environment), which is a very typical and widely applicated VLE. We also consider the keyword “education” to be congruent with “teaching” and “learning”.
We found, in total, 80 related papers to further consider. We reduced the amounts of papers related to the content, considering the degree of perfection of the teaching process and the depth of discussion on immersive factors. Finally, we identified 14 best practices following the following selecting roles:
1. the purpose of the study is to fulfill an educational task, or the experimental process is educational;
2. the process of the research is well observed and recorded (through scientific description or supported materials), to better cover the three features of virtual reality and provide enough detail for the analysis;
3. the curriculum/ training is fully designed to exert the potential of an immersive learning environment.
The final list of case study 2 is as below:

Table 4. The list of case study 2 selected from scientific papers and web-based platforms

Research Group	Reference
Kyan, M., et al.	Kyan, M., et al. (2015). An approach to ballet dance training through ms kinect and visualization in a cave virtual reality environment. ACM Transactions on Intelligent Systems and Technology (TIST), 6(2), 1-37.
Collins, K., & Borowski, K.	Collins, K., & Borowski, K. (2018, August). Experimental Game Interactions in a Cave Automatic Virtual Environment. In 2018 IEEE Games, Entertainment, Media Conference (GEM) (pp. 1-9). IEEE.
Voto, D., Viñas, L. M., & D’Auria, L.	Voto, D., Viñas, L. M., & D’Auria, L. (2005). Multisensory interactive installation. Sound and Computing, 5, 24-26.
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the Institute of Technical Education (ITE)	https://www.eonreality.com/portfolio-items/virtual-technology-training/
EON Reality	https://www.eonreality.com/portfolio-items/virtual-anatomy-simulation/?portfolioCats=609
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Formula D Interactive; Frost Museum of Science in Miami	https://www.formula-d.com/projects/virtual-everglades-tunnel/
Laia Cabrera; Isabelle Duverger	https://www.laiacabreraco.com/illusion

Analysis method
The method of analysis is addressed on the basis of three basic aspects of VR, stemming from the research of Burdea and Coiffet (2003), detailing "immersion", "interaction" and "imagination", also inspired by the constructivist approach by Huang, Rauch and Liaw (2010). The details are adjusted according to the needs of studying design-related, course-related elements, including synaesthetic approaches.
The analysis method contains several areas of focus:
1. a focus on the sensory engagement, especially with concern to how audible/visual/tactile contents are used to achieve specific teaching effects, and the combinations within (synaesthesia approach) to achieve immersion;
2. a focus on the modes of interaction through "learner-instructor-content";
3. a focus on the course framework and assessment.

Discussions: Typologies of Immersive Learning Within VLE

In this section, we discuss the two changes that basic design education faced: one is the teaching need of transformation from visual to multisensory and synaesthetic communication; the other is the use of virtual environments to teach design. Therefore, we are able to hypothesize the concept of immersion (usually provided by virtual learning environments) as an innovative teaching method for design.

Behavior correction

The model of behavior correction passes out functional knowledge mapped into relevant interactions such as providing supplementary action guidance or giving correct answers. The behavior correction educational model has clear training goals, such as dance training, problem solving under specific scenes, or remembering certain knowledge (theory or application).
Two sub-categories are classified: motion correction and info/knowledge correction. Motion correction focuses on rectifying movements and behaviors, usually equipped with a virtual teacher to demonstrate correct behavior. The info/knowledge based model will give the correct answers and verify them with pre-set questions. The expression of "correct" does not always refer to a certain answer, but instead it also includes the correction of cognition and the understanding of specific concepts.

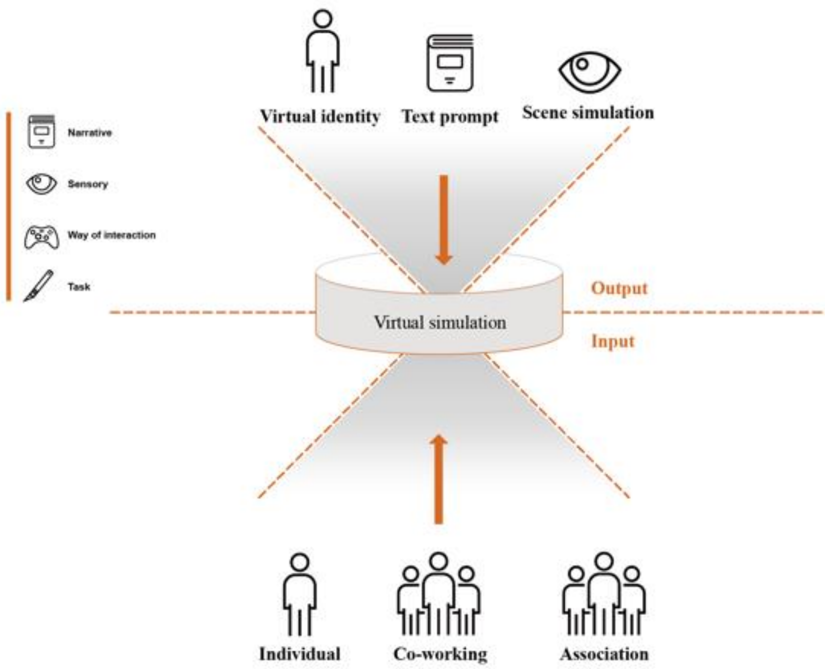

Figure 6. The model of behavior correction for virtual simulation, wherein, both individual and group participation are allowed

As shown in Figure 6.1, within the behavior correction model, human-environmental interactions remain

simple. Three types of participations are engaged: individual work, co-working and association. Co-working means multiple users working together for a common decision or discussion facing the same problem. Association specifically refers to family engagement for children's educational activities, such as parental escort or guidance from guardian.
Virtual simulation is mostly framed as a pre-set scene with sensory engagement, wherein virtual content largely depends on the progress of task completion, not the performance of participants. Three main types of reflection are given:
1) text prompt: the text to guide the student's behavior;
2) virtual identity: including the virtual teacher which could provide correct action instructions; or virtual identity such as an avatar; or virtual co-workers to create a certain working scene;
3) scene simulation: the scene like behavioral guidance (e.g. animation and demonstration).

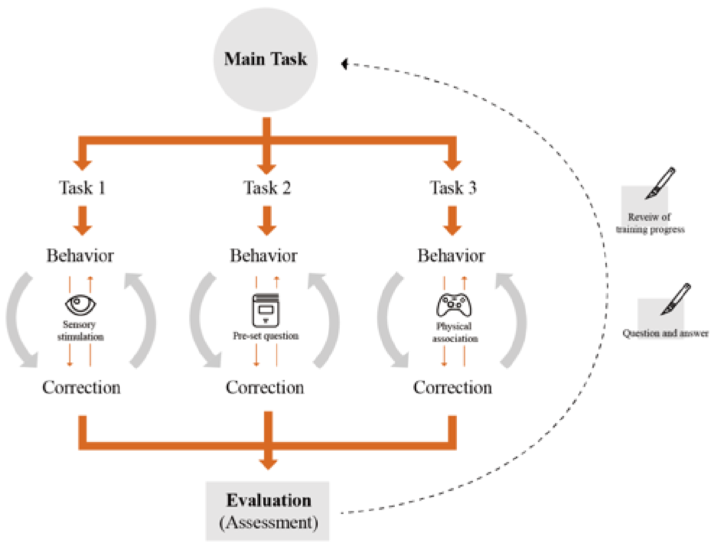

Figure 7. The model of behavior correction between task and evaluation

For the behavior correction model, the teaching process is mainly guided by groups of tasks in parallel. Rich teaching content is implemented by laying out a knowledge framework, setting after-class questions, and adjusting according to students' feedback. These tasks largely depend on the course designer (usually the teacher), not the activity or ability of the students.
Normally, the study identifies one main task and then splits it into several groups of specific tasks. Missions are given such as "guarantee your team's safety", and the program simulates different scenes of weather situations to imitate varying and unexpected situations.
Three types of reflection are provided to value the behavior of participants:
1) sensory simulation: certain visual or sound simulation for correction, such as red lights or sound prompts during mis-operation;
2) pre-set questions: to evaluate the effectiveness of the work through provided questions, which can appear during progress or at the end of an activity.
3) physical association: the indication from member or teacher.
Generally, the tasks within educational activities present a linear state; that is, one task corresponds to one answer. Sometimes, the content of the course is adjustable according to the results of evaluation, which also depends largely on the assistance and role of a "teacher". The evaluation (assessment) process can be fulfilled by reviewing training progress, or by question and answer in the form of text prompt.

Free exploration

The free exploration model refers to learning that happens naturally during the exploration of the virtual environment. This approach focuses more on the experience and fun during the learning process. Normally, free exploration happens within an open space, while the program provides virtual sensory content including visual, auditory and textile stimulations using interactive formats. The participants are usually divided in

groups wherein open social communication is welcomed.
The interaction between the participants and environment could be understood as a circle, as there is no clear directionality between the participants and virtual contents. These interactions exist not only between learner and content, but also between participants. They are able to fulfill the tasks through physical movements thanks to motion tracking or physical tools. The output from the virtual simulation remains in the area of visual display, while spatial sound and textile stimuli (with the support of gloves) reframe the realism of a certain scene or enhance the emotional experience. Compared with the focus of a certain sense, this usually emphasizes the coordination between senses.

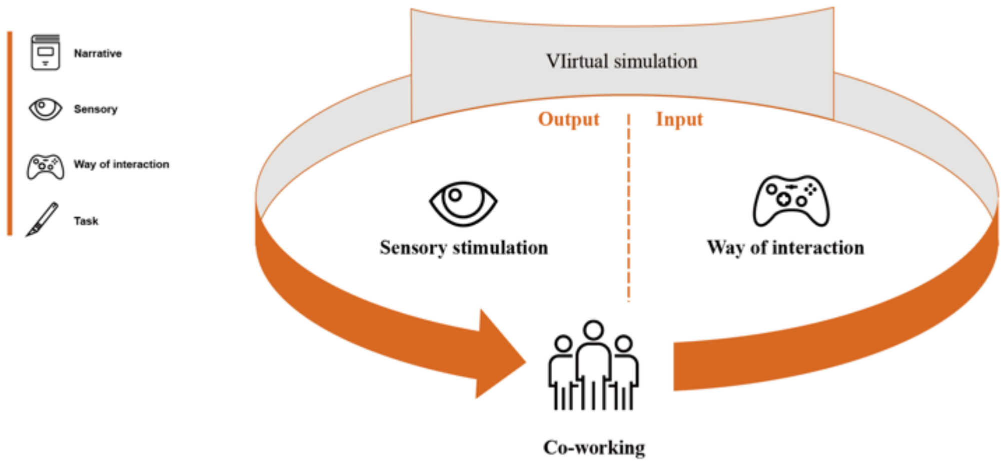

Figure 8. The model of free exploration for virtual simulation, wherein, sensory simulation and interaction are the two essential ways to create virtual simulation

Free exploration often appears in educational exhibitions under a broad premise, wherein certain themes might involve enjoying nature, exploring statues, or conducting art exploration. The themes identified can be understood as main tasks, and there is a triangle framework involving the “main task”, “behavior” and “reflection”, as shown in Figure 6.4. Unlike the behavior correction model, the participant's behavior affects the virtual content, and even makes new contributions continuously. Virtual contents are first provided under the form of sensory simulation, background story and physical association, and participants act on content through body interactions. Reflections from participants act on the virtual content through sensory input and scene, while the main task transmits into the participants’ attribution.

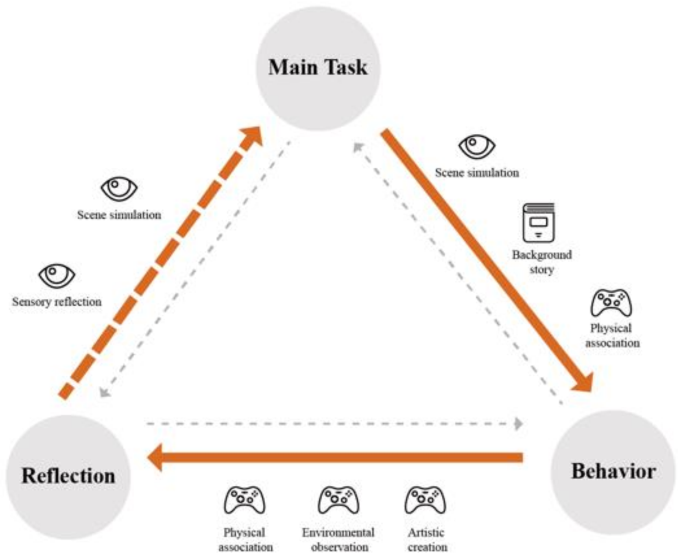

Figure 9. The model of free exploration between task and evaluation

The knowledge spreads in a softer way compared with behavior correction models. Indeed, during the experience, participants need not remember or evaluate much knowledge. This form of learning allows a wider range of interactions and sensory engagement, and more possibilities for social communication. This method is more suitable for comprehensive experience activities, while behavior correction models can play a role in specific knowledge dissemination and acquisition.

Conclusion

The relationship between design education and virtual technology could develop a new integrated system. We consider the technological involvement of virtual tools based on the demands of sensory training, which has been studied for decades, yet the teaching tools still rely heavily on traditional methods. In the twenty-first century, more sensory-involved technologies needed to be addressed by designers who are better equipped, leading to innovation in educational tools and spaces.

Instead of focusing on the technically driven parts of virtual technology, we focus on the experience provided by virtual reality: the feeling of immersion. Although we discuss CAVE as the existing suitable environment for basic design teaching, any virtual tool that provides immersion - even online platforms - could be an effective platform for learning activities.

This research understands the experience of immersion on the cognitive level and further explores the content under sensory engagement and virtual narrative. As there is extremely limited research into design learning alongside virtual technology, we believe it essential to conduct theoretical investigations with a basic and solid method. Therefore, two groups of case studies are driven for the theoretical support for the framework proposed to achieve immersion for instructors.

The first group of case studies includes 24 spatial virtual exhibitions, while the second group of case studies includes 14 scientific learning approaches. Four typologies of immersion (passive sensory; exploration-based; knowledge-based; user-contributed) are categorized, and related factors of presence are addressed to support achieving different types and degrees of immersion. Two in-class models are presented: behavior correction and free exploration.

For the second phase of applying this framework, we consider several general research plans. The most reliable one is to discuss what kind of sensory interactions are adaptable within a CAVE-like learning field, and how to claim the current framework for immersive learning.

We understand this approach as the starting point to design an actual usable tool for instructors to teach basic design with immersion. Course structures and interactive formats can be adapted straightly by the engagement of web-based tool. We consider this part of the research as the second path. Since the content of basic design is also innovating and constantly producing new knowledge, this subject is also constantly evolving and requires constant exploration.

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Teaching with Virtual Simulation: Is It Helpful?

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A growing number of construction-related virtual simulations demonstrate the benefits of providing students with a realistic and interactive learning experience to help them develop knowledge applicable to real-world situations. Virtual simulation provides a new form of teaching for physical experiments with high complexity, safety hazards, and excessive space. This study examined a course on the construction of Chinese traditional wood architecture for students majoring in architecture and related subjects. An experimental teaching platform with virtual simulation was utilized to respond to challenges of physical experiments. A questionnaire was administered to 74 undergraduate students and three teachers, and interviews were conducted with a subset of the participants. The results revealed that virtual simulation was helpful for students and teachers. This case study highlighted the potential of experimentation in the learning process through new technologies and reflected on whether the application of new technology was helpful to students majoring in architecture design.

Keywords: virtual simulation; Chinese traditional wood architecture; interactive learning; undergraduate curriculum

Introduction

In recent years, significant growth has occurred in the development of special-purpose applications for education, including the implementation of virtual simulation (VS) and virtual reality (VR) (Hao et al., 2017). Prototypes and applications developed to date target various types of users, such as children, undergraduate students, postgraduate students, and students with cognitive or physical impairments, and cover a wide variety of training programs, such as pilot training, industrial production training, cognitive skills, and pedagogical targets, such as arts, study of historical sites, and development of real life skills.

Kavanagh et al. (2017) conducted a meta-analysis of 99 papers with various educational applications, and found that 51% were intended for implementation in higher education. VR and VS experiments can fully use the virtual space to simulate complex objects as well as ancient experimental operation methods, allowing students to learn easily and safely at low costs (Huang et al., 2020). As such, a growing number of universities are involved in creating virtual worlds for educational purposes (Zhao & Sun, 2017).

Internationally famous online virtual laboratories include the WebLab at the Massachusetts Institute of Technology, the virtual laboratory at Carnegie Mellon University, the virtual chemistry laboratory at Oxford University, the Material Science and Engineering Virtual Simulation Experimental Teaching Centre at Tsinghua University, the Chemical Engineering Virtual Simulation Experimental Teaching Centre at Tianjin University, and the Mechanical Virtual Simulation Experimental Teaching Centre at Tongji University (Zhao & Sun, 2017). With the gradually increasing maturity of applications in physics, chemistry, machinery, and other disciplines, architectural education has also begun to implement VS technology.

The construction of Chinese traditional wood architecture (CCTWA) is a fundamental part of the undergraduate curriculum in architecture, landscape architecture, and related disciplines. In the regular teaching process of Chinese traditional architecture, wood structures are regarded as an important factor in space composition, and the analysis and study of wood structures is one of the main ways to explore the concept of space and layout (Hao et al., 2017). This focus helps students obtain an overview of Chinese traditional wood architecture and systematically learn fundamental theories (Wu Lei, 2019).

However, this course contains two major challenges:

1. Traditional teaching of the theoretical aspects of CCTWA focuses excessively on class lectures, with construction methods complex and difficult to understand from drawings (Chu et al., 2020).
2. Traditional teaching of the practical aspects of CCTWA is combined with hardware-based experiments that are restricted due to complexity, limitations, and safety.
    - Complexity – After the Song Dynasty, all dynasties stipulated the height and thickness of various wood materials in detail. It is difficult for students to fully understand the wide variety of timber-frame building components.
    - Limitations – Scale models were developed to preserve this culturally unique architectural technique by allowing student to learn through the process of assembly. Due to the limitations of the school site and the number of mock-ups, only a small number of models can be constructed.
    - Safety – The models are usually large, creating challenges for students' work with them and risking students' safety. Furthermore, wood is vulnerable to fire, creating difficulties for laboratory preservation.

Figure 1. Complexity, limitations, and safety of a traditional CCTWA course.

VS offers a way to overcome the disadvantages of traditional experiments. For instance, Ohio State University utilized VR for graphical simulation of the construction process of the Chinese Dougong (Hao et al., 2017). Texas Health and Science University and National Tsing Hua University conducted manual assembly/disassembly experiments using augmented reality for engineering students (Chu et al., 2020). Tongji University set up a "virtual construction of the Song Dynasty Baoguo Temple" in its school of architecture and urban planning, where the names of components and the building process of the Baoguo Temple were introduced to students through an online VS experiment (Zhao & Sun, 2017). Peking University Archaeological Virtual Simulation Experimental Teaching Centre digitally recorded and displayed cultural relics through VS technology. The Art Experimental Teaching Centre of Sichuan Normal University used VS to teach students how to make a mortise and tenon structure with tools.

However, in general, more effective methods of knowledge transfer and the presentation of wooden structures assembly are still lacking (Chu et al., 2020). Not many VS experiments were offered by architecture departments in Chinese universities, and the content of those that were available generally focused on a specific ancient building rather than the basic structure and construction process, which is difficult for beginners to understand.

VS Experiment Project

VS technology could effectively address the challenges of traditional teaching. This study collaborated with a technology company to develop a VS platform for undergraduate students, aiming to demonstrate the potential of VS in aiding in the teaching of construction techniques. From a general perspective, the discipline of architecture is likely to benefit from technology in the education process. As such, the use of VS in CCTWA courses should not be regarded as a new approach. However, unlike other VS experiments, the present experiment was based on the basic shape and modulus of the Dougong in *Yingzao Fashi* from the Song Dynasty, which is the earliest officially published architectural structure book in China.

Experiment Description

The experiment focused on the study of the Dougong structure. The main characteristic of ancient wooden buildings is the lack of nails, screws, and other hardware parts due to the use of the Dougong. In Chinese, the word "dougong" consists of two parts, "dou" and "gong," denoting the two basic elements of the dougong structure, where "dou" indicates the inverted cap used for support and "gong" refers to the bow-like block used for supporting the load (Hao et al., 2017). The Dougong structure is a compulsory basic knowledge for undergraduate students in almost all architectural colleges and universities in China.

The VS experiment contained three sections:

1. The basic knowledge section, which introduced the basic knowledge and architectural background of each wooden component in detail. Students could drag the monomer in the interface to examine and study from different angles in a 3D view.

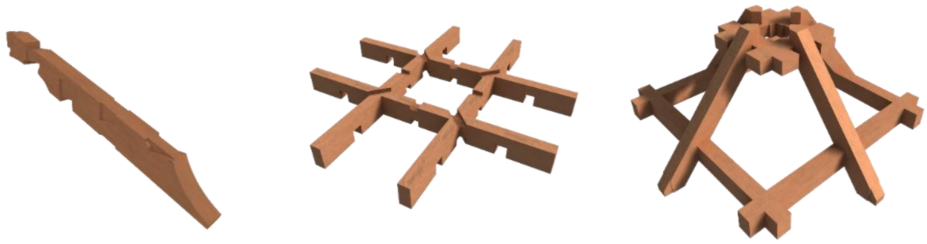

Figure 2. Single part and combined parts of the wooden component.

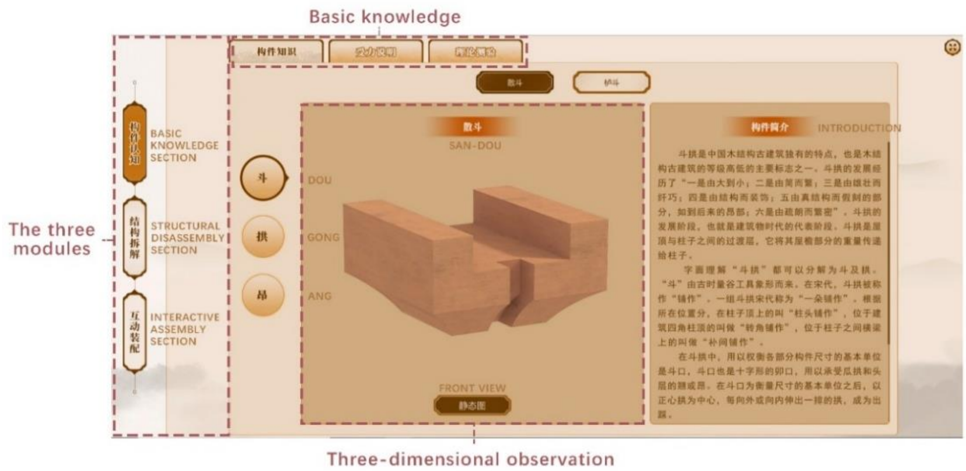

Figure 3. Interface of the basic knowledge section.

2. Structural disassembly section, where several typical wooden structures and detailed videos were displayed to help students fully understand the construction process.

Figure 4. Interface of the structural disassembly section.

3. Interactive assembly section, where students could choose single or combined wooden components

in the system, build wooden frames, and experience the assembly process of wooden structures in VS. The system calculated the time spent in the experiment and gave a score immediately after the experiment was completed.

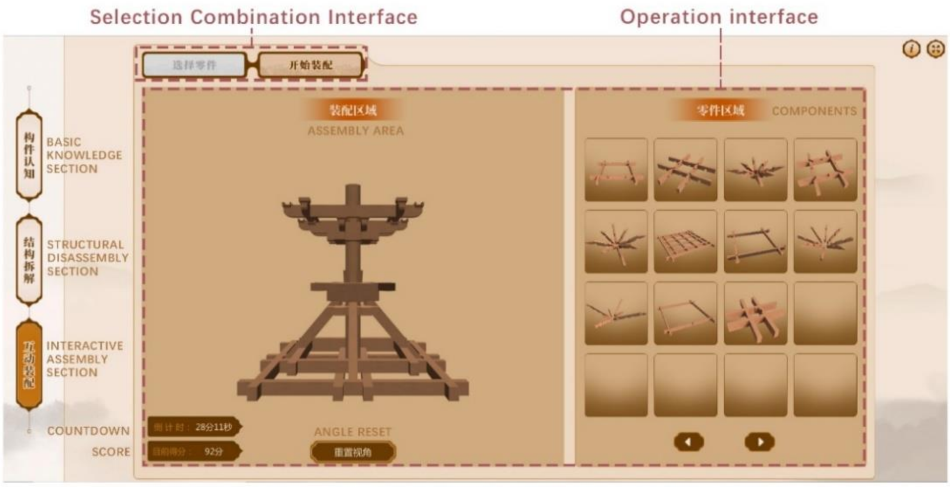

Figure 5. Interface of the assembly section.

The experiment was designed following game-based learning, where students had to complete assessments in each section before they could enter the next section. After completing the experiment, students had to complete a design assignment (small coffee bar or book-store) based on the newly acquired knowledge. Communication between instructor and students was conducted through email.

Data Collection

74 students signed up after the information of the experiment recruitment was sent out. All participants were sophomores of the School of Architecture at Tianjin University with majors in architecture, landscape architecture, and urban and rural planning. The majority of the participants had little or no prior experience with VS. After the students completed the experiment, the teacher side of the experimental platform displayed the experimental time and score for each student. In addition, online questionnaire (including 5 questions about how they feel after the experience) were completed immediately after the experiment is completed in order to document students' first-hand impressions and feelings. With the commitment of privacy and confidentiality of participants, the written informed consents were obtained from all participants through emails. The experimental time and scores of students and non-students, as well as questionnaire results of the students were statistically analysed. In addition, 2 teachers and 2 teaching assistants were interviewed about reflections about this experiment after the teaching process.

Results

A total of 74 students (41 men and 33 women) participated in the experiment and completed the questionnaire. The majority of participants (62.16%) rated the experiment as very interesting and satisfying (Fig. 5).

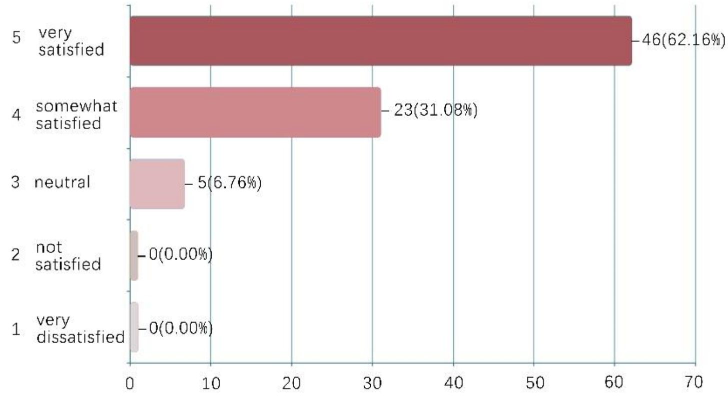

Figure 6. How would you rate your experience with this VS experiment?

In addition, compared with traditional wood structure experiments, most students thought that learning through VS was more rewarding (Fig. 6).

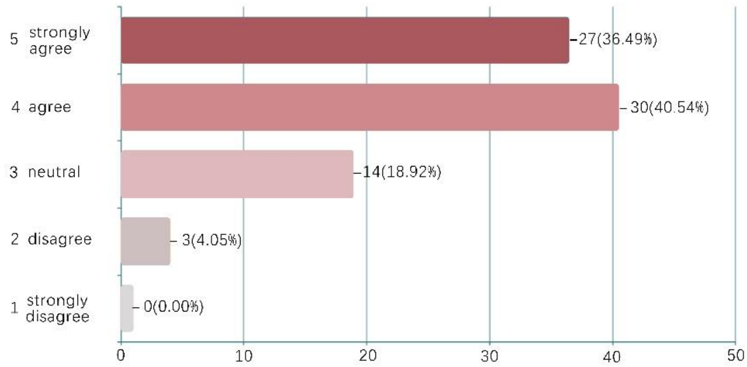

Figure 7. Do you think learning Chinese ancient architecture through VS is rewarding?

Less than half of the students (35.14%) reported little difficulty in getting used to the VS environment and completing the experiment, while more than half (64.87%) expressed some degrees of difficulties for the experiment (Fig. 7).

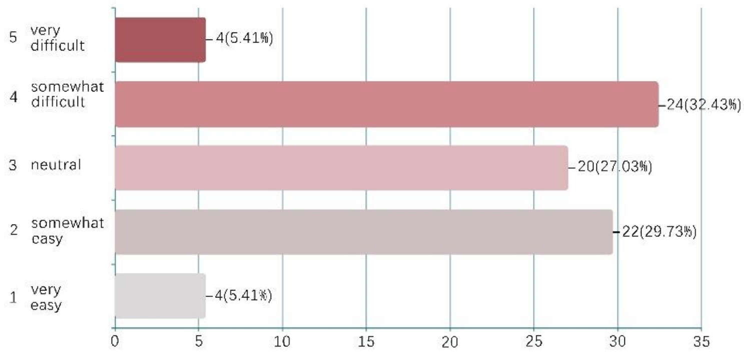

Figure 8. How was your experience in terms of difficulty?

When asked about the most interesting section, more than half of the students (58.11%) indicated the interactive assembly section (Fig. 8). This was the most creative part of the experiment. Students could choose components freely and assemble the Dougong structure. A total of eight experimental results could be assembled.

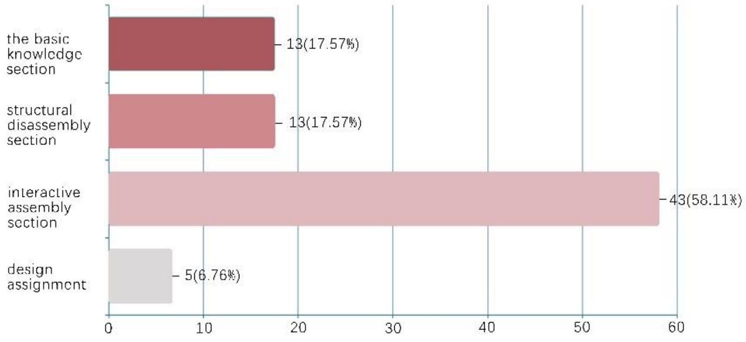

Figure 9. What was the most interesting section?

Although most students were satisfied with the experiment, they indicated necessity of improving all sections of the project (Fig. 9).

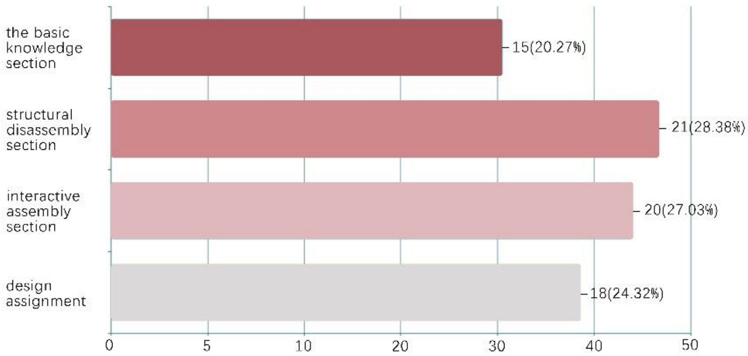

Figure 10. Which section do you think should be firstly improved?

This experiment was open to the public; therefore, people who were not students could also participate in the experiment. The experimental duration and scores of students and non-students were compared. There were no significant differences in scores between these groups, while students spent more time on the experiment (Fig. 10).

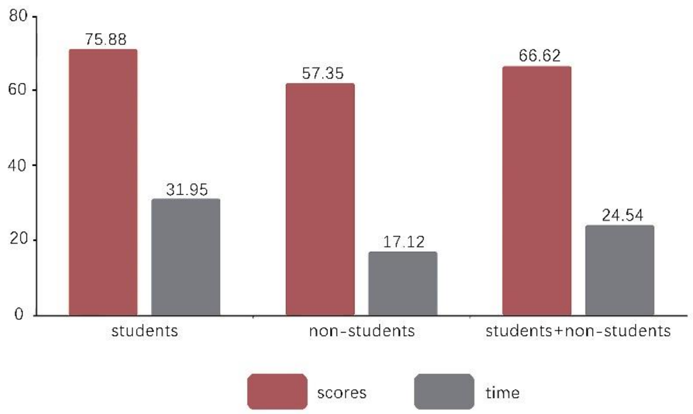

Figure 11. Analysis of experimental data of students and non-students.

Discussion

This study aims to increase the overall student knowledge of Chinese ancient wooden architecture, and evaluate the acceptance and future possibilities of virtual technology in the field of architecture education. In addition to student questionnaires, this study conducted interviews with teachers.

Students

According to the experiment results and feedback collected, students' satisfaction with this experiment was over 90%, while approximately 80% of the students thought this experiment was useful. The participants generally responded well to the experiment, thought it was novel and interesting, and acquired a further understanding of the wisdom of traditional Chinese wooden architecture, which was consistent with previous studies (Sun et al., 2010; Liang et al., 2019).

Students regarded the interactive assembly section as most interesting, indicating that students are eager to acquire knowledge actively in experiments. The traditional teaching of critical thinking can only rely on abstract methods, such as sketches and models. Due to a lack of technical means, large-scale tests and experiments cannot be conducted, and judgments continued to be based on experience (Wu Lei, 2019). However, diversified experimental results enable students to critically consider the best result within their own ability.

Furthermore, the participants suggested improving the interactive communication function of the experiment, in order to increase interaction and feedback during the experiment. As such, the participants considered real-time communication important. This should include communication between teachers and students, as well as among students.

Teachers

The implementation complexity of this VS experiment project exceeded the teachers' expectation; however, the teaching effect was perceived as good, as it helped teachers address the inconveniences of real experiments, including reducing the experimental consumables expenditure, saving cost and space, and providing a safe controlled environment.

The VS experiment required teachers to devote more energy than traditional courses when compiling study guides and recording videos. In addition, it could track and provide feedback on practical teaching effects on students through time, which enabled teachers to improve teaching quality through self-reflection and teaching according to aptitude. Moreover, online learning provided access to high quality education at any time and from any location for both students and teachers. Therefore, this experiment was useful for situations such as the COVID-19pandemic.

Limitations and Future Work

The experimental results of students and non-students were largely the same, indicating that the experiment was suitable for beginners. However, the scores of students and non-students were around the passing line, suggesting that the experiment did not fully account for differences in people’s capacity. Future experiments should include assessments with difficulty gradients. For students with relatively high self-learning capacity, it is challenging to provide improvements matching their desire for new knowledge. As mentioned above, similar VS experiments were set up in several universities (Hao, et al, 2017; Zhao & Sun, 2017). Future projects should consider collaboration to allow students to participate in various types of experiments.

In addition, some students prefer in-person to digital learning (Kavanagh et al., 2017). Some students and teachers may be uncomfortable with the idea of engaging in or delivering a course entirely in a virtual classroom. As the goal of this experimental teaching was to cultivate students’ practical skills, this experiment was a pre-course of practical operation, which could make up for the shortcomings of traditional experimental teaching, and provide more targeted coaching for future offline experiments.

Conclusions

As both students and teachers considered the experiment helpful, teaching CCTWA with VS may provide a new path for the learning of architectural history and design. Experiments with potential safety hazards and challenging space requirements should utilize VS education. VS is an active teaching exploration, which could provide real interaction between students and teachers. It is hoped that this case study will spark a much-needed dialogue in the field of VS experiment teaching and promote discussion on effective applications of VS technology in the field of education.

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Materiality of Space and Time in the Virtual Design Studio

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Digital structures as well as time can be described as crucial material affordances of the virtual design studio space. We question the notion that digital spaces are inherently immaterial and intangible. We challenge the concept of presence and flexibility in the context of the virtual space, and claim that digital infrastructures can be as materially inflexible as physical worlds. Simultaneously we argue for the potential of understanding virtual spaces beyond binary conceptions of presence/absence. We use concepts of practice and materiality to analyse virtual spaces as distributed spatiotemporal structures that can be designed to afford flexibility. We are interested in the design of spatiotemporal spaces that on the one hand provide flexible learning environments and that teach on the other hand this understanding of materiality of virtual structures to its participants.

Keywords: digital; physical; hybrid; flexibility; work

Introduction

Digital collaboration spaces have been praised as opportunities for flexible working and learning. With digital tools, geographical locations can be overcome easily (Bohemia & Harman, 2008). This fact provides flexibility for people who have disabilities, care commitments, or other personal reasons for not being able to attend sites of working and learning either temporally or longer-term. Especially during the recent pandemic, when many learning and work sites were closed, this flexibility enabled a continuation of many activities in geographically distributed ways. However, shared studios being shut created a problem for designers. Physical environments are constitutive of creativity and important factors of learning in design (Gonçalves et al., 2019). The absence of physical meeting and working, with university workshops widely closed for on-site collaborations, has made it difficult to continue the traditional design studios. Design students were unable to meet with their teachers and peers in person, or work on projects that require machines and materials that are typically available at the design studio. Concerns are voiced that the digital space cannot be a substitute for onsite teaching and for the work with 'real' materials.

These sentiments about the virtual studio do not quite capture the quality of virtual structures: neither is there absolute flexibility, nor is there an absence of the real world, in the virtual space. In the dichotomy between the 'digital' and 'physical'/'real' there is a missed opportunity to conceive of the virtual collaboration spaces we inhabit as material structures (Devendorf & Rosner, 2017). We claim that these material structures can be designed to suit the needs of flexibility on the one hand, and can enable material learning on the other.

To help us overcome this binary divide between digital and physical spaces, we explore the concept of *presence* as an affordance of the virtual learning environment. We present our experiences of teaching a virtual design studio at the university. We explore and illustrate the materialities of digital tools and time schedules, which we inadvertently used to structure class. We review our structuring of the virtual class, and respectively the students' resistance against it. We aim to understand how virtual structuring materials can be used to design for people's needs and, in particular, around the concept of creating a flexible space for all participants. We discover time to be a critical material component of the virtual space. The enforced synchronicity of activity, such as live interaction through video, provides a rigid spatiotemporal material that does not allow much flexibility. We argue that understanding presence in the virtual space as a spatiotemporally distributed material condition, allows to design more flexible virtual learning environments.

Simultaneously does this treatment of virtual spaces provide a pedagogical potential to teach students the design of spaces with richer textured materials.

Learning Spaces

The design studio is a part of the curriculum of learning design (Julier, 2017; Tovey, 2015). It is a space for students to engage with their teachers, with their peers, and with the materialities of making. It also allows students to mimic professional design activity (Tovey, 2015, p. 63). Activities in the design studio encompass the design brief, the exploring of materials and of existing uses, the concept, the modelling, the critiquing and the prototyping of design solutions. In the course, where we teach, the design studio also encompasses the exploration of economic viabilities and the embedding of a design within wider networks of production and consumption, such as sustainability or novel business models. Learning in the studio is understood to be practice-based and reflective (Schön, 1983). Important aspects of the design studio are the "studio" itself, as a room that enables interaction as well as individual working, the "design tutorial" as the tutoring interaction between the students and the teachers, the "library", as the store of useful resources that students can draw on, and the "crit", as the critical review and evaluation of presented designs (Tovey, 2015, pp. 63–64). The engagement with materiality is key in design. The "doing and making" foregrounds design skill as an embodied knowledge (Shreeve, 2015, p. 87). The "reflective conversation" with materials enables the moves required to shape these materials (Schön, 1983). This physical engagement in the workshop or the studio is considered to be very important for learning designing. Even in design disciplines that consider themselves to design 'intangible' solutions, such as service design or experience design, the co-location with all stakeholders and the on-site engagement with the topic is considered to be important (Gothelf & Seiden, 2013; Knapp et al., 2016; Stickdorn et al., 2011). The interactions between the teachers, the students, and the materials are the fundamental structures of the design studio. For the virtual design studio, which has popped up ubiquitously during the recent pandemic, this centralises the question of what the 'structures' of learning environments—the interactions and the materials—are made of.

Embodied Learning

Virtual studios currently serve as platforms of interaction between teachers and students. However, embodied interaction with each other and with the materials of making is seen to be suffering. It is harder for students to get to the workshops, which are often physically located at the universities and have restricted access. Interactions with teachers are perceived as 'distant'. The guidance in using materials can only be done through, what is perceived as a 'translation', such as video meeting, remote presentation, extra cameras, screensharing, photos, or scans. Teachers cannot 'directly' demonstrate the work with the materials, and neither can they 'directly' guide the students' work and intervene accordingly.

In our course, we aim to teach how to move beyond the studio and how to extend the design space towards the communities who are a part of that space (Botero, 2013). The studio further seeks to get students to extend their own personal spaces and encourages the "getting out of the building", or "GOOB", principle (Gothelf & Seiden, 2013, p. 9). This may serve us as a vantage point when exploring the topic ahead.

We may question what it means to *teach* design and scrutinise the notion of *developing knowledge through embodied engagement*. In this context, the masterclass system has been criticised, which is based on the master-apprentice model of learning (Harman, 2016). Art and design education have traditionally been based on a system where an outstanding master as professor shows their craft to the students (Julier, 2000). However, in our own experience of studying, these professors were largely absent from the daily business of teaching. Instead, the learning spaces were much defined through the biographical story of being part of that particular learning space, and finding one's own professional identity and competences within the materialities of that space (Ghassan & Bohemia, 2015). This challenges the idea that students and teachers must be physically together at all times, in order to provide a space for creative learning. Research into the spatial qualities of the design studio has shown that creative spaces are made of a range of stimuli, activities, atmospheres and interactions that go beyond the teacher-learner relationship (Gonçalves et al., 2019). It is possible to take a more decentred approach to teaching in the virtual studio.

Reality and Material Structures

The matter of the virtual space also invites the question of its relationship with the *real world*. Currently, virtual engagements are perceived as mere translations of physical interactions. These digital translations are seen as representations, and thus as neat workarounds, of the 'real' engagement. However, digital space is more than just a translation or reflection of the 'real' space (Devendorf & Rosner, 2017). Research in digital materiality has shown that information technology is not an immaterial space (Fuchsberger, 2019; Rosner, 2012; Smit et al., 2021; Taylor, 2015). Firstly, the digital space heavily relies on physical materials, if we consider the real restrictions of disk capacities, screen sizes, and battery lives of our devices, or the connections, cables, servers, the data centres, their heat and their air conditioning, that enable our data flows (Dourish, 2017; Taylor, 2015). Digital infrastructures have a very physical presence. Furthermore, virtual collaboration spaces are never digital-only. They are also made of desks that hold the devices we use, cameras and microphones to see and hear other people, chairs that hold the people participating, hands that hold devices, coffee mugs, paper and pens nearby, weather conditions that either give us good or bad internet connections, etc. Digital interconnections have real materialities that do have real effects (Dourish, 2017). Secondly, the representational materialities of digital infrastructures create social realities (Dourish, 2017). If we think of the example of the format of database fields, they can either support or restrict non-binary gender identifications, depending on whether they can store binary or multi-character values. Another example of the material effect of virtual data structures are the loss of thousands of Covid-19 test results before they could be processed—many to be assumed positive—due to the limited number of rows an Excel sheet can hold (Hern, 2020).

Information technology is material; virtual structures are real: they have real effects on our lives. To assume that virtual spaces are made of elastic and malleable materials that can create ideal interaction scenarios—perhaps even escaping the unforgiving 'real world'—means to turn a blind eye on the materialities that virtual spaces do have. We are instead invited to perceive the hybridity of our lives. Especially if working from home, we have kitchens nearby, our bedrooms, bathrooms and the people and animals we live with. Our virtual studios demonstrate to us the overlapping spaces of practices and identities – we are being students, teachers, friends, parents, partners simultaneously. In the light of this diversification of everyday practices, we are invited to reassess our ways of teaching, learning, and being, and our designing of learning environments. We take this as an opportunity to explore the materialities of the virtual studio, as part of the real world.

The Politics of Space and Presence

Virtual environments have enabled the flexible *presence* in spaces of working and learning (Bohemia & Harman, 2008). Flexible working and learning can be described as a *presence* that can be adjusted to one's needs. Originally, flexibility in the work place has meant for workers to be able to adjust traditional work hours from 9 to 5 o'clock, to suit other commitments such as parenting, while later it expanded to mean geographical location and also employment status (Erickson et al., 2019). Flexibility in its contemporary form does not only mean a flexible participation of the worker, but also a certain elasticity of the worker-employer relationship that suits the employer and new types of economies (ibid). These flexible working and learning spaces could be scrutinized as to how flexibility is constituted in these spaces.

Spaces can be viewed as territories (Yelavich & Adams, 2014, p. 80). Who is allowed to be present in a space, is determined by the rules and materialities of the space. For example, trains without wheel-chair accessible doors, or pubs without wheel-chair accessible toilets, make it harder for some people to be present in it. Digital structures that normalise working from home, learning from home, and even music concerts from home, have removed participation barriers for people with disabilities in the spaces of working, learning and social interaction (Ryan, 2021). Space has a political component to its design. Space, and the ability to be present in this space, as well as the rules of participation, are constituted through its material structures.

Understanding Spaces Materially

We are interested in understanding the materials of virtual spaces so we may design them flexibly for its participants. We therefore analyse the material ecologies that constitute these presences.

Material ecologies mesh as "artful integrations" to build the material worlds we live in and interact with (Suchman, 1994; Wright, 2011). These material worlds are made up of our homes and infrastructures, our rooms, our routers, our desks, and our devices. They are also made up of video images, sound, still images, and text representations that fill—as digital materials—the interfaces of video, chat, email, and whiteboard applications. These digital materials are the material structures that define our agencies (Haraway, 1991)—what we are able to do—for example, participating in a virtual studio space through speaking, showing something, hearing, learning something etc. Also, temporality is constitutive of space (Schatzki, 2010). The virtual design studio is also defined by time schedules, manifest in time tables and calendar entries. Time schedules define how we are present together as teachers, students, and colleagues.

Our virtual design studio space is made of spatiotemporal infrastructures that including the physical work materials such as rooms, desks and devices, our digital collaboration tools, and our time schedules.

The virtual studio space is also affected by our practices. When working or learning from home, our spatiotemporal structures of the studio space overlap with those of our personal spaces. Our personal infrastructures involve our homes and cohabitants, children, breakfasts, lunches, kitchens, fridges, heating, electricity, Wi-Fi, school pick-ups and drop-offs, shopping, personal calendars, … We have overlapping spaces for multiple practices. Some spaces can easily get reused. The kitchen may now be the place to eat and to work. The home may now be the place to work and to be with the children. Other spaces can get crowded, such as multiple people in the home using the same Wi-Fi connection, or multiple people trying to use the kitchen as places to eat and to work. Or homes simultaneously trying to be playground and office.
Practices intermingle and each practice follows its own organization principles (Gherardi, 2012). The overlapping of practices creates a density of relationships which may be difficult to disentangle. However, practices can be analysed as units that are distinct but interweave. Practices are units of analysis that describe socially understood distinct areas of activity (Shove et al., 2012). Specific to learning, we might understand these as "communities of practice" that demarcate what it means to be a practitioner (Wenger, 2000). Being a designer, as in the example of the virtual design studio, means to participate in the practice of design. In the learning setting, the teachers are understood as experienced designers while the students are novice designers. Even non-professional practices, such as cooking, parenting, home-schooling, are organized around their own aesthetic principles that reinforce how a practice is done and what a competent practitioner looks like (Gherardi, 2012). Social practices as a lens, are helpful in understanding how environments provide participants with the agency to participate.
The lens of *materiality* of digital and physical materials, together with the concept of *practices*, allows us to analyse the space of the virtual design studio. This lens is sensitive to the multiple materials, activities, and principles. We choose this lens to explore *presence* within a space. We use it to understand flexibility, and to design for a flexible presence in the virtual design studio.

The Experience of Being in the Virtual Design Studio

The data we draw on was collected during a research project that investigated materiality in the design studio. We, the authors, co-teach several undergraduate design studio classes, in which we use design as a method of innovation. The curriculum of the three-year undergraduate course comprises of design studio classes with practical working in the intersection of design, economy and society. A typical project outcome involves an innovative design, which could be a product or a service that is economically and socially viable. Being thrown into the situation of remote teaching by necessity rather than by choice during the pandemic, we initially organized our virtual studio very similar to the structure we had created for the design studio class at the university. During the semester we realized that this direct translation of the course syllabus had not worked well in all areas, while some elements translated well. Afterwards we sought to analyse the experience of the virtual-by-necessity design studio, in order to find out in what ways we could design a virtual-by-design design studio that would support flexibility, without compromising but rather exceeding our studio's normal quality.
The syllabus of the design studio IV is organized around practical design projects, comprising of the tasks of researching existing uses and practices, defining aims and objectives, exploring innovative service concepts through prototypes, and designing an object or service for transformative intervention. We gave students the task to design a sustainable clothing solution. We familiarized the students with methods of service design, such as empathy maps (Kalbach, 2016), story mapping (Patton, 2014), and crazy eights (Knapp et al., 2016). In particular, story mapping was introduced to them as a useful tool for creating an overview, the "whole picture" and a "mutual understanding" of the situation (Patton, 2014). Guest designers from the practice of service and UX design (user experience design) joined us for workshops and talks in order to bring practice-oriented knowledge to the class setting. They showed us how they use mapping in their practices, and techniques for identifying opportunities within these maps.

Tools

We were meeting online on the Microsoft Teams and Zoom app, using the video, microphone and chat. Each participant in this digital meeting had a video feed showing up in the interface as tiles next and underneath each other, and an audio feed with potentially overlapping sounds. Our own digital presence was defined by a video image of ourselves, and by the fact that we could see and hear other people's video and audio feeds. Students liked to turn their cameras off. Frequently, we discussed that it was a better experience if everyone turned their camera on. It would create the experience of a mutual space, was our idea. We often switched to Zoom, because Zoom had the feature of showing up to 25 tiles per screen, while Teams could at that point only show a maximum of nine. The disadvantage of Zoom was that chats and files, that were shared, weren't stored, and that any structures set up for the meeting duration, such as break-out rooms, were gone afterwards. It was also not possible to move between rooms, unlike Teams which had permanent “channels” that could be accessed, and that had the ability to store chats and files. We further used Miro, a digital collaboration space with a whiteboard that permitted us to draw, where we created diagrams, uploaded files, links and images.

Rules for Togetherness

We wanted to create a space where we were present together and work together, so we felt it was important to see everyone. There were accepted uses of a disabled camera. There was a shared understanding that during official breaks it was OK to turn the camera off, for example over lunch. And it was possible to explain the disabled camera in other situations, such as being at another site of work, whether physically or virtually, being in transit, being ill in bed, attending to children, helping someone else, or taking pets out on a walk. The microphones we agreed to be off while someone was not speaking. The overlapping sounds, when they happened, were such painful experiences that the practice of turning off the microphone was perfected soon. For meeting and speaking in smaller groups, we used break-out rooms where each group had their own conversations. We even experimented with using in parallel Zoom for our large group meeting, and Teams for small group meetings, which allowed a permanent video feed with all participants, while restricting audio to the relevant group meeting only. The idea persisted, that video feeds and seeing each other at all times would reconcile the geographical distance and would encourage a mutual experience.

In Miro, the students were asked to create their personal ‘work desks’ in the virtual space, and they enjoyed creating these desks and decorating them individually. For group work they created group areas. Working in Miro also created a sense of togetherness through the indicator of who is present on the whiteboard. The presence of others in Miro was indicated through the cursors with names attached, and through icons with initials at the top of the screen. This co-presence, manifested through cursors and names, created a togetherness in one’s presence. On the other hand, for the teachers it was also a control mechanism to check who was present and who was absent. This was also perceived by the students, who reacted by signing in, when the teachers asked – “Where is everyone? I can only see 5 people!”. The teachers sometimes even made it a rule that students needed to sign-in before they would begin. The presence of cursors and names was used as a guiding principle that gave a reassuring feeling of being together, and it gave the teachers a handle on the structure of the class.

For us, the teachers, it was also good to know when we were by ourselves. Preparing a Miro board for class felt similar to preparing a room – such as preparing the materials on the tables and on the walls to be ready for when the students arrive. While preparing, it was reassuring to be alone (no other cursors and names visible) and to try out different things before making them ready to be seen and used. Similarly, through the participants list in Teams and Zoom the teachers could determine who was present. In video meetings, when we noticed that we were amongst ourselves, because students were in groups, we used this situation to coordinate our teaching activities and schedules. Presumably also for the students it made a difference, being by themselves or having teachers present. Like teachers, students might have had a close eye on the participant list during video meetings.

The rules about cameras, microphones, sign-ins, etc. turned out to be important control mechanisms of the space, materially creating its design.

A Flexible Space … for Some

Within the vast landscape of possible ways to set up a virtual studio, our studio emerged as the space that is was through the technical configuration, which was largely driven by the rules that we had set up. Setting up the technologies was challenging. For example, using Miro required the teachers to set up the space, get the correct licenses, add the students with their email addresses, and everyone then needed to sign-in, create an account, install the app, and begin learning how to use it. The unfamiliar technologies entailed a steep learning curve for all involved. In the light of these difficulties, the students reflected critically upon the usefulness of the method of story mapping, given the effort and labour it took them to generate it. They felt it was too laborious for the benefit it gave them, and they felt it was too big a task for the time that was allocated to the design studio.

We set out using the same time table which we had originally created for the studio, if it had taken place physically at the university, which was 11 days distributed over the semester with set start and end times. This schedule was made up of two studio classes, one focused on the teaching of the techniques of service design, and the other one on the practical applicability of service design. We, the teachers, began to shift around the start and end times of classes to accommodate for the ways in which some activities took longer during the virtual studio than we had anticipated. And we also adapted the times to other virtual work meetings that had themselves shifted, presumably due to similar issues. Furthermore, as we, the teachers, working from home, were confronted with our home practices of parenting, sharing infrastructures with cohabitants, and other personal practices, we noticed that these influenced the ways we defined the studio time structure. For example, we kept the lunch time according to our own experiences of how long it would take to prepare it and feed the children. We experienced the necessity of keeping the time structure of the virtual studio flexible, and we used our own experience in order to create this time structure. In effect, the virtual studio usually started at 9 and lasted until about 2pm, 3pm, or 4pm and often longer. Lunch time was around midday and lasted between 30 and 45 minutes.

It soon emerged that our time structure, which we had at first translated directly from the university situation to the virtual situation, and then adapted in a flexible way, did not work for the students. We noticed negative sentiments and fewer and fewer students willing to turn the camera on. Eventually, a group of students approached us and told us that they really struggled. They were exhausted from the studio work, and they did not know 'where' they were – how much work they had left, and what tasks they needed to finish by what time. A studio space had emerged that was fluid, but it was not theirs, at this point, and they struggled to inhabit it.

As a constructive outcome of this emergency meeting, we managed to reorganise the time and task management. We created a map to make all tasks visible. We used the same mapping method which we had given to them as a design tool for the clothing innovation. Together, we created another map—a time planning board—with all activities that we had 'behind' us and that we had 'before' us along a timeline, with an indicator of 'now'. Through this activity we managed to create a shared understanding of the timetable structure and of the tasks that had yet to be done. It created a shared presence. The students participated in the structuring of the space and we thus created a space where we could be present together.

The Design of the Virtual Design studio

Virtual work and learning spaces have materialities, and they mesh with the materialities of our other practices, such as being parents, having pets to look after, or working at multiple sites. The virtual design studio is an opportunity to structure these meshing worlds more flexibly, using as the building materials the technologies and infrastructures we have.

In our virtual studio, we have identified the following practices to be interconnecting with the practice of learning in the virtual design studio space: A) work practices in other spaces both virtual and geographical (for students it is part-time work, for teachers it is other classes or collaborations, often internationally); B) other people's practices that partially share our spaces (sharing devices, infrastructures such as Wi-Fi or rooms, or account logins); C) caring for others such as children, sick, elderly, for ourselves, or for pets.

A virtual-by-design studio allows the participation in all these practices; it is designed to afford a flexible organization and configuration of space. Agency—what we are able to do—is configured through the material ecologies in which we participate (Suchman, 2012). If we view *presence* as a distributed form of being in a space, we are not caught up with the binary understanding of being *there* or *not-there* in a space, and we are able to structure *presence* in more subtly textured ways. We might not need a camera feed to assure that someone is present, and in order to create togetherness. A distributed *presence* allows us as teachers and students to be *present* in the virtual studio while we are also engaged in other practices, and may be *present* elsewhere too. A distributed presence does not need to diminish the quality of our presence and the quality of our learning. We even aim for exceeding the quality of learning in the virtual studio by enabling this materially flexible presence.

Presence in Spatiotemporal Distribution

What is a materially flexible presence? When we, the teachers, responded flexibly to scheduling studio times, lunch break, and end time, this timing was sensitive towards the situation of learning as it unfolded; as some tasks took longer. And it was sensitive to our other commitments as teaching employees of the university with multiple classes and responsibilities. And we were able to even adapt it towards our commitments as parents. The live video worked well for us teachers, because we were able to define the temporal structure of the day. However, it made the studio space inflexible towards the needs of others. We had intended to create an experience of togetherness through the live video, which we lacked at the time. But despite our geographically distributed locations, the temporal structure enforced a 'centralised' presence of everyone at the same point in time and space. The spatiotemporal structure of the space was not very flexible. The students responded by turning off the cameras as soon as they could. They sought to regain some agency over their space – withdraw from the control that it entailed. They sought to regain agency over *where* they *were*. Their experience of presence in the studio depended on the spatiotemporal structure that had been created by the teachers. And this structure was unpredictable; it was flexible towards the constraints that arose in the teachers' practices, and thus it was inflexible and ad-hoc for the students.

'Being' somewhere is organized through the material affordances that a space gives (Gibson, 2015). Presence arises in the interaction with spaces (Suchman, 2007). We are interested in creating a virtual space that enables a flexible presence for students. The advantage of the virtual space over the physical university situation is, that a virtual space enables a spatiotemporally flexible presence, in which students can be present in distributed ways, so they can experience the learning activities through their own structuring input. Students can distribute their presence across their practices as they need to, if, for example, another class starts in 5 minutes in another city, a child needs attention, or the washing machine might be beeping, a lunch needs to be cooked, or a prescription medicine fetched from the pharmacy.

The virtual design studio facilitates activities of learning design. As the teachers of a virtual design studio, it is our responsibility to organize and structure this space well – to *design* this space well. As much as we *teach design*, we *do design*, when we create the learning space for our students. We have experienced a learning curve. In this paper we reflect on the experiences we have had. Our aim is to design the ideal virtual design studio that provides flexibility to its participants. The distributed view on the virtual studio provides a richly textured material to design this space. Simultaneously as students can be provided with the experience of participating in the virtual studio, they can also learn from adopting this view on virtual structures and how they organize and structure them well for themselves.

The Materials of Spatiotemporal Distribution

Interactions in the virtual space are grounded on the interfaces of the digital tools. These are made of *text* (read about one another and their work), *image* (see one another and their work), *sound* (hear one another), and *video* (seeing and hearing one another). Some materials can be *edited*, and some cannot. Interacting with these materials synchronously, during the same point in time, adds another material layer on them. Synchronous interactions in the virtual space are the least flexible, because they tie actions to specific points in space and time. Especially live video enforces a fixed spatiotemporal structure where interaction is temporally fixed in space. This means that *time* is a significant aspect in the virtual design studio. If text, images, sound or video can be interacted with independently from points in time—asynchronously—they can afford more flexibility. Asynchronous interactions can be spatiotemporally structured around other practices, and provide therefore more agency on behalf of participants.

Designing the Spatiotemporally Distributed Design Studio

Affordances—what actions are possible—emerge between a person and their surroundings (Gibson, 2015). "Signifiers" indicate the possible functions of a space (Norman, 2013). On the one hand, it is necessary to design the structure of the virtual space and the teaching interactions. On the other hand, the signifiers of interactions—what needs to be done, by when, and how—needs to be given. The students responded well to the map of our schedule that we created after our emergency meeting. It gave them a timeline of activities and indicated clearly where we were. Signifying structures such as these could be created in more detail, and relevant to each task. Here would be the opportunity to indicate whether a task can be completed in someone's own time or at a specific point in time.

The virtual studio landscape and its affordances—possible interactions—need to be signified clearly. This provides participants with orientation and a sense of *where* they are, giving them an experience of *presence* in a mutual space. Signifiers can indicate the possibilities of different interactions. The virtual studio designed in this way—designed for a virtual presence—would provide participants with the flexibility to organize their practices around these structures effectively.

When designing for spatiotemporal flexibility in the design studio, it is important to consider the key learning activities: To reference again the pillars of the design studio, it is necessary to design the "studio" as a space, and also the interactions such as the "design tutorial" – the guiding interaction between teacher and student, the "library" as the pool of resources, as well as the "crit" – the critical review on the student's work.

A design presentation – does it require a live video interaction? Probably yes, due to the exchange and the feedback through which these presentations become alive. Furthermore, these presentations provide a training opportunity for publicly presenting and pitching one's work. But it is possible to appoint particular times when these events take place, so it is possible to organize *around* it. A design tutorial – does this require a live interaction? If yes, does it always and with everyone? It might not be necessary for everyone to meet at the same time. Videos and text tutorials that can be accessed asynchronously for a period of time may work just as well. Asynchronous content allows a structuring of tasks by the students themselves, perhaps even organizing their own small work groups. Providing a tutorial as a live event does enforce a presence at a particular time, but it does not ensure that everyone participates. Providing a tutorial to be accessible in one's own time, allows more flexibility and thus maximises the opportunities for successful engagement with the learning material. Spatiotemporal flexibility increases the quality of the design studio.

Togetherness was an important factor in our experience of the virtual design studio. Togetherness is enabled through the material affordances of the studio space. Activities that we do together as a studio class do not need to overlap temporally at all times. Text, image, or video content about the activities we undertake together, can give a material scaffolding to mutual activities, so that togetherness can be experienced in an asynchronous, open way.

There is much practical work to done in designing better virtual design studio spaces. Consideration needs to be given to each interaction. Above we touch on some of these considerations. Time shows to be a strong means of structuring. It is a material of design and it can be used selectively to maximize both learning quality and flexibility.

As teachers and designers of virtual studios, we can use these virtual materials to design for spatiotemporal flexibility in learning interaction. Creativity and personal creative development in higher education are encouraged when students can participate in creating their own learning spaces (Ghassan & Bohemia, 2015). If we design the spatiotemporal affordances of the virtual design studio flexibly—open to a spatiotemporal distribution according to personal needs—we provide the perfect learning environment for design students, giving them the best learning practice for their future work.

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Designing Criteria for Developing Educational Multimedia Games

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Increasing research is being done into the relationship between learning and games in recent years. Player engagement and intrinsic/extrinsic motivation have shown to be pertinent in improving the quality of knowledge retention in game-based learning environments. Similarly, the use of multimedia in game-based learning environments has also shown to have significant potential for effective learning; however, it is unclear whether a generalized criterion can be designed for it. This work presents a review of theories and guidelines that pertain to learning environments, game design, and multimedia learning, in an effort to distil the key elements which can help develop design criteria that can contribute to efficient educational multimedia game development.

Keywords: learning environments; design education; educational games; multimedia learning

Introduction

One of the overall goals of educational game design is to develop game-based applications that can be compared to the contemporary classroom teaching-learning methods in their efficacy, engagement, and acceptability. In a venture to design these interactions and activities, it is necessary to recognize what constitutes good design and development, in terms of engagement, usability, and educational effectiveness. This paper presents two sets of criteria that could help support the design and development of computer games for the purpose of education. A review of the existing guidelines in the areas of game design, learning environments, and multimedia learning was done to understand the factors that can influence educational game design. In the end, the review was used to put together two sets of criteria for the effective development of educational games, where one focused on the educational design of the game while the other focused on the multimedia use and design. The following section studies the guidelines that are descriptive for designing appropriate learning environments, game designs, and multimedia learning.

Guidelines for Designing Learning Environments

In a paper that tries to theorize *Rich Environments for Active Learning*, Grabinger & Dunlap (1995) review the works of Hannafin (1992) and Collins (1995) and define learning environments to have the following qualities (Grabinger & Dunlap, 1995; Hannafin, 1992; Collins, 1995):

- Learning environments resonate with constructivist concepts and theories
- They are able to encourage the learner to study and investigate within authentic contexts
- Trains qualities in the learner for responsibility, making decisions, taking initiative and curios learning
- Encourages collaboration through an atmosphere of building knowledge and mutual learning
- Is dynamic and interdisciplinary in transmitting knowledge and has activities that can help the learner merge old knowledge with newly learned information, consequently helping them in building mental models and concepts

McLoughlin and Oliver (2000) in their pursuit to develop an online unit for the indigenous learners of Australia, highlight ten guiding principles for flexible and responsive learning environments (McLoughlin and Oliver, 2000) while Rieber (2001) emphasizes in their research that serious play needs to be a fundamental goal for developing learning environments and describes these environments as space where time, resources, and reasons are available to encourage the learning of a specific set of information (Rieber, 2001). When trying to understand why it was difficult for participants to understand scientific concepts and how the construction of learning environments could help rectify this problem, Vosniadou and team (2001) described four principles that might affect the development of a successful learning environment (Vosniadou et al., 2001). The principles suggested in these publications have been brought together and distilled into the following pointers below:

Flexibility Towards the Needs and Preferences of the Learner

The tasks included in learning environments should be flexible enough to accommodate the preferences, learning styles, and speed of various participants. The tasks could range from the goals that transmit learning as well as the simple navigation and understanding of the new environment itself. Even the mode of instruction should be inclusive of the varying learning capabilities of different participants. In the context of serious games, De Freitas & Jarvis (2006) highlight the need for understanding the learner preferences through demographics, preferences, groups, and skills.

Social Communication

This alludes to the presence of channels that allow the learner and the teacher to interact with each other. These channels are encouraged to be free highways of information, independent from any technical or performative complication. Social communication also includes participant-to-participant interaction which, if not intentionally difficult to achieve, should be easily accessible to the users. A literature review by Kangas et al. (2017) regarding educational games in the classroom, emphasized that the teacher’s communication activities helped the learner/player understand the goal better. The teacher’s role was described as a scaffold that can help the students during gameplay and support learning.

Progression by User Actions

The learning and the environment that provides for it should excite the learners by having action-based results. This ensures that the participants feel that their actions will affect their environment and thus navigate and interact accordingly. To take an example, in contrast to a textbook, where no action can be taken to interact with the content, a web page can provide for a much more versatile learning experience where multimedia and information navigation could very well be dictated by the user. To achieve progression through user actions in the context of games, Juul (2002) suggests giving the user some freedom to explore an environment where interesting actions and reactions take place only in one direction. This can encourage the user to direct themselves at meaningful interactions, which will consequently progress the game to completion.

Varied Resources of Information

The learning environments should include multiple resources of information that can help impart teachings from different perspectives. A simple example could be to use both animations as well as a physical 3D model to explain the workings of a human heart; here one resource of information describes the kinetic nature of the heart’s performance whereas the other can help understand its physiology in life-size. Similarly, some concepts in the learning environments could benefit the learner if they can have multiple perspectives of the same information. An example from the research done by Schrier (2006) in their augmented reality game *Reliving the Revolution*, the participants had to construct their way through the game environment. The author observed that though the abundance of information and information mediums were at first overwhelming for the participants, it later helped them in orienting themselves and encouraged them to develop geographical and intellectual routes throughout the game.

Collins and team (2000) in their paper wrote about the role of different media in the design of learning environments describing the distinct characteristics that varying mediums have to offer in terms of recording, production, transmission, and social interactions. They highlight the constraints of using the most effective mediums for learning environments as there is observed to be a tendency to shift back to familiar forms of teaching-learning. Collins, et al. (2000) also observe that producing digital media can be expensive and timeconsuming but emphasize that the appropriate selection of a medium can be exponentially beneficial to the learner as in most cases, one medium can transmit certain information much better than another; to take an example of how an animation would be greatly more efficient for teaching biology than using images, even though textbooks tend to revert to the use images in most cases (Collins, et al., 2000). The use of different media to effectively convey information highlights the need to understand the role of multimedia in learning.

Guidelines for Multimedia Usage in Learning

In addition to the guidelines that direct the development of learning environments in the preceding subsection, a review of the potential of multimedia usage in the field of learning is performed in this subsection. When considering the learning from technological interfaces, it is key to consider the range of informational channels that exist. Audio, graphics, animation, images, video, augmented reality, virtual reality and haptic feedback are all possibilities that can be built into digital learning. The support of multimedia usage in learning is first examined in this subsection through the review of a few theories that define and support multimedia learning, following which a review is conducted of the available guidelines that present factors which could improve learning outcomes.

Multimedia & Learning

The premise being that learners can understand concepts better through multiple mediums of information (like images and text) when compared to a single medium of presentation (only text or images), Mayer (2002) defines multimedia learning as a system in which there exist multiple modes of information delivery. This 3 information can be delivered to the varying sensory modalities of the user through a diverse set of equipment. Mayer (2002) summarizes multimedia learning as an information acquisition process or the process of knowledge construction in which multiple mediums of information contribute to the delivery of information. This is an extension of the dual coding theory by Paivio (1990) where it was hypothesized that there exist two cognitive subsystems for the user, one which deals with verbal information, while the other specializes in dealing with non-verbal information. Mayer (2001) displays supportive research that combines the use of text and visual images resulting in better learning when compared to the text alone and also that the effectiveness of learning is increased when the text is physically closer to the images, making way for better correlation. The research also supports the theories that in multimedia learning, unrelated information is better-left excluded and that the narration along with animation is far more effective than animation with text only.

In the study done by Schnotz & Bannert (2003), they randomly assigned sixty students to one out of three groups where they were presented with similar information but in varied visual formats. One group was presented with only textual information, while the other two groups were given different images along with the text. The goal of the research was to analyze how the structure of graphics can affect the learning capabilities of the students. The results indicated that the structure of the graphics affected the structure of the mental models of the students. Some questions were better solved by the students of the first group with graphical representations, while certain questions were solved better by the other group with graphical representations. There were also some questions that were better solved by the only text group. The results indicated that appropriate graphical representations (in relation to the task questions) were beneficial to the construction of mental models for learners. It also found that though task-appropriate graphics encouraged meaningful learning, task-inappropriate graphics could instead hinder the efficiency of learning for the participants.

In the research by Plass, et al. (1998), the effectiveness of providing visual information along with text was tested on English-speaking college students who had enrolled in a German course. In a test where they had to read a German story, the students were given an option to either see the translation of some of the keywords in the story(textual annotation) or they could view an image/video clip that represented the word(visual annotation) The results, consistent with the generative theory of multimedia, showed that the students who had opted to view the textual as well the visual annotation performed better than the students who had opted just the textual translation.

Cognitive Theory of Multimedia Learning (CTML)

Multimedia learning observes that learners can meaningfully acquire information better from multiple mediums of information reception than only one. For example, learning the same information from images and text might help the learner retain the content better when compared to just plain text, this is referred to as the multimedia principle (Mayer, 2005). It is asserted that multimedia learning occurs when the learners is able to mentally develop cognitive representations of concepts through the help of correlation between more than one medium of information. Here the textual nature of words can range from audio narration to the written text on an interface, and the reference to pictures can range from graphical imagery, illustrations, videographic content, and/or animated representations. This observation is consistent with the generative theory of multimedia learning that suggests that the participants mentally pick out appropriate verbal and visual information, assort them and then organize the information into cohesive and cogent mental models of representation that they then integrate with existing information in their cognition (Mayer, R. E. & Moreno, R., 1998). Sorden (2012) draws the key points from the theories of multimedia learning and distills them into the 'cognitive theory of multimedia learning' by mainly examining the works of Paivio (1990), Baddeley (1986), Mayer (2002), and Sweller (2005). The main takeaways from these works are as follows:

- Cognition is bifurcated into a dual-channel subsystem containing a visual and an auditory channel
- Sensory, working, and long-term are the three key memory stores
- The magnitude of cognitive processing in the working memory is limited
- The selection of words and images, the assortment of words and images, and the integration of new knowledge with old knowledge are described as the 5 key processes of cognition when performing selection, organization, and/or integration.

Application of CTML - After understanding some of the viewpoints that help describe multimedia learning and the cognitive theory behind it, the key aspects of the application of CTML (Cognitive Theory of Multimedia Learning) are highlighted by Sorden (2012) in their paper under five points. The first point is the use of a learner-centered approach where the medium of instruction and learning, rather than being technology-centered, takes into account the comforts and cognitive range of the learner. The second point highlights the importance of taking into consideration the cognitive load that the instructional medium will entrust upon the user and how it can be managed safely and efficiently. Exercises that contribute to a reduction in cognitive load and an increase in the learner's interest are shown to be two efficient learning strategies by Mayer et al.,(2004) in their research. The third important aspect highlighted by Sorden (2012) pertains to the proper analysis of a task; in this scenario, a task refers to an exercise or an activity that a learner will face when trying to understand a concept. If the task being designed is outside the learner's range of abilities, it can cause unnecessary frustrations for the user, which might even make the learner drop the activity altogether. It is suggested that the task analysis should be done to evaluate the content being transmitted towards the learner, understand the range of the learner's ability, and breakdown the educational objectives that the task needs to achieve. The fourth point concerns the guided instructions that are given to the learner. According to CTML, solved examples and guided instructions are better for familiarizing the learner with the activity than when compared to discovery learning by the learners themselves. The last point is interactivity, which is in itself a large area of research, but here it pertains to the emergence of interest in learning when attention is paid to interactive things like learner control, feedback, and guidance into the lesson. The interaction is suggested to be constructive, which positively informs the learner about the workings of the new environment while letting them freely control their abilities to perform the task fluently (Sorden, 2012). The positive acceptance of multimedia learning is reflected in many studies, including the survey in which Pastore (2016) shows that the scores of the multimedia preference groups were higher than the groups that preferred single media.

Evaluation of CTML - Sorden (2012) observes that it is difficult to ascertain any single method of evaluating CTML research. According to Mayer (2009), a key approach in CTML's evaluation could be by quantitatively experimenting and drawing comparisons, where randomized and experimental control could try and determine which of the instructional method is more appropriate for learning. Retention of information and the honest transfer data could be considered attributes that validate learning (Sorden, 2012; Mayer, 2009).

Pedagogical Praxis

Shaffer (2004) in their paper Pedagogical Praxis: The Professions as Models for Postindustrial Education outlines a general theory of how under the right conditions, the use of digital information technologies to create various professional learning environments can be helpful for the participants to learn and transition themselves into contributing professionals of their own communities. The basis of this theory is to use technology to build a digital bridge that imitates, but bypasses conventional learning and lets the users adopt information about certain professions through recreated learning environments of those respective professions. Finally, the results can be measured by a comparative analysis between the learners generated through conventional teaching methods versus the learners informed through the developed technological aide. The theory is described in five steps which are as follows: (1) To conduct a baseline study of how conventional training methods are given to future professionals and understand how the learners relate to the respective professional ways of ideation and execution (2) To conduct ethnographic studies that can inform the researcher better about the training practices of future professionals (3) After a careful analysis of the ethnographic practice, to develop or adapt existing technologies that can recreate the general mechanisms of the profession and still be within the operative reach of the learner (4) To build a learning environment that contains the technology built/adapted and apply it to the learners using the heuristics found in the ethnographic studies earlier (5) To finally examine the outcomes by comparing the learning with the domain of

the respective profession, and by documenting how the learning contextualizes itself with respect to the professional practice (Shaffer, 2004).
Although, Shaffer (2004) does not specifically mention the use of multimedia, their suggestion to adopt appropriate technology or set of technologies that can suit the learning of a particular profession axiomatically indicate the use of multiple mediums. In a concluding study, Shaffer (2004) tests this theory by applying it to the domains of architecture, mediation, and journalism. The results indicated that pedagogical praxis could be employed to teach other professional domains (and consequently subjects such as biology, mathematics, ethics, etc.) and that this methodology was applicable to learners from varying socioeconomic backgrounds (Shaffer, 2004).
It has majorly been accepted that the appropriate application of multimedia teaching can contribute to increased learning. The work by Mayer, Shaffer, and others has been largely appreciated, and though there holds some criticism as to whether this approach is effective, most of the supportive research for multimedia learning is evidence-based with publications in significant journals. The key findings from the above researches which guide the development of an effective multimedia learning activity have been summarized as points in the following:
Technology Selection - The selection of the set of technologies that build the multimedia experience should complement the teaching content as well as the learner's range of abilities. For example, when considering the content, the use of audio narration and pronunciation will be better for learning a spoken foreign language than when compared to learning a written foreign language. Similarly, when taking into consideration the range of abilities of the user, the use of bright vivid colours in the visual representations would be better suited for teaching young learners than the use of subtle shades and hues. The technology selection, which was denoted as delivery methods of information in the study by Buch & Bartley (2002) reinforced that all participants had diverging learning styles and preferences, where one group preferred learning through traditional methods of information delivery while the others preferred various novel technologies.
Task Analysis - The design of the multimedia experience should involve a clear analysis of the task that would require the participants to do or absorb. If the task turns out to be difficult for the learners, or if the task is unable to achieve the educational objectives that it was intended to, then the use of multimedia might have negative effects. To take an example, the use of drawing activities to teach history to a class might or might not be the most efficient method when compared to showing images and videos of historical events. The effectiveness of the task and the activity will greatly depend on the educational objectives that the teaching is trying to achieve. Practical methodologies like the Cognitive Task Analysis (CTA) technique, could be applied in understanding and dissecting the task at hand (Schraagen et al., 2000).
Content Representation - Some of the research showcased how the appropriate representation of content was key to the increase in meaningful and applicable learning. In an exercise where the students asked to answer various questions about the circumnavigation of the world, some questions were answered better by students who had a circular representation of the world's geography while certain questions were better answered by students who were given a flat, carpet-like representation of the globe (Schnotz & Bannert, 2003). This testifies to the theory that every piece of information will have a certain way of representation that can help the learners understand it better and meaningfully retain the contents. The previous step of task analysis can aid in the understanding and selection of an appropriate medium and format to represent the content.
Interactivity - The interactivity of the experience will need to complement what the teaching is trying to achieve, however, it has been found that an easy introduction to the exercise, along with giving the learner's some freedom to explore the new environment has had positive effects on the learning experience. The design of interaction will need to encourage the emergence of interest in learning for the user. The demonstration of some solved activities along with some guided instruction could help learners get a better understanding of the interaction. Kim et al. (2019) in an effort to develop a pedagogical framework called the game-based structural debriefing (GBSD) also emphasize the initial use of a simpler introduction for multimedia interactions.
Through the above reviews of works, it can be positively induced that the use of multimedia, if applied appropriately, can result in an increased interest of the learner, consequently resulting in better and meaningful learning. Some research has also indicated that the activity being performed by the learner, needs to constructively engage the participant in order to impart learning. Educational games are learning environments that make use of multimedia in an effort to impart knowledge. The following section reviews some of the guidelines that theorize how games can be better designed in order to enhance learning.

Guidelines for Game Design Intended for Learning

The following subsection will first review some of the theories of educational game design, after which a review is done for understanding some of the guiding principles that emerge from these theories. It is also important to examine the use of learning theories that are employed to develop educational games or game assisted learning. The theories examined under this subsection range from the earlier learning concepts like behaviorism and cognitivism, to the relatively recent learning concepts like situated learning theory and distributed authentic professionalism.

Behaviorism

Generally attributed to Thorndike (1913) and Pavlov (1927), behaviorism subscribes to the thinking that learning can be generated and incorporated through stimulation and reinforcement. The theory bases itself upon the assumptions that firstly, a change in behavior can be described as learning, secondly that the environment of the individual greatly influences behavior and consequently learning, and finally that the application and process of stimulation and reinforcement are pertinent to the process of learning (Grippin & Peters, 1983; Thorndike,1913; Pavlov, 1927; Watson, 1997).

Cognitivism

Unlike behaviorism, cognitivism pertains to the assumptions that firstly, the memory is responsible for the assessment, organization, and processing of information, and secondly, that the existing prior knowledge is one of the most important factors in learning. The learner is portrayed as a processor of information, where the mind is basically responsible for all learning and should be examined thoroughly (Merriam & Baumgartner, 2020).

Humanism

The theory of humanism treats individuals as vessels with values and intentions. The theory differentiates itself from behaviorism and cognitivism as it does not subscribe to learning being defined by the construction of meaning, or that the recurring stimuli and reinforcement could provide for definitive learning. Experiential learning is endorsed by humanism, as it defines its goals to enable every individual to be self-actualized and cooperative. The theory suggests tailored learning which is learner-centered, where the educator facilitates every problem or difficulty that the learner might individually encounter (Combs, 1981; Kolb, 1984; Huitt, 2001)

Constructivism

Considering learning as a continuous constructive process, constructivism portrays the learner as an entity with the capability of constructing information and consequently learning. The theory assumes that learners continuously create and build their own subjective mental models of objective reality, and by linking newer information with their existing knowledge base, individuals can keep updating their personal mental representations (Brown, Collins, & Duguid, 1989; Bednar, Cunningham, Duffy, & Perry, 1992).

In a systematic literature review by Wu et al. (2012) which used a meta-analysis approach, it was found that most of the studies pertaining to game-assisted learning did not focus on foundations of learning theories. However, the studies that did highlight the use of learning theories revealed that, in recent times, humanism and constructivism were more popular in game-assisted learning when compared to behaviorism or cognitivism, even more for experiential learning. One of the reasons that were highlighted for humanism and constructivism theories to be more popular in recent times was due to the increasing adoption of learnercentered approaches when compared to teacher-centered approaches (Wu et al., 2012).

Situated Learning Theory

Defined by Lave and Wenger (1991), situated learning subscribes to the notion that learning is deeply influenced by the particular physical or cultural environment that it takes place in. Here, learning becomes an active engagement process of the participant with their environment through tasks. The activities that redirect the participant to interact with the immediate setting contextualized learning for the user where they gradually learn and master the inner workings of that environment. Situated learning encourages research to analyze the relationship between the component units such as the participants, the environment, the activities and discourages the analysis of units as single identities (Lave & Wenger, 1991). Gee (2009) mirrors the use of situated learning in games by highlighting how some games require the player to accomplish objectives within the rules, values, and norms of a new environment, where the player would need to understand, learn, and gain expertise over a certain set of skills, along with other procedures and principles that dictate the working of the new world. In the example given by Gee (2009), the author describes how a military game provides for the player, a set of equipment, and a world to operate in, however, the appropriate and efficient use and mastery of those things is in fact the learning that comes out of the gradual playing of the game. The mediation of the

player with the environment and its objects to achieve rules and norms dictated objectives is assumed to be the contextual and experiential learning that the user gains through situated learning (Gee, 2009).
Another instance of situated learning is highlighted in the findings by Hayes (2006) where the researcher tried to observe players who participated in a virtual simulator called *Second Life,* which is described as "a 3D online persistent space totally created and evolved by its users. Within this vast and rapidly expanding place, you can do, create or become just about anything you can imagine" (Second Life, 2021). It was found that the participants had learned to participate in the simulator's economy without any intervention by the researcher. The simulator required the participants to learn certain skills to be able to craft products which they could then sell for in-game money. A notable finding was that the money earned in the simulator had value outside the game as well, people constantly traded the game money of "real-life" money. Observing that, the research suggested highlighted the need for value creation for situated learning. The participants could self-motivate to learn the various mechanics of the simulator, as they perceived a value to be derived from it.

Distributed Authentic Professionalism

Coined by Gee (2005) in their paper What Would a State of the Art Instructional Video Game Look Like? distributed authentic professionalism refers to the division of knowledge, activity, commands, and control between the player in the physical world and their digital avatar in-game. Gee (2005) showcases an example of the game Full Spectrum Warrior, which is an instructional video game intended to inform the player about the operative procedures of a U.S. Army soldier. The paper encourages the researcher to observe how the game distributes the set of responsibilities between the player and their virtual character, for example, the virtual character and their squad in-game are already aware of several real-life formations that the army uses, whereas it is the responsibility of the player to choose and decide when that particular formation will engage throughout the game. Similarly, the virtual squad in-game is aware of all the military commands and follows them immediately, however, it becomes the critical responsibility of the player to memorize those commands and use them appropriately in various situations. According to Gee (2005), this is exactly where the learning occurs. The game's manual explicitly informs the player that this is not a generic shooting game and the completion of it will rely on how professionally the player can think, act, plan, and execute like a soldier. Distributed Authentic Professionalism then becomes important in highlighting the need for balancing the information dispersion between the player and the virtual avatar and the environment (Gee, 2005).
Motivation - Although there exists research that attests to the contribution of motivation as an important factor in games, there happen to be varying opinions as to where the motivation can come from. Some have found motivation to be a part of the narration of the game, or the unfolding of the story, while some have demonstrated the existence of objectives, goals, and rewards as the generator of player motivation (Dondlinger, 2007). The research conducted by Amory et al., (1999) showcased that students of the first and second year appeared to like the graphics, audio engineering, and storyline as a factor for motivation in playing the game ahead, whereas other games that were simulation-based were played less by the same students. The research concluded by encouraging the use of factors that can help build intrinsic motivation for the students to play the game (Amory et al., 1999). Here intrinsic motivation refers to the intentional act of the players to play the game further out of their own free will, whereas extrinsic motivation is said to be gained from in-game system, goals, and rewards (Denis and Jouvelot, 2005). All research admits that motivation is pertinent to game design, and both intrinsic, as well as extrinsic motivation, should be considered throughout the building process.
Contextualization - The provision of a cognitive framework through narrative and descriptive contextualization in-game has shown to be helpful as an element of game design. In their survey, Dondlinger (2007) found five articles that supported this finding as well (Dondlinger, 2007). Narrative, descriptive contextualization was shown to help the participants situate themselves in the new environments while in games that required 3D navigation, it helped them build spatial relationships with the game. Here the reference to narrative contexts does not limit itself to textual or descriptive information, for example, in their research of 3D environments and 3D modeling, Dickey (2005) reported that the representation of in-game perspective as first-person helped the participants relate better with the environment and situate themselves better (Dickey, 2005).
Rules, Objectives, and Goals - Here the rules, objectives, and goals, though they are a part of the overall game context and narrative, they are a pertinent factor in game design themselves. Swartout and van Lent (2003) describe how the goals and objectives in a game are used by game designers to achieve engagement. They give an example of how game designers employ three levels of objectives for the player, wherein the first level, collection of tokens/keys can last for seconds, purchase of objects or the opening of safes can be the second level taking up to minutes of the gameplay, and finally the goal of defeating the end boss or saving the world could take up the entire gameplay and can the third and last objective. Swartout and van Lent (2003) observe that it is the interplay between these levels that give rise to engagement and consequently interest in the game.

They also suggest the combinatorial usage of these goals and objectives to emotionally immerse the players throughout the game (Swartout and van Lent, 2003).
According to Dondlinger (2007), it is key to distinguish between games that are educational and games that provide edutainment. The key difference between the two is observed to be interactivity, where the didactic nature of the educational games does not veil the intention of imparting learning; whereas the edutainment games focus more on the interest of the players to explore the game, where they end up learning and grinding skills by repetitive action to master some aspect of the game's mechanism, often called the 'skill and drill' format (Denis and Jouvelot, 2005). Educational games, on the other hand, demand a more serious progression of thinking and problem solving, where the system follows through with goals, objectives, and rewards. Both educational and edutainment games have shown to contribute gains in learning if applied appropriately. In addition to a consideration of learning theories in game design, below are some of the guiding principles that are either drawn from the above theories or are well established in the literature.

Criteria for Designing Educational Computer Games

In the last section of this paper, the guidelines, theories, evaluations, and discussions regarding educational game design, learning environments, multimedia usage are combined to produce two sets of objective criteria for the design of game-based learning applications; the first deals with the aspects of game design that can enhance education in the form of learning and understanding, while the second deals with the elements of multimedia design that influences the application of learning.
The theories and guiding principles of game design, learning environments, and multimedia learning have been used to describe five areas that collectively address the first set of criteria for the educational design of the game and four areas that collectively address the second criteria of multimedia use for learning.

Table 1. Criteria for the effective educational design of game-based learning applications, and elements that support the fulfillment of each criterion

№	*Criteria*	*Elements that support the fulfilment of the criteria*
01	**Content appropriateness**	Is in line with the curriculum and evaluation Reflects subject matter honestly Matches conventional teaching time of subject matter
02	**Player reliant gameplay**	Story progression through user action Customization and personalization Environment manipulation and player empowerment Bifurcated responsibilities between the player and the in-game avatar
03	**Problem transmission and solving**	Order of the problems Increasing Complexity Solved work examples Constructive frustration Contributes to increasing expertise Varied resources of information
04	**Learning through exploration**	Exploration possibilities Encourages situated learning Interactive environment Sandbox features
05	**Goals and reward systems**	Generates Motivation Rewards are proportionate to the difficulty Tangible rewards Rewards contribute to story progression Placeholder for milestones

Table 2. Criteria for the effective multimedia design of game-based learning applications, and elements that support the fulfillment of each criterion

№	*Criteria*	*Elements that support the fulfillment of the criteria*
01	**Technology Selection**	Complements the educational objective Complements the range of user abilities Robustness of equipment and apparatus used Flexibility towards the needs and the preferences of the learner
02	**Task Analysis**	Solved example and progressive complication Achievable tasks through the multimedia operation Complementary to the educational objective
03	**Content Representation**	An appropriate representation of educational information Multiple inputs i.e. visual, audio, verbal, on-screen text Structured order of information representation Contributes to increasing expertise
04	**Interactivity**	Supports emergence of interest Offers a range of interactions Guided instructions Meaningful Feedback

Conclusion and Discussion

This paper has used both the theories as well as the guiding principles in literature to develop and present these two sets of criteria to evaluate the elements of educational and multimedia design that influence the appropriateness of a computer game-based activity for learning. A review was provided that pulled together research on the design of learning environments, the use of multimedia in games, and the design of educational games. It was found that elements like content appropriateness, player-reliant gameplay, problem transmission and solving, learning through exploration, and the goals and rewards systems, are pertinent in the design of educational games (See Table 1). While an effective multimedia experience that can encourage learning needs to take into account elements like appropriate technology selection, task analysis, content representation, and the all-over interactivity of the experience (See Table 2).

The criteria generated through this research can contribute in designing better educational games as well as better learning environments that are assisted through multimedia. It will be an important step to analyze the findings of this paper by developing multimedia games through the criteria presented here and then performing a comparative analysis with the educational games that currently permeate the market, as well as compare the learning gained through the developed games with the learning provided by the contemporary methods of schools and colleges. However, that is the scope of future research.

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The Intellectual Diet in Pastoral Spaces of Activity in Digital Design Education

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During lockdown, students are excluded from the inspiring learning space of the university. Students receive a different "intellectual diet" here than they do in the university. In the studio learning of the traditional face-to-face university, the artistic and cognitive impulses are curated with a design pedagogical concept. This concept contains visual, intellectual and social impulses. This concept did not exist in the previous three semesters - it was left to the respective family and home environment of the students during the lockdown. While this is generally the case for distance learning students, it was exacerbated during the lockdown. Students operate in remote-learning mode via primarily digital channels. For the case study presented here, the question of the holistic nature of these stimuli presents itself. The adjective "pastoral", for example, is to be understood as the hypothesis that, over the course of the past two semesters, in addition to subject-related teaching, teachers were partly responsible for the aesthetic and – this remains to be demonstrated – the pastoral dimensions of a degree course in design. On the basis of in-depth interviews, the case study develops categories of teaching activity within digital spaces of action to which students attribute a particular degree of effectiveness. The feedback was evaluated by means of a written survey and in-depth interviews with students of online programmes at the bachelor's and master's level. A working atmosphere that was free of hierarchy in digital relationships was a prerequisite here. On this basis, teachers convey "internal" stimuli (that are specific to the curriculum at hand) as well as "external" stimuli (that fall outside of the particular curriculum). These then express themselves in autonomous learning, which is motivated by appreciative criticism in social groups. In digital spaces, too, this does not succeed from the start, but is rather built up through personalised contact in the form of relationships of trust. These gain in effect through the dimensions of the verbal, non-verbal and symbolic interventions.

Keywords: Design pedagogy, hybrid studios, distance learning, aesthetic education

Starting Point and Relevance

Over the last two semesters (2020/2021), the discourse about hybrid studios has taken on a new, substantial dimension. Up until then, the actions of learners in virtual learning spaces were a minor exception, but the isolation of design students in their digitally networked studios provides a complex laboratory of global proportions for design education. It is to be expected that the construction of theories for developing design competence in digitally expanded studios will increase in intensity.
The case study outlined here makes a contribution to this by researching the effects sizes of teaching from the reflections and the feedback from students.

Theoretical Contexts

In the learning behaviour of students taking virtualised design courses, status passage (first year of study), self-organisation and self-care (second year of study) as well as expansive learning (third year of study) emerged as central concepts (Lanig 2019). The research question pursued here of communicative interaction in hybrid studios builds on these findings. The three core concepts, as sensitising concepts, are premises of this study. The literature on coaching in artistic processes of development points out that special interaction concepts

(Truninger 2019) and spatial concepts (Thoring 2019) must exist. In the spatial concepts, in particular, the "signature pedagogy" manifests itself as a didactic calculation that is tailored to the character and socialisation of young designers: these "signature pedagogies" (Gurung et al. 2009, Sowa 2019) reflect the deep structures of the profession. These dazzling semiotics are formulated in design using the deep semantic field surrounding the term 'studio'. This term is scintillating because it is part of a lasting discourse about an often transcendently documented space of creativity and its current justification.
In the past two semesters, far beyond providing support in their own subjects, teachers in design schools have dealt with questions of social and learning space, which has been fundamentally changed by the lockdown situation. Even institutions that do not explicitly practice remote learning had to deal with the potential and shortfalls of "hybrid studios" (Lanig 2019). This is because the educational and social communication strategies for learning in studios are known and intuitively tangible. This is mainly due to the fact that teachers can reproduce their own learning experience in the studios. For digital learning spaces in which teachers do not have their own learning experience, this is a theoretical requirement. The case study therefore focuses on processes of support and advice in artistic contexts.
The coaching process must empathetically incorporate the specific development processes involved in the generation of ideas. The studio concept is also intended as a social concept of symbolic communication. This studio concept particularly emphasises social learning in groups. The "community of practitioners" (Wenger 1998) shows the learner paths by cultivating critical and favourable feedback.
The transfer of these principles of design education into the virtual space is explored from the perspective of the general "internal" and "external" development of students (within and outside of the curriculum) (Lanig 2019) as well as the supporting educational and technological settings (Lotz et al. 2019). The focus on the effects of artistic coaching in virtual learning spaces still represents a conceptual need here.
Based on this consensus of design education that has been established for decades around the studio as a place of learning, the last few semesters have shown that these two premises of design education can only be transferred to an online environment with shortfalls. At this point, empirical evidence of distance learning within design departments can offer insights into the transfer of design education.

Research Questions

The paper proposed here introduces the pastoral realm as an approach to virtualised design education. Drawing on the pastoral profession, the aim is to address the question of how lively learning relationships can succeed in design education in view of distance. It is not the religious connotation of this term that is intended, but rather the holistic view, as was also cultivated in historical studios of the past.
Regardless of the religious connotation, the pastoral idea of multiple coding (Bucci 1997) describes the field of tension in education between verbal and non-verbal stimuli. The leading idea is that in the area of implicit communication, the symbolic becomes effective and affects the subconscious. This emphasises the important role of dramatic art and staging, as was traditionally practised in religious contexts and – and this is the thesis – as is also used in traditional studios as a form of holistic education. As a result, the case study considered here raises the question of to what extent design teachers can use the three poles between the verbal, the symbolic and the unconscious in a didactically targeted manner in teaching–learning scenarios that are conveyed digitally.
In order to provide an empirical foundation, the proposed case study considers a number of interventions that were offered optionally and online during the 2020/2021 winter semester. During a first, quantitative phase, three question contexts were opened:

1. What changes do students see when looking back over the past year?
2. What interventions and ideas/stimuli from the teaching staff were helpful or hindering?
3. What affective dimensions were activated in this regard?

Study Design

These question categories were asked in February 2021 to students in the "Design and Media" department at DIPLOMA University. Twelve students took part at the bachelor's and master's level. The answers that were submitted in writing were analysed for similarities in content. The resulting codes were managed and displayed in MaxQDA. Research was thus carried out in this way for content-related clusters in the verbal data.

Table 1. Categories of verbal data (phase 1) and their frequency distribution.

	Changes in self-image	Effective input from teachers	Affective influence of the input	TOTAL
Development internal to the curriculum	7	4	0	11
Positive self-image	9	1	0	10
Connection to the professional profile	0	7	2	9
Financial issues	5	2	2	9
Appreciation	0	6	1	7
Personalisation	0	7	0	7
Self-efficacy	1	6	0	7
Social learning	4	2	0	6
Space for experimentation	0	3	2	5
Humour	0	3	2	5
Doubt and crisis of meaning	0	3	1	4
Own decision	0	2	2	4
Leaving the comfort zone	0	0	3	3
Hierarchy-free working atmosphere	0	2	1	3
Teachers' self-disclosure	0	0	1	1
Own standards too high	0	0	1	1
Authentic interest on the part of the teacher	0	0	1	1
TOTAL	26	48	19	93

Key Results of the First Phase

The verbal data from this **first phase** show the following key results:

1. General stimuli that are external to the specific curriculum in the introductory phase of the study positively change the way one sees oneself and others. This can be seen in the self-confidence category. Students tie this to a changed response from their environment. These developments are closely related to the social processes in the small groups.
2. In order to be able to experiment successfully, students work on perfectionism, which was perceived as a hindrance. The prerequisite for this is the knowledge that one has to go one's own way and not that of the teacher.
3. Discussions result in a systemic expansion to include subject-specific questions. When teachers create an empathetic closeness to the learners, credibility is created. This results in self-efficacy in artistic development. The systemic change of perspective is often related to the effect of humour. Students particularly appreciate this when the teachers authentically identify with the educational issue at hand. This applies, in particular, to the relevance for applying the learning content.
4. The unsettling openness in conversations during the introductory phase of the course turns into a helpful appreciation of one's own development. Teachers and fellow students thereby become a part of this "internal" and "external" development within and outside of the curriculum.

These causal relationships of design education activities verify existing findings. This makes them the starting point for an in-depth study during a second, qualitative phase of the case study. Selected aspects of the verbal, the symbolic and the unconscious were questioned here in depth. This survey, which took the form of in-depth interviews, is interested in the subject-specific and educational effects of these interventions.

Key Results of the Second Phase

In the **second phase**, two test subjects from the first sample were specifically spoken to. Both test subjects are studying design degree programmes. **Subject** 1 is a student in the master's programme (4th semester, aged 32 years). At the time of gathering information, this subject had already completed twelve semesters of online study. Subject 2 is a student in the bachelor's programme (5th semester, aged 38 years). The in-depth interviews were initiated with the following narrative stimulus:

> *"My research interest is interactions in the hybrid space. What interactions are there and how are they effective? They are probably subject-specific things, but there are also things that are unconscious, that are informal, that are between the lines." (In-depth interview 2, item 4)*

In these conversations, the symbolic interactions in the conversations of the hybrid studio were deepened. This is because the question of how an effective level of openness between learners and teachers can be established promises to yield the greatest gain in knowledge for design education in digital learning spaces. This question category focused on how an efficient way of dealing with verbal, symbolic and unconscious communication can be achieved from the student's point of view.
By means of interviews, the stimuli from teachers are sought that are effective for development in digital learning spaces. By focusing on the interventions in design education that are actually effective, work carried out in this field promises to uncover strategies that are particularly effective in a virtual framework.
As already stated in the "hierarchy-free working atmosphere" category, communication with the individual is the starting point for a lively learning relationship:

> *"With [person], (it was) the constant reference to 'how we (as designers) work'. (It went) from 'we' to 'me'. At some point, I then had the sensation of 'oh, he's talking to me' – he wasn't talking to us as a group, but rather was talking to me" (in-depth interview 2, items 11–12)*

This personalisation of communication makes it possible to pass the responsibility for the learning process back to the individual. The learners understand that it is not about collective expectations in the sense of a learning path. A relationship thus builds up and this results in the first pivotal moment where this responsibility for one's own learning progress is laid down during the introductory phase of a seminar as a basis for learning through discovery:

> *"For me, it's about, was I able to do what I wanted to do? Was I able to do what I thought was right? And can I then actually defend what I then do in the assignments?" (In-depth interview 2, item 19)*

Only when this autonomy of the part of the learner has been clarified is the basis established for independent development of learning content. In the process, teachers only provide elementary technical contexts of design as resources by means of subject-specific explanations and demonstrations. These principles are acquired during a phase of acquisition. During this phase, everyday experiences and explicit study activities become blurred:

> *"This freedom to be able to do that all the time, including outside of my assignments in photographic design, and to develop oneself as a creative photographer opened my eyes. (I learned) to act, work and design as a student." (In-depth interview 2, item 30)*

In this respect, students' perception of space constitutes a continuum that results from their own actions. It is described as an "area, a form of surface that (can) be reached in various ways. To take up the example of the studio – one that arises and expands in the moment, but then also shrinks and closes" (depth interview 2, item 35). A first criterion for success can thus be derived, which is that teachers must make clear that one is responsible for one's own learning. Only by doing so in the necessary condition created for students to be able to gain mastery of creative activities beyond the already diffuse boundaries of an online degree course.
In a further step of development, it then becomes possible to assess the subjective and relative performance of others. This is done through active participation in group and project meetings, which have a systemic function. These meetings are not about grading learning progress. Instead, they are a matter of confronting a

social group or the teacher with one's own development. They must instead be about socially reflecting on the development process. Precisely because this is not about a "model solution" (in-depth interview 2, item 31), learners can distinguish between personal and factual criticism:

> *"I even had to turn off the camera in one lecture and cry. I took it personally. It wasn't until later that I understood that [the person] who made me so frustrated and angry at the time was actually encouraging and supporting me." (In-depth interview 1, item 4)*

This learning process through group discussions is the norm in traditional studios. At the same time, a transfer into the digital space has to be designed with special features that entail technological fragility of the interpersonal contact between those involved. It is a path that involves creative developments on the part of those involved and which is accompanied by crises and humiliations. As a result, one generates the skill to assess one own performance through internalised group discussions and to lead one's own creative development process:

> *(It gave me the ability to) "assess myself, assess my own abilities as a student. To see: Okay, I have shortfalls here. These are shortfalls that I want to work on. These are shortfalls that I don't want to work on." (In-depth interview 2, item 63)*

When Looking at the first and second phases together, it becomes possible to determine which interventions, strategies and methods of teachers are particularly effective from the perspective of the learners:

Table 2. Categories of the verbal data from the written survey (phase 1), their weighting and reference to classic examples from the in-depth interviews (phase 2).

Categories from phase 1	**Weight**	**Classic examples from the in-depth interviews in phase 2**
Connection to the professional profile and development internal to the curriculum	20	She gives you a lot of freedom (...) but is always there when you call her. If you don't call her, then she's not. Like a guardian angel maybe. (In-depth interview 1, item 7)
Affective influence: positive self-image, doubts/ crisis of meaning, humour	19	I notice this by how emotions stir in me, be it joy, pride or frustration, for example. (In-depth interview 1, item 3)
Self-efficacy and own decision	11	You (become) ready to continue developing throughout your life. If a path (...) doesn't work, it doesn't mean that you can't get there. There is probably another way. (In-depth interview 2, item 53–54)
Opening up spaces for experimentation and social learning	11	[People] insist on requests to speak, which does not allow for anonymity. Some are very challenged by this. This promotes the relationship with one another. (In-depth interview 1, item 16)
Hierarchy-free working atmosphere and personalisation	10	With [person], it is the video messages that personally speak to me emotionally. It feels good to be treated as an individual. (In-depth interview 1, item 6)
Appreciation in the teaching–learning relationship, systemic mirroring	7	His authority and his human, non-judgmental manner make me gain a lot of confidence in his leadership and professional competence. (In-depth interview 1, item 9)

With the highest number of mentions by far, students rate the **connection to the professional profile** the highest. That makes sense – after all, the "internal" desire (as relates to the curriculum itself) to learn about the domain of design by studying is the real reason for a degree course that is mostly practised part-time. There is also help that is provided "outside of the study context" (in-depth interview 1, item 9), which blurs the boundaries of the degree course and general subject-specific coaching: in the online relationship, in terms of **emotions**, value is placed on the fact that the course "gives you freedom, offers support – including beyond the boundaries of the degree course – that teachers provide personalised care and thus create meaning" (in-

depth interview 1, item 12). In retrospect, it is also appreciated when teachers "contribute personal anecdotes" and use humour and provocation and addressing people authentically (cf. in-depth interview 1, item 4) to make this relationship multi-faceted. This way, "emotions of trust, joy and motivation" (ibhttps://doi.org/10.21606/drs_lxd2021.) are aroused, which arise in particular through personalised video messages. It is made clear here that didactic stimuli are effective when they happen promptly and on informal platforms via messenger (in-depth interview 1, item 11).
It is clear here that the teacher not only acts on the basis of an advantage of skills internal to the curriculum, but also on the basis of **systemic sovereignty**. This is the only way for it to be made credible that the teacher is concerned with the process of development and not primarily with the result. Only then do the students gain autonomy and self-responsibility for their own development (in-depth interview 2, items 53–54). This seems to be a high requirement, especially in online replacement lessons that are geared towards efficiency. However, this systemic boundary is important in order to enable learning that is divorced from the studios, by means of personal responsibility. At the same time, this educational technique is probably the most valuable gain in knowledge for design education for the time after the pandemic.
One conceptual element here is that the teachers stand on a systemic boundary between thematic domains and the learners. When viewed in this way, the cultivation of relationships mediated via media gains particular importance through personalised address. In terms of method, this means using suitable experiments to allow design skills to be discovered. The learners need the courage to cross this systemic boundary. To do this, they need encouragement from an authentic teaching–learning relationship.

Summary and Conclusion

The expansive learning within a project, i.e., the agile acquisition of required skills over the course of the project, provides the scope for this teaching–learning relationship. It is interesting that in the discussions the students pointed out the heterogeneity of different temperaments among the teachers as well as the effect of humour. Both criteria indicate the relevance of this systemic boundary between domain and project, of which the teacher is the gatekeeper.

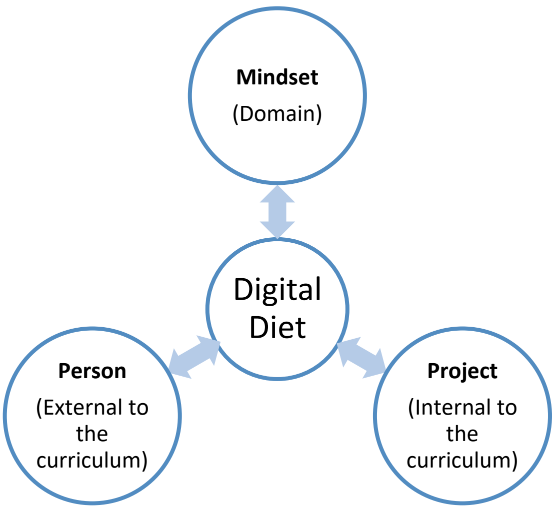

Figure 1. The cause-and-effect relationship of the "digital intellectual diet" for learners in the 2020 summer semester and 2020/2021 winter semester.

Aesthetic education in general is an essential domain for universities. Naturally, this is restricted in lockdown. It makes sense to diagnose general socialisation in the professional field as a need.
If this need is combined with the above-mentioned gatekeeper function, this results in a pastoral function on the part of the teacher: if the socialising effect of the complex learning space of a university with its studios is limited to digital channels, the "digital intellectual diet" must be curated with an even greater degree of responsibility. Because the interdependence of these stimuli precisely does not result from formalisation within official lectures, but rather from **serendipity**. On the one hand, these are the already identified processes of observational social learning (Lotz et al. 2019). The survey and the conversations during the two semesters during lockdown also show that the optional events and the informal interactions contribute to providing stimuli in creative development processes.
The following methodological approaches result for the pastoral idea of multiple coding (Bucci 1997):

Table 3. Summary of digital principles of care in the three dimensions according to Bucci 1997

Verbally coded stimuli	**Non-verbally coded stimuli**	**Dramaturgical and holistic coding**
Auditory lectures and talks Written feedback Customised and personalised video messages	Visual contact through facial expressions and gestures Passive feedback ("likes") and observations during the projects Expanding of boundaries through contact beyond the degree course	Ritualisation and rhythmisation Bodily stimuli, e.g., online gymnastics Unconsciously effective symbols

The key moments and episodes identified therein prove that these discoveries must not be a mere accessory in digital learning cultures. The "digital intellectual diet" of a university should be a consciously curated and carefully produced educational offering on a voluntary basis. The three dimensions of pastoral care can represent a blueprint for achieving an academic holistic approach in the arts in the digital world.

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Rethinking Experiential Learning in Design Education

The Shift of the Systemic Design Course to a Multimodal Online Learning Environment

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The outbreak of the Covid-19 pandemic has generated serious consequences on the higher education sector, highlighting its existing vulnerabilities and forcing it to face complex challenges. However, the current situation can also be seen as an opportunity to deeply rethink the learning activities and the environments in which they are carried out, whether online or in the classroom, designing long-term innovation plans that extends beyond the end of the crisis. The paper aims to explore the process of redesigning an experiential and social learning course for an online learning modality. The reported case study, the Systemic Design course held in the M. Sc. in Systemic Design at Politecnico di Torino (Italy), was analysed in order to identify and address its main challenges, related to the redefinition of its learning activities and the improvement of the interaction and cooperation between the different actors in a context of social distancing. The project led to the adoption of new strategies and tools, tested on the course itself.

Keywords: Systemic Design; Systemic Education; constructivist teaching; experiential learning; social learning.

1. Introduction

The current Covid-19 pandemic has generated significant consequences on most aspects of our lives. The need for social distancing has imposed the substantial, quick, and unplanned reorganization of many human activities, sometimes determining a strong shift from their traditional forms.

In this scenario the educational sector suffered heavy consequences, from primary to higher education. Teachers and students were forced to overnight change strongly consolidated habits and to shift from a physically shared learning environment to an online one, in order to ensure continuity in the educational processes.

Online learning is a well-established practice that has seen a remarkable development over the last decade, also thanks to the increasing growth of Massive Open Online Courses (MOOC) platforms (Yuan & Powell, 2013; Liyanagunawardena, Lundqvist, Mitchell, Warburton & Williams, 2020).

The forced transition to online teaching and learning has encountered various critical issues under many aspects, from the social to the technological, methodological, and organizational point of view, mainly due to the substantial unreadiness and inexperience of the actors involved in the process (Wunong, Wang, Yang & Wang, 2020). This condition has significantly accelerated, albeit not spontaneously, the adoption of online educational forms, offering an unrepeatable opportunity to test and experiment innovations capable of generating long-term effects on the educational sector.

For what concerns higher education, some examples of how different courses have been adapted to better fit the new global scenario can already be found in literature. However, this adaptation process entails further challenges in the case of experiential courses, in which the activities and the interaction within the teaching space are essential elements of the learning experience. Some useful examples can be found in relation to STEMM disciplines, requiring extensive use of specific equipment to carry out hands-on experiments. Bhute, Inguva, Shah & Brechtelsbauer (2021) describe different online and hybrid modes for those disciplines and they also define the tools and the resources needed to enable the transformation towards new learning

environments.
However, narrowing the research to experiential courses belonging to the field of design, it emerges that the literature is still incomplete and fragmentary, mainly because of the recent and unprecedent time in which those processes took place.
Consequently, this paper aims to specifically focus on the online transition of experiential design courses in higher education in order to determine which design actions become necessary when the condition of unity of place-time-action is deprived of its first element, the physical space. This question is addressed through a specific case study, the Systemic Design course held at Politecnico di Torino (Italy). This course is characterized by a peculiar learning approach and social structure and it offers a unique opportunity to tailor an effective online learning experience.
The paper is structured as follows. The case study section is dedicated to an overview of the course, with a particular focus on its educational approach. The following section defines the methodology used to design the transition from a physical to an online environment and the three identified challenges. In the fourth and fifth section the project is presented and its outcomes are reported and discussed. Finally, the main findings and limitations are defined in order to state the challenges and opportunities related to the current scenario, aiming to set new trajectories for the Systemic Design education and, in general, for experiential courses.

2. Case Study

The relevance of the presented case study is given by its learning environment, which was historically meant as the context in which relations between the actors of a learning community take place and not just as a space providing tools and equipment useful for the fulfilment of specific activities.
The Systemic Design course takes place in the last term of the Master of Science in Systemic Design "Aurelio Peccei" at Politecnico di Torino. It is part of the Open Systems module, consisting of four strictly connected courses providing theoretical, methodological and design tools to face complex problems related to the environmental, social, and economic sustainability of a given scenario, with a holistic approach. The four courses are Procedures for Environmental Sustainability, Economic Evaluation of the Projects, Theory and History of Systems and Systemic Design. The courses work together to create a cross cutting and transdisciplinary learning environment, according to the definition of Piaget (1972).

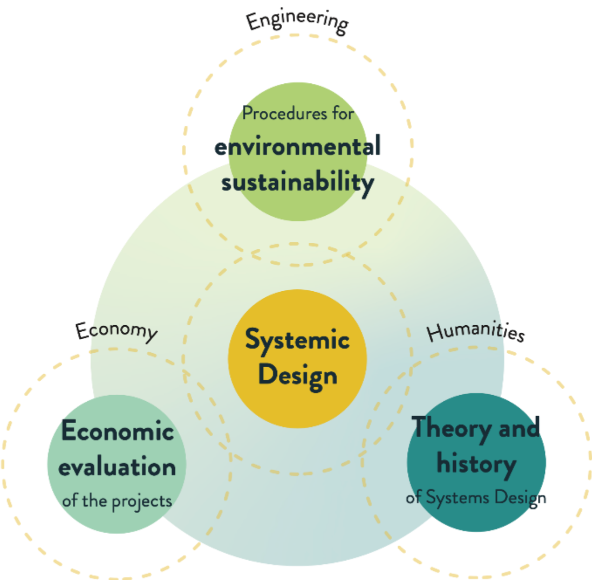

Figure 1. Representation of the four courses of the Open Systems module

The Systemic Design course has a twofold nature: it coordinates the other disciplines and it is primarily involved in the development of the projects carried out by international students in a real experimentation lab. The course aims to design the flows of energy, matter and information of a given productive process and its context in order to generate a new open and autopoietic system based on the relationships between its actors, in which the outputs of a process become inputs of another one (Bistagnino, 2011). In this perspective, the Systemic Design methodology (Bistagnino, 2011; Battistoni, Giraldo Nohra & Barbero, 2019) is taught, which is readapted into four key moments, given the specific educational context:

1. **The Holistic Diagnosis**, a mapping of the state of the art in which a quantitative and a qualitative analysis of the context is performed at different levels of investigation (social, economic, environmental) and visualized via infographics and gigamaps.
2. **The identification of challenges** of the context **as opportunities** for the new systemic project.
3. **The Systemic Project,** redesigning flows of energy and matter and valorising the waste as a resource.
4. **The Study of the Outcomes**, evaluating the benefits for the territory at different levels (social, economic, environmental).

This methodology allows the student teams to work on real case study companies and to face a direct and effective learning experience, shortening the distance between academia and the productive world. Since 2018 more than 60 partner companies settled in Piedmont Region (Italy) have been actively involved in the course, cooperating with students to redesign their productive model. Those companies span from small to large enterprises and belong to different sectors, including agri-food, textile, building and construction, engineering, cosmetics, and others.

The educational approach of this course is strongly influenced by Systems Thinking theories and practices, deeply rooted in the theory of complexity, which evolved on the basis of Von Bertalannfy's General Systems Theory (1968) and which influenced the Cybernetics Theory, the works of Odum on ecosystem ecology (1975) and Capra's living systems (1997). Moreover, it is connected to the Constructivist Theory of education, in particular for what concerns the contributions of John Dewey (1938), Jean Piaget (1950) and David Kolb (1984).

With this strong theoretical and methodological background, the key features of a Systemic educational approach can be summarized as follows:

- It aims to develop a holistic, critical, and connected mindset in the learners.
- It identifies the experiences as sources of learning.
- It generates circular flows of information and knowledge instead of linear ones.
- It is based on the active role of the actors of the educational process and their mutual relationships.

For what concerns the given case study, those principles have shaped the structure and the methods of the course and are put into practice with different solutions and strategies (Battistoni & Barbero, 2017).

The transdisciplinarity of the module allows the enrichment of the four involved disciplines thanks to their mutual influence and contamination, creating new fluid relationships between the different contributions (Celaschi, Formia & Lupo, 2013; Peruccio, Menzardi & Vrenna, 2019). Moreover, this process contributes to the development of co-disciplinary skills in the learners (Blanchard-Laville, 2000). Such an asset is fundamental for the role of the Systemic Designer intended as a mediator between different disciplines (Celaschi, 2008).

In order to create an experiential learning environment, the Systemic Design course adopts a learning-by-doing approach, derived from the theories of John Dewey. As he stated in "Experience and Education" (1938), fruitful experiences can positively influence the learner's development, both in the short term (with their agreeableness) and in the long term (with their impact on the future experience, the so-called experiential continuum). Those principles are applied in the course with a project-based learning, allowing students to directly approach the real world and its complexity. Experiences are not limited to the above-mentioned situations, in fact every activity, from the group work to project reviews involving students and teachers, becomes a learning experience capable of developing some useful skills in the students.

Lectures are also designed as condensed methodological contributions, in which students can build new knowledge by inter-relating the new content with their previously acquired notions without falling back into a transmissive, hierarchical, and passive learning modality. This required the re-definition of the role of the professor, who becomes a mentor and a facilitator of the learning process (Forbes, 1994), adapting his approach towards the learners according to the specific activity carried out in the class (Kolb, 2017).

All those features help to emphasize the importance of relationships within the physically shared educational space, in bidirectional flows: among student teams and professors, among professors and among students, giving shape to an active educational community which is the foundation of the course itself.

However, the social distancing has dealt a heavy blow to the course, depriving it of its physical learning environment and jeopardizing its success. Consequently, the need to design innovative solutions to deliver the course in an online mode has emerged, answering to the weaknesses of current experiences where the traditional educational model has simply been proposed in an online version.

3. Methodology

Given the background stated above, the course has been redesigned taking advantage of the Holistic Diagnosis tool (Battistoni, Giraldo Nohra & Barbero, 2019). The first step consisted in fact in the analysis and the visualization of the whole module, taking into account the actors, their activities and interactions, the structure and the timeline of the courses, the teaching contents and methodologies and the required deliverables. Therefore, three main challenges have been identified:

1. Redefine the way in which the educational activities are carried out, in order to maximize interactivity.
2. Preserve and improve the effectiveness of the interactions among the actors of the course.
3. Identify new ways to ease remote activities such as group work, cooperation, and discussion between peers.

The following steps of the methodology consisted in the research, the comparison and the definition of the best strategies and tools to face the previously mentioned challenges, which were then integrated in the new educational model currently being tested in the course.

4. Project

In order to address the challenges of the online transition, different methodological, organizational, and technological solutions (De Rossi & Ferranti, 2017) have been analysed, following these selection guidelines:

- the active involvement and collaboration of the actors must be preserved;
- the activities must be conveyed in ways capable of guaranteeing their effectiveness;
- the activities must be characterized by a strong coherence and continuity;
- the tools used in the course must be highly integrated;
- the experience must be accessible without strict technological requirements.

The following paragraphs better explain how the challenges outlined in the methodology section have been addressed.

4.1. Redefine Activities

The first action aimed to increase the duration of the relational moments through the definition of a new balance between theoretical lectures and project reviews. A flipped classroom approach has been consequently adopted, turning a considerable number of lessons into short methodological videos released on YouTube. A Q&A session is scheduled after the release date of each video in order to ensure a deep understanding of the contents.
The videos, starring the course teaching team, are shot with professional equipment and are enriched by texts and animations, emphasizing the key concepts. Their maximum length, about 7 minutes per each unit, was determined on the average student engagement in MOOC videos (Guo, Kim & Rubin, 2014).
A large number of hours, previously occupied by lectures, is now dedicated to the "Systemic Design Talks" in which international experts are involved to deepen the course methodology with their contributions and through open discussions.

Figure 2. A frame retrieved from a Systemic Design lecture, released on the Systemic Design Lab YouTube channel (https://www.youtube.com/channel/UCQSHSdMlqXqG-uSbay8TUqQ/about)

4.2. Improve Interaction

In order to grant a high level of interaction, it was necessary to integrate other tools in addition to the current video conferencing platforms, aiming to shorten the distances and facilitate communication between all the actors involved, even beyond the lesson time.
Consequently, Slack, a business collaboration tool, was selected and transferred to the educational context. This platform allowed the creation of thematic channels for the different courses, workgroups, and topics as well as private ones, allowing new moments of discussion and insights.
Compared to traditional emails and to the Politecnico learning platform, this tool provides greater speed and more communicative possibilities, as well as integrations and bots. If properly exploited, Slack also allows to emphasize the boss-less approach, enabling a more informal communication between professors and students.

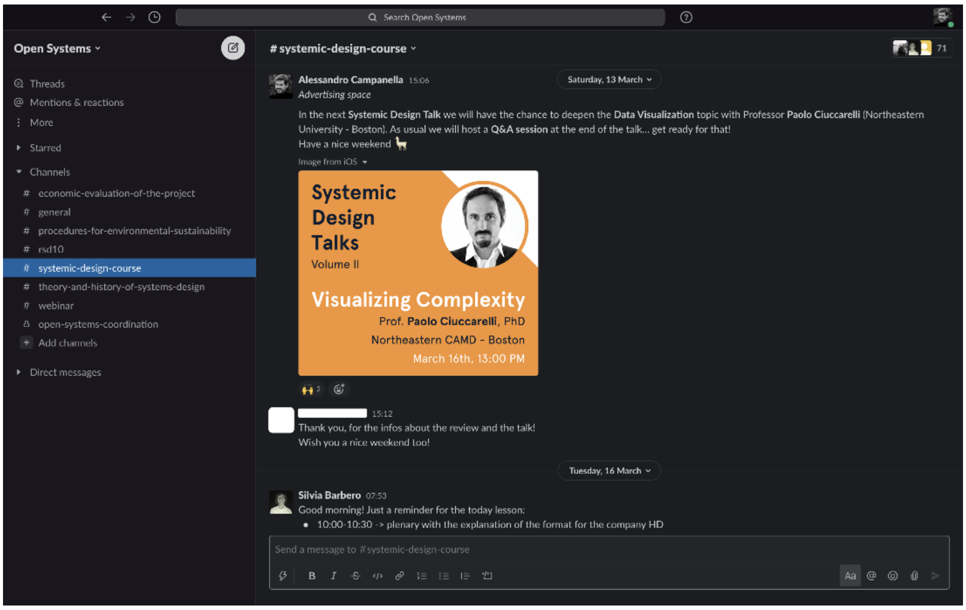

Figure 3. A screenshot of the Open Systems Slack workspace

4.3. Ease Remote Cooperation

The analysis of the activities of the working groups allowed to identify those most influenced by social distancing, that is visual mapping of territorial gigamaps and systems. The first stages of the activity often made use of sticky notes and freehand representations in order to build non-linear and interconnected visualizations (Sevaldson, 2011), then processed with vector graphics software.
The Miro board has the right features to bridge this gap, in fact it provides a shared and multi-user virtual space in which students can view, manage, connect, and comment the analyzed data and their visualizations, ensuring an effective and simultaneous teamwork experience.

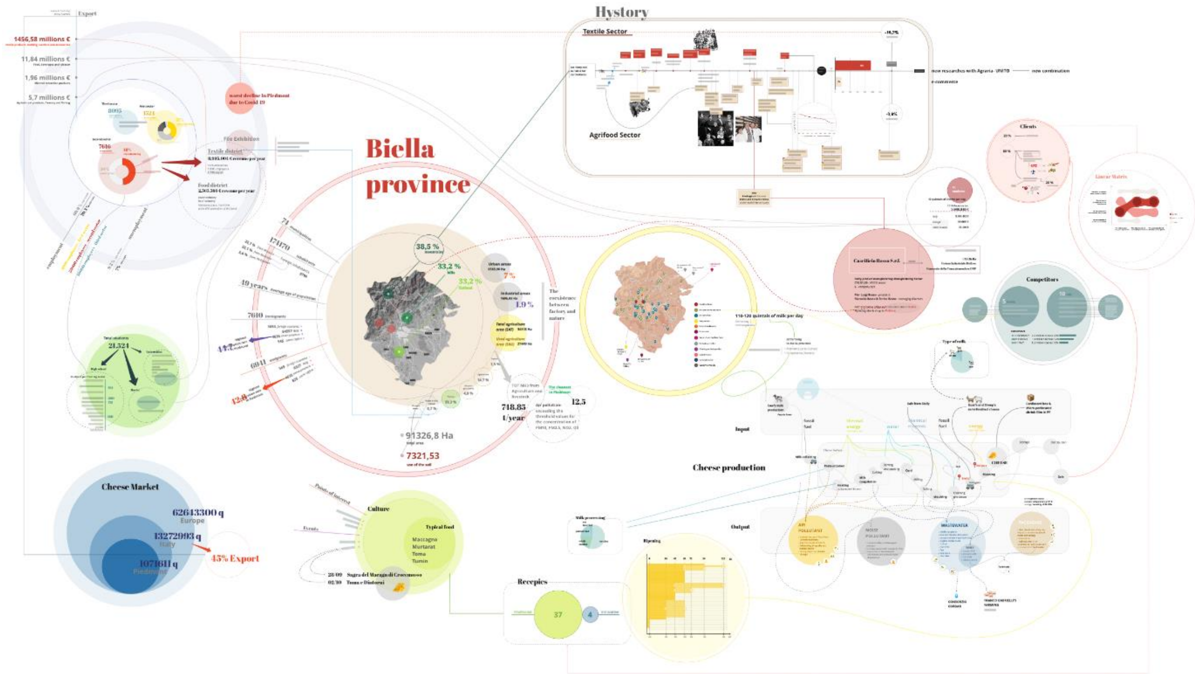

Figure 4. A territorial gigamap made on Miro, courtesy of A. Marchesi, F. D. Moldovan, M. Puglielli, W. Tonelli, M. Troppino and X. Wu.

5. Project Outcomes

The redesign of the Systemic Design course has been completed in January 2021 and it has been tested for the first time during the 2021 semester (March – June). In order to evaluate its results, two different approaches have been adopted: the first one consists in the teaching team's constant collection of qualitative and quantitative data on the overall learning experience, which have been analysed and compared with the ones gathered during the previous course editions, while the second implies questionnaires and open discussions aiming to better understand student's opinions and feelings.

Based on empirical data collected during classes and on questionnaire results, students reported a high rate of satisfaction concerning the clarity and quality of the video lessons. Thanks to the theoretical and methodological background provided through the video contributions, they have proved to be able to confidently master the methodological contents and to apply them into their projects. In the same way, Systemic Design Talks have been appreciated by the majority of students, who frequently interacted with the various international experts during the Q&A sessions hosted after each Systemic Design Talk.

Concerning the use of Slack, a high percentage of daily active users has been reported (90%-100%) and almost 30% of them were posting and interacting on a weekly basis. This tool has been exploited by the teaching teams of the whole module to quickly update the class about their courses and to frequently give them detailed information about the schedule and the required deliverables. Regarding the interaction between teachers and students, many of them took advantage of this tool to directly connect with the teaching team, explaining their doubts and asking for clarifications and advice.

Anyway, despite its evident strengths, Slack has never been exploited by the students to openly discuss and conversate about topics related to the course itself. It is therefore evident that this kind of online platforms are not the best tool to host and support those activities, for which, according to the students themselves, physical presence is still an essential element. This reticence has also been noticed during the Q&A sessions held on Zoom, in which some students struggled to overcome the psychological barrier represented by expressing their opinion in front of their classmates during an online lecture. Instead, the introduction of poll and open questions supported by tools like Mentimeter contributed to lower the psychological barrier, thus facilitating interaction during these sessions.

Miro, instead, played a key role in the whole module. It allowed the groups to reach an outstanding level of visualization richness and complexity, especially if compared to the works produced in the previous editions of the Systemic Design course. Obviously, some groups encountered several difficulties in carrying out their projects remotely, but the vast majority recognised that the widespread and systematic use of Miro really changes the experience of the online course for the better, as it represents a highly efficient tool to work on

complex data without meeting in person.
Combining all those considerations, a promising scenario can be envisaged: the selected tools and strategies are generating positive effects on the educational environment, actively contributing to shorten the gap given by the absence of a real shared space. The integration of the recorded video lessons, the weekly reviews and the interactive live discussions are witnessing to be a useful way to preserve the relationships among the actors of the course, while supporting the effectiveness of the interactions and the activities.
Anyway, some of the natural nuances of human relationships, typical of the experiential and social learning environment, tend to emerge with greater difficulty in such virtual contexts. Despite having little apparent relevance, the informal interactions established between students in the physical space are important catalysts of possible relationships. Indeed, these interactions help to weave connections between groups, to confront each other, to overcome common problems or simply to socialize and empathize as actors belonging to a common social context.

6. Conclusions

The current pandemic has posed major challenges in the educational field. In the case of the Systemic Design course, run at Politecnico di Torino (Italy), these have been addressed as opportunities to innovate the learning experience on the basis of consolidated educational methodologies. During course redesign phase, new strategies and tools have been identified to reshape the activities and to support interaction and collaboration.
It is possible to state that the main limitation of this new solution lies in the difficulty, given by the virtual environment, to encourage spontaneous and informal interactions. In this regard, the digital solutions introduced in the course are fundamental and efficient tools and, at the same time, barriers that often stand in the way of informal and instinctive communication. Despite the exceptional results reached by most of the groups under the lens of the project results, the lack of a common and physically shared experience determined a less solid and remarkable connection between the teams. This is evident from the tendency to individualism that has sometimes been developed by the groups, a phenomenon that was much less prominent in the previous editions of the course.
Another criticality can be found in the lack of unified digital solutions integrating the different tools required by the case study course, even among the most popular Learning Management Systems. Consequently, the forced adoption of different standalone tools has sometimes resulted in a fragmented user experience.
The research also highlighted that it is necessary for professors to quickly acquire new digital and communication skills to better involve and engage the students. These new skills imply the essential and critical ability to innovate and change well-established habits (Humphreys & Hyland, 2002).
Moreover, the holistic diagnosis performed on the systemic design class in a pre-covid scenario enlightened how the physical structure of the class and the distributions of the furniture hampers the relational dynamics at the base of this course. Thus, the future return to physically shared spaces will have to imply the re-thinking of the learning environments. The same analysis can be performed in other educational environments, highlighting challenges and opportunities, also considering that many of the obtained results will persist beyond the current crisis.
The case study has indeed some limitations, as it refers to a specific educational environment. However, most of the proposed solutions can be easily transferred to other courses and disciplines implying practical knowledge. In conclusion, this work aims to contribute to the discussion around the topic of online education in experiential design courses based on social interaction, favouring the comparison and sharing of possible innovative solutions.
Despite its limitations, the main contribution of this paper stands in the proposed model of integrated knowledge, strongly grounded on the Systemic Design methodology, which:

- redesigns the traditional learning experiences and environment, through a wise combination of synchronous and asynchronous activities, in order to maximize interactivity;
- preserves and, sometimes, improves the effectiveness of the interactions among the actors of the course, through communication tools;
- Identifies new ways to ease remote activities like group work, cooperation, and discussion between peers through collaborative virtual boards.

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Utilising Collaborative Online International Learning

COIL as a Pedagogical Framework for Design Thinking Projects

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The University of Derby (UoD) and Jiangxi University of Technology (JXUT) run annual, joint projects that provide students with an opportunity to develop cultural awareness and work on participatory Design Thinking and professional practice projects. These have normally taken place on the Derby campus but in 2020/21 the teaching delivery moved entirely to a virtual realm, due to the Covid-19 restrictions in the UK. This year, participants were tasked to propose products and services to improve student wellbeing in inner-city areas. This case study presents the results of this collaboration. The online Design Thinking project, undertaken by UK and Chinese students utilises the COIL framework (Collaborative Online International Learning). The goal of this approach is for students to become independent critical thinkers, who use empathetic methodologies to Design. Furthermore, it will present visual samples of students' work and present how online real-time interactive platforms facilitated their research and communication skills. The conclusion summarises what was learned from this way of working, together with suggestions of how this might feed into design pedagogy in the post-Covid era.

Keywords: Online Learning Environments; Design Pedagogy; Participatory Design Thinking

Introduction – Case Study 2021; Outlines

The Design Thinking project presented in this case study is a part of the ongoing partnership between UoD and JXUT. It reflects the objective of advancing students' capabilities to work within collaborative and participatory, methodological contexts to build confidence in team-work skills and utilise interdisciplinary methods in their thinking and making processes. These types of projects have been running since 2017 and would usually take place in a studio environment on campus. Due to Covid-19 restrictions in 2021, all teaching and work were moved online to Microsoft Teams (MST) and Miro. MST replaced face to face delivery and allowed for virtual communication channels that students could use privately or as a group. The studio environment was moved onto Miro, a real-time interactive platform that hosts student-designed collaborative exhibition spaces.

A mixed group of Level 4 & 5 Interior and Fashion Design students were briefed to propose solutions in the form of products or services that might improve student wellbeing in the Derby inner city area. This was to be visualised through data and process mapping that would be informed through contextual, site and visual research. For the participating international students from China, this project was also a first introduction to Derby as their new place of study and residence.

Design Thinking modules are a firm part of the UoD curriculum and act as a core learning development asset for conceptual and practice-driven work. The benefit of these modules and briefs lies in their ability to present inter-disciplinary and exploratory environments for students, in which they can experiment and further their critical thinking and making skills (Razzouk & Shutte 2012).

The learning objectives set in this brief revolved around students' core-skill development; their competence to work in interdisciplinary teams; critical thinking about the Design process and improvement of their practice and methodologies through diverse inputs, experimentation and crit.

The Framework: Collaborative Online International Learning (COIL)

Due to the prompt shift from campus to online study, the framework of the project could no longer rely on studio pedagogy alone but had to take a hybrid form that would correspond to the new shared learning environments. Although studio pedagogy reiterates the necessity of interaction and designing in a creative space (Dutton, 2014, Carpenter, Valley, Napier & Apostel 2013), it was no longer possible to rely on physical interaction, but on simulated spaces that mimicked the exhibitory nature of the studio and workshop. A different framework was necessary to bind project objectives with student development and experience that would build on positive and supportive networking as the main driving force for collaboration, whilst fostering holistic methods to Design Thinking and making. In the process of looking for models and frameworks for this shift to blended and online learning, lecturers at UoD came across an online learning model that was written within the parameters of Design Thinking and participatory practice. The COIL framework was founded and developed at Coventry University, as a model for online collaborative short projects between UK and International students, who were predominantly from China (Hilton 2019). At its core, COIL aims to create inviting, interactive and playful environments for students to collaborate and work within, whilst allowing for the development of culturally aware and empathetic thinkers and makers. COIL builds on students' intrinsic motivations to learning and sets constraints to working within playful boundaries that are to be individually interpreted but collectively developed and solved (Hilton 2019). As a model, COIL presented an opportunity to frame the project at UoD in parallel to the objectives and proposals that were originally set when the project was to be undertaken on campus. Therefore, this presented an ideal opportunity to test the model in the collaboration of Chinese students who were already residing in the UK and those who were still at home in China. This case study will present the testing of COIL and analyse its application to online learning contexts of culturally related, yet geographically distanced groups of students and how those factors affected their thinking and learning.

Barriers to Collaboration

In Chinese education, it is common for the students to attend seminar lectures (Sit 2013), where a passive learning style is fostered (Zhu & Gao, 2012, Hilton,2019). In this model, students listen to the material, take notes and then proceed to study further outside the classroom. At the UoD, Design Thinking is taught in a predominantly interactive way, where all learning is driven through discussion and debate which subsequently encourages peer-to-peer learning. This approach is in stark contrast to the common learning models and methods Chinese students encounter in their home education institutions (Edwards 2006, Qing 2008) and they were therefore experiencing a major difference in approach, to which they had to get quickly get used to. Furthermore, not only did the Chinese students need to get used to different delivery and learning styles, but also to the fact that the briefs were set entirely online. This meant that students were no longer in an open, face-to-face environment, where prompting them to participate was a standard procedure. Being on MST meant that students could choose if they wanted to proactively participate or not. The facilitator's role in this instance was not to force the students to talk or participate on camera but to overcome their anxieties over being put on the spot. One of the main initiators for this fear was the existing language barriers in those students who did not feel entirely confident in their spoken English. This curbed the collaboration from the beginning of the project and meant that alternative ways of communicating and interacting were necessary to run the project.

Alternative Communication Channels

To overcome the differences in learning approaches and existing language barriers, a shared learning Miro board was created (see Figure 1) where all project details, reading materials and finished tasks could be posted on. This way, students could communicate with their peers and lecturers via post-it notes, whilst being in group calls on MST.

Figure 1. Shared Learning Miro Board (Excerpt), UoD & JXUT (2021) Project Developments and COIL Implementation

Once the alternative communication channels and their operation was established and familiarised to the students, the project was faced with its first stage of the Design process, developing research methods that would be applicable to the new circumstances. This posed direct challenges given the geographically linked nature of the brief. Whilst one group of the students was already residing in Derby and had an introduction to its layout, infrastructure and destinations, the other group was still at home in China and had only seen the city digitally.

Figure 2. Shared Learning Miro Board (Excerpt), UoD & JXUT (2021)

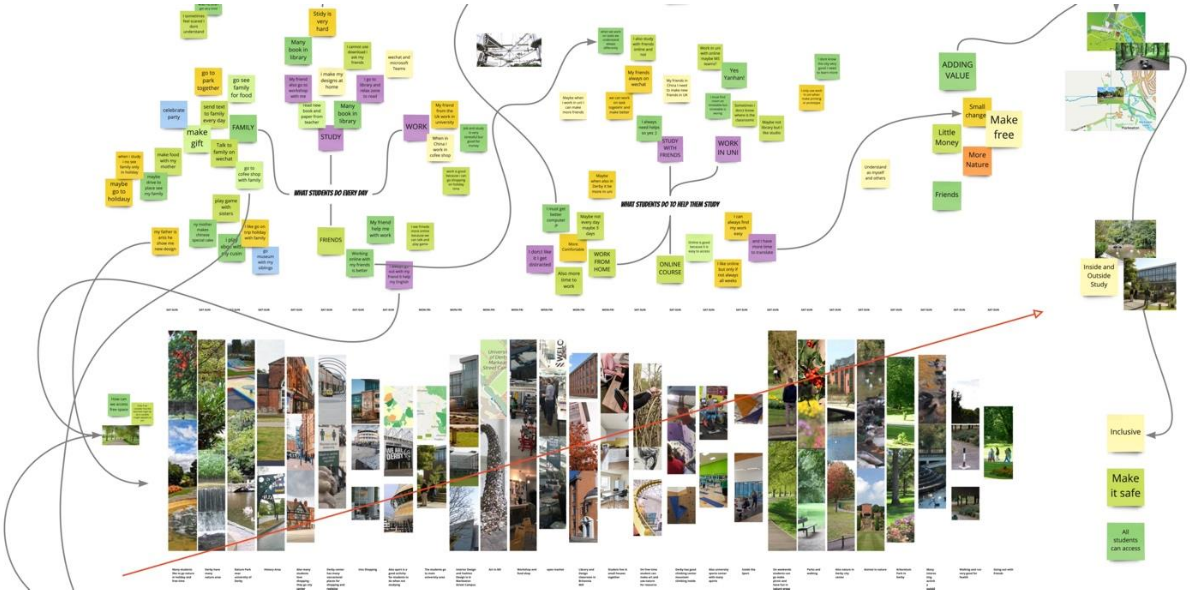

Figure 3. Shared Learning Miro Board (Excerpt), UoD & JXUT (2021)

The groups had to collaborate and develop their own Design Thinking process that would allow all participants to have equal input, whilst recognising and utilising the strengths and specialisms of both disciplines. The COIL framework was used to scaffold the brief in such a manner that students had to rely on both groups' knowledge of the city, as well as their abilities to research about it further in a playful and exploratory way.

The group that was already residing in the UK, did multiple individual site analyses,§ strictly following the government's social distancing rules. Students took photographs and videos of places commonly used by students and proceeded to undertake online Design probes with students who shared dormitories and campus with them. The group that was still in China, did online research and collected data from the local council, study libraries and the student union online spaces. All information was shared and collectively developed into creative and experimental site and context maps (see Figure 2, 3 & 4).

Figure 4. Shared Learning Miro Board (Excerpt), UoD & JXUT (2021)

Throughout the project, students increasingly became more open to discussion and collaboration, and the video call meetings hosted through MST became longer and busier with each stage of the research. Interior Design students were able to contribute with their knowledge of site research and analysis and share those methods with their colleagues from Fashion Design. Simultaneously, students from Fashion Design shared data collage visualising methods with their Interior colleagues, resulting in new collaborative visual methods evidenced on the shared Miro.

COIL as Constraint

Evidently, by framing the project around COIL's playful knowledge exchange and encouragement of experimental Design Thinking, students were able to overcome their initial language barriers and develop their creative and critical skills further. However, due to the open nature of COIL and the students' need to undertake self-directed collaborative study, the majority were asking for clarification of research roles and how the amount of work each group did was to be justified. This was not only an issue that emerged out of the acclimatisation from a Chinese to a UK learning structure but also an issue of data accessibility. In the example of the group that was in the UK, students were able to undertake site studies on locations and collect qualitative data directly, whilst students in China could only rely on information that was available online. This led to discussions about parameters of quantity and how students could evaluate the impact of both sets of data. Given the open-ended nature of COIL and its emphasis on peer learning, coupled with the students' pre-existing patterns of working, occasions arose where groups felt directionless and unable to generate tangible proposals.

The challenging circumstances also posed questions about the lack of experience of site research that students who were not in the UK missed out on. Whilst a common method in Design research, when undertaken in groups, site research presents an opportunity for further shared learning experiences that foster a stronger team ethic. Something that should be anticipated in the future for similar projects is this imbalance in opportunity research experience and how it might be used more intentionally to promote an exchange in knowledge between students. These debates were subsequently addressed in the online sessions, where through peer-to-peer learning, students taught one another about the different methods to visual research, however, it is yet to be tested further if aspects of physical research can work within this paradigm.

Although these are not straight criticisms of COIL, these might be adjustments to bear in mind for future projects, where the learning and pedagogical adaptations are anticipated and pre-calculated in advance before being converted into a transitioning period.

Ultimately, the desire for a specified purpose that the Chinese students sought was complemented and extended through the free-flow real-time interfaces used and translation of the studio environment to a more constrained domain. Furthermore, the opportunity for some students to conduct site research where others could not, facilitated their roles as experts within their groups, encouraging them to share knowledge and develop their communication skills.

Evaluation

Throughout the collaboration between the UoD and JXUT, undergraduate students from Interior and Fashion Design worked on a collaborative Design Thinking brief, proposing products and services to improve student well-being in the Derby inner-city area. The brief was successfully delivered online using MST and Miro as digital learning and working platforms, allowing students to replicate social and participatory elements of a studio environment.

By framing the project around COIL, both groups of students, although in different countries, were able to undertake exploratory and playful investigations together, whilst developing new research and visual methods to enhance their practice and methodologies. This collaboration and knowledge exchange produced several creative site and data maps, which led to numerous proposals to solve the brief. Although students needed to get used to a new learning approach and structural attitudes, COIL allowed for the generating of skills and a knowledge-driven creative enquiry.

It is worth mentioning that throughout the process, a transformation in student engagement and adaptation to the UoD teaching methods was observed through the use of COIL. From the start, Chinese students were hesitant to participate and felt at unease to talk out loud in MST calls, fearing it might come across as rude or disrespectful to the lecturer. This was not an act of passiveness but one of respect. Just as Chinese students adapted to the UK learning models, UoD lecturers learned about these cultural aspects, and rather than dismissing them as barriers to learning, they celebrated them by acknowledging the value it was adding to the overall learning experience of the whole group. These investments into their culture and values were rewarded with a new openness of students, who consequently started to initiate conversation and discussions in online meetings.

Additionally, within a Design Thinking learning environment in which failure wasn't seen as a negative attribute, but an opportunity for great achievement, students found themselves faced with different ways of approaching critical thinking and designing. COIL directed this experience up by placing the students into the position of the main investigators, critics and creators, whilst fostering a dynamic and respectful approach to all participants. The openness of the brief and the active encouragement of students to undertake their

research playfully rather than following a strict and prescribed model was a completely new way of learning and working for these students.
The outcomes of this project were not only reflected in the produced visual material but the enhanced learning experience of the students, who subsequently asked if these types of projects will continue on campus later on in the semester. The untrue stereotype that Chinese students are passive learners (Radclyffe-Thomas, 2007) and do not perform in participatory environments was overturned throughout the whole length of this project. Not only were these students the initiators of communication and investigations but it was also clearly demonstrated that they have shown a vast tolerance to uncertainty by overcoming any barriers collaboratively through discussion and team-work.

Conclusion

Though collaborative and participatory approaches to Design pedagogy are already common practice at UoD, such endeavours have always shown difficulties if they included international students with language or cultural barriers. Through COIL and utilising online collaborative tools such as MST and Miro, students were not only able to overcome their barriers to learning but unlock their intrinsic motivations to develop in dynamic studying environments, that didn't dismiss their situation but rather celebrated their diverse input and knowledge.
Whilst COIL proved to work well in an online environment, it should not be dismissed that the same approaches and tools would have benefits in face-to-face teaching, which is yet to be tested after the UK Covid-19 social distancing measures are fully lifted.

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Hybrid Spaces Teaching for "Chinese Traditional Costume Craft"

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The general teaching mode for practical courses of design education was demonstration teaching by face-to-face and step-by-step. This exploration perhaps could provide a teaching method as a reference for practical courses in other design contents. An improved teaching mode about Chinese traditional costume crafts focusing on hybrid spaces including online teaching platforms, digital technology, and virtual interactive learning was introduced. Lu embroidery as the teaching object was shown in this case study. Online teaching platforms and interactive learning system of crafts based on virtual technology were employed, and students were required to study embroidery knowledge and crafts by self-learning at pre-class activities. Intangible cultural heritage inheritors and teachers at physical space discussed with students face to face and guided students to carry out innovative designs. This case study demonstrated that hybrid spaces for design education could improve the ability of students' self-learning and teaching efficiency.

Keywords: hybrid spaces; Chinese traditional costume crafts; teaching online platform; interactive learning

1 Introduction

"Chinese traditional costume craft" is a practical course of the fashion design discipline (Li et al., 2017). Its content includes theoretical knowledge and practice. The theoretical content was recorded into a video and uploaded on an online platform. Students could freely arrange a time, learn online by themselves and complete knowledge assessment tasks according to the course requirements. Practice required students to learn basic traditional clothing crafts through an interactive learning system based on virtual technology. Li Shengnan et al. (2018) presented similar method. They completed a traditional Chinese clothing display system Based on virtual reality technology and Unity3D development tools. Intangible cultural heritage inheritor helped students understand the ingenuity of craft by on-site teaching. Guo Chen et al. (2018) pointed out that the virtual reality interactive teaching approach could expand upon traditional teaching methods for fashion design and the study of traditional costume for design development. Then, students innovated the basic crafts while fully mastering them and designed works that met the current aesthetic needs (Ma et al., 2012).

To meet the different requirements of teaching goals at every stage, the hybrid spaces teaching mode of this course means that physical space and online virtual space were used at every stage, such as pre-class, in-class, and after-class activities.

2 Hybrid Space Teaching Implementation

2.1 Pre-class Conceiving and Resource Preparation

Pre-class conceiving

For the characteristics of the practical course, the teaching group comprehensively analyzed study habits, interests, performance, personality characteristics of students, and considered the features, course goals,

completed courses, follow-up courses. Then the course was conceived pre-class by a teaching group. A complete chain of teaching links was planned, and the content of each link was detailed as follows (figure 1). The first step in the teaching program was course analysis and student analysis, then the next step was planning teaching goals and content. Finally, according to these goals an online teaching platform was chosen, teaching group prepared to the teaching resource, determined teaching tasks, formulated learning evaluation rules, and set learning outcome display methods. A summary and reflection would be conducted when the course was over, and the teaching program of the course was adjusted to improve the teaching effect continuously.
Because practical courses needed to spend a lot of time on work guidance, teacher-student interaction was frequent, each link must be in-depth and meticulous, and needed to consider the smooth transmission of teaching information from teacher to student.

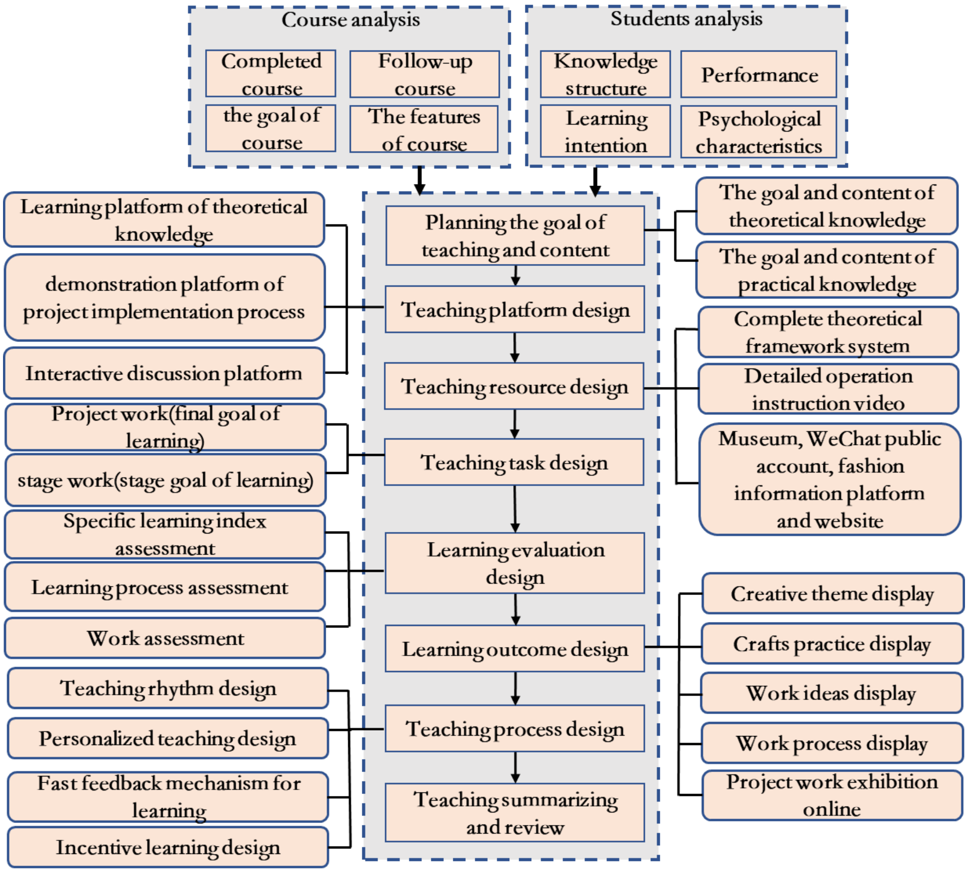

Figure 1. The mind map of the teaching program.

Preparing online pre-class teaching resource

Theoretical knowledge of traditional costume crafts included four categories: weaving, printing-dyeing, embroidery, hand sewing. The pre-class theoretical knowledge has been recorded. The videos were made by a professional team. Examination points such as the quiz and special discussions were set up in videos of the course. The content of the course was uploaded on the online platform.
There was a wealth of craft types in the practice content of traditional costume crafts. It was impossible to learn all the crafts in a limited time. Therefore, it could only be problem-oriented and selective learning according to design projects, design tasks in cooperation with enterprises, and self-made Design themes. The final goal results were needed to clearly be presented.
Based on determining the target results, firstly crafts were classified in a modular and thematic manner, and organically divided into fragments. A hierarchical structure was used to build a knowledge system of crafts (Figure 2), and then upload the text and pictures of the fragmented crafts on the learning platform or video files, so that students could choose to study independently according to their own topics.

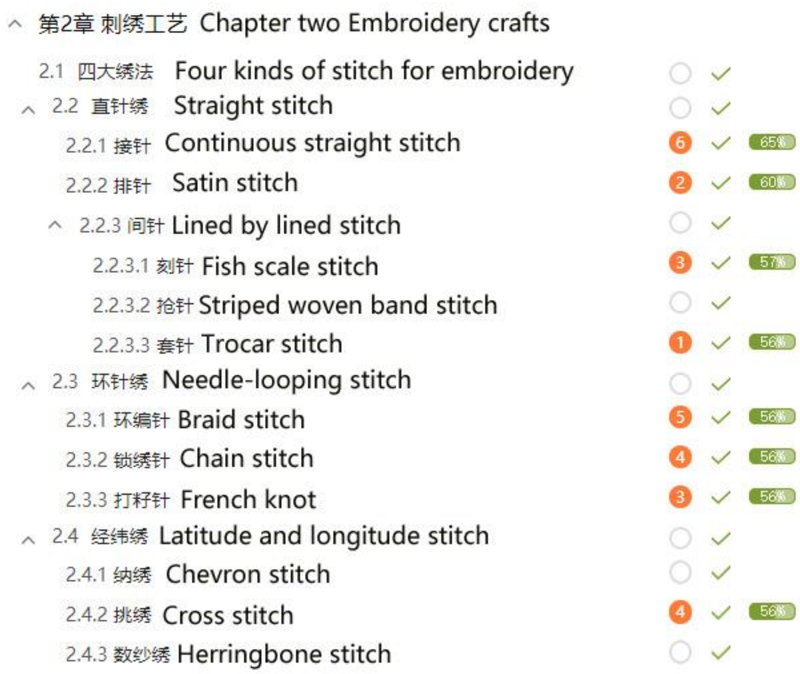

Figure 2. Craftmanship was built in a hierarchical structure. (portion)

2.2 In-class Teaching Implementation

Hybrid spaces

For the effect of theoretical knowledge learning in practical courses, the teacher group conducted a comparative analysis between the online platform and traditional face-to-face teaching in the classroom by analysis of survey results (as shown in Table 1). In pre-class activities, students began to learn theoretical knowledge on the online platform in hybrid spaces mode. Then teachers guided students to discuss the different methods of traditional costume crafts, respective characteristics, advantages, disadvantages, and how to apply them in the planned target results in physical space. Finally, teachers made a summary. While deepening the understanding of the knowledge having learned, the mode of hybrid spaces also indirectly urged students to think actively and open ideas.

Table 1. Comparison of Two Learning Modes of Theoretical Knowledge for Traditional Costume Crafts

Points	*Hybrid spaces teaching*	*Face-to-face teaching*
The content of theoretical knowledge	knowledge was divided into fragments, diverse forms of knowledge, however, knowledge expansion was limited.	According to the class schedule, single form of knowledge, but knowledge could be freely expanded.
Learning time	Free to arrange.	By course schedule.
Learning methods	Repeatable self-learning.	Non-repeatable passive learning.
Teaching interactive	Online Q&A and discussion, Free and plenty of time, and discussion was insufficient.	Face to face communication and Q&A, discussion was sufficient, but time was limited.
Teaching management	Automated, flexible time, and get feedback quickly.	Required teachers to control flexibly, and teachers complete statistical analysis after class.
Teaching efficiency	High efficiency and realizing the flipped class mode	Less knowledge learned in the same class time

On the online platform, the modular and thematic knowledge of traditional costume crafts was presented in the form of videos, pictures, and electronic books. Task points and time could be set in videos, electronic books. There were data records in detail and statistical charts for students' learning activities. The teaching group could check students' learning progress and problems, manage students, assign homework, and organize group learning, etc. on this platform.

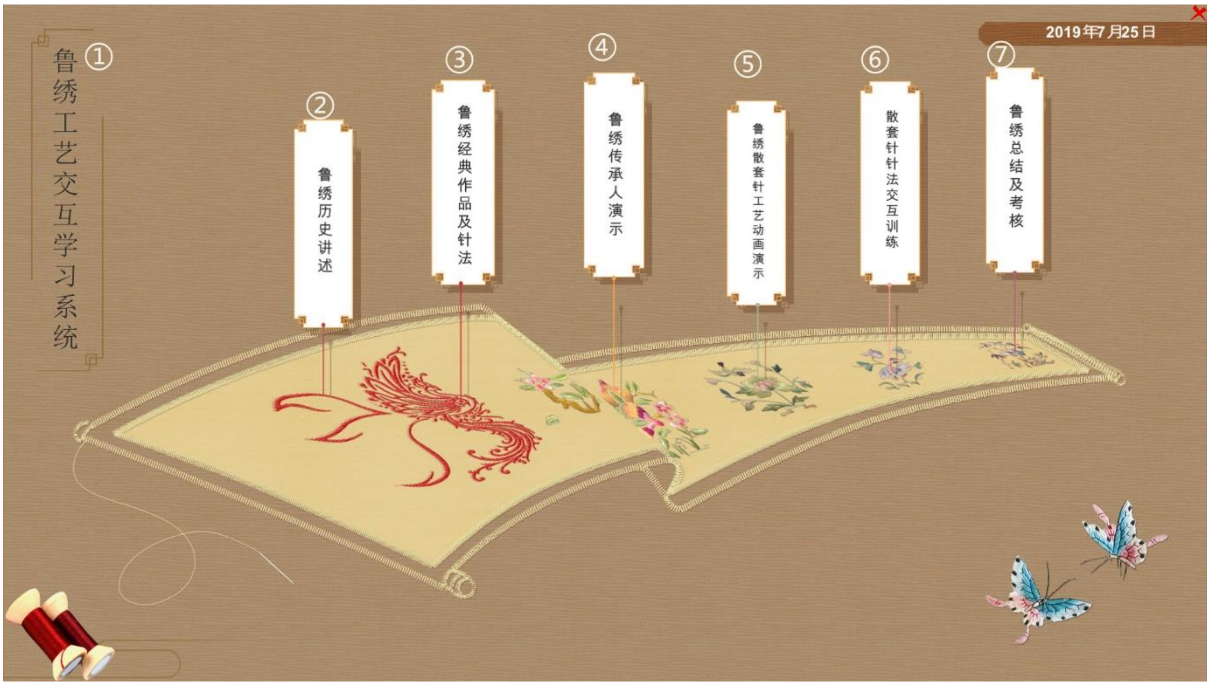

Figure 3. Lu embroidery interactive learning system. Translation: ①Lu embroidery interactive learning system; ②History of Lu embroidery; ③Lu embroidery classic handicrafts and stitches; ④Demonstration of the inheritor for Lu embroidery; ⑤Animation presentation of long and short stitch; ⑥ Interactive practice of long and short stitch; ⑦ Summary and assessment

Virtual simulation technology was tried to apply in in-class process, the teaching group developed the "Lu embroidery interactive learning system" (Figure 3), the system recorded the intangible cultural heritage inheritor's demonstration of Lu embroidery crafts video, and based on three-dimensional animation and interactive technology Lu embroidery crafts interactive learning was developed, which simulated the operation process of Lu embroidery crafts: material preparation, thread splitting, stitches, stitch density, needle arrangement of various batches, and thread changing according to patterns, etc. The system provided an interactive training platform to students with a virtual three-dimensional environment.

The virtual simulation interactive learning system was used for the purpose of realizing the flipped classroom teaching. Through interactive learning, students could pre-class preview online and after-class learn repeatedly. It reduced the consumption of class time and improved teaching efficiency. It tightly coincided with the concept of academic credit systems reform which emphasized self-learning and more time for practical teaching. Breaking the restriction that craft could only learn by on-site demonstration and follow-up. Creating independent learning opportunities for students restricted by time and space. The interactive creation in the virtual environment solved the problem that students could complete the innovative design of Lu embroidery without mastering the actual skills of Lu embroidery, which made up for and solved the shortcomings of the intangible cultural heritage inheritor's on-site teaching.

In-class activities at physical space

Theoretical knowledge was only learned through the online system, which could not solve the problem of internalization of knowledge. It was also necessary for teachers to organize in-class discussions and methods of creative design in-class discussions to help students complete the construction of the knowledge system, so as to achieve the internalization of knowledge and truly realize the transfer of knowledge for students.

If traditional costume crafts only displayed through videos and pictures, it could not be real, three-dimensional, and experiential learning. Intangible cultural heritage inheritors were invited to conduct on-site teaching in the classroom (Figure 4), it not only allowed students to experience the charm of traditional costume crafts fully, but also students had ideological resonance with the ingenuity of intangible cultural heritage inheritors during in-class teaching.

Figure 4. An intangible cultural heritage inheritor was demonstrating the traditional costume crafts.

In order to strengthen the interaction among students, according to the different content of the practice work chosen, students were divided into several groups and discussions are conducted in every group. Experiences and lessons obtained in the practice process are shared, so that they could fully participate in learning activities. The teaching group made comments and feedback timely at appropriate times and guided students to innovate. The teaching group conducted personalized guiding by summarizing the students' problems, experiences, and submitted assignments in the process of practice, uniformly explained some common problems, gave individual guidance to individualized problems, and helped students find reasonable solutions.

2.3 After-class Evaluation and Reflection

The hybrid spaces teaching mode stimulated students to self-learning, abandoned the traditional passive learning mode in-class space, and a more comprehensive process evaluation form was adopted for achievement assessment. 92% of students thought that the fragment learning form of theoretical knowledge could freely administer time and had a better effect for absorption. It provided good feedback for new teaching forms such as intangible cultural heritage inheritors' participation in teaching and virtual simulation interactive learning. Learning theoretical knowledge online and breaking the traditional teaching time and space limitations of practical teaching, teachers, and students could communicate and discuss at any time. Through this teaching practice, it was discovered that how to reasonably set the assessment points and supervise students to complete the pre-class preparation independently were the focus of online teaching for the hybrid spaces teaching mode. The effect of on-site teaching for intangible cultural heritage inheritors was indeed very good, however, this mode was affected by uncontrollable factors of the conflict between teaching time and intangible cultural heritage inheritors' time and took more money to hire them. Another problem was that there were too many students in the teaching process. Intangible cultural heritage inheritors needed to repeat many times for the same demonstration, which led to the low teaching efficiency (Figure 4). Therefore, virtual simulation interactive learning was introduced. The evaluation of the course was recommended to be comprehensively evaluated from the dimensions of attendance, preview, interaction, participation in-class discussion, and completion of work for hybrid spaces teaching mode.

3 Teaching Summary

After the teaching case of the "Traditional Costume crafts" course was practiced, analyzed, and summarized, the teaching group formed the course teaching mode and process as shown in Figure 5.

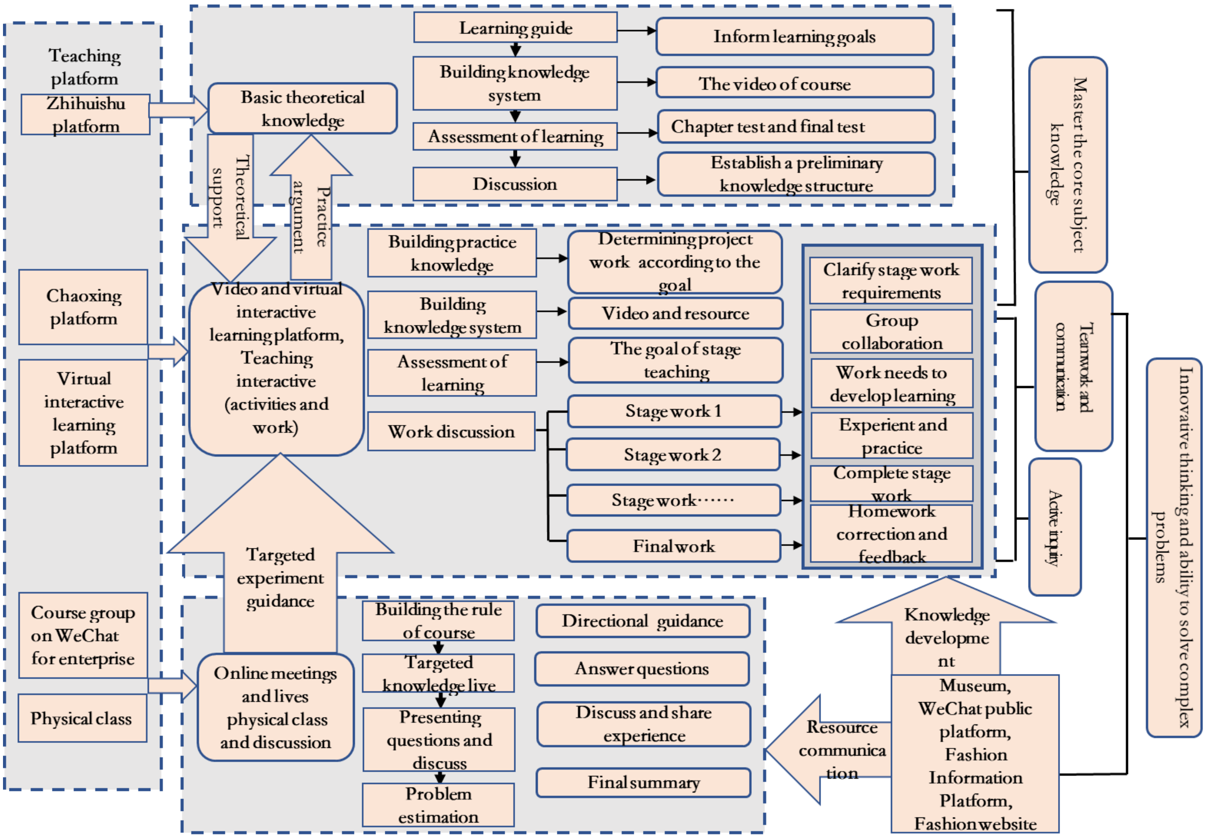

Figure 5. The course teaching method system and process

The teaching case was composed of four online platforms and one physical space. Different teaching spaces of theoretical knowledge and practice raised students' innovative thinking and the ability to solve complex problems. The hybrid spaces teaching fully made use of the advantages of online and physical teaching scenarios to form a complement, improved the teaching efficiency of practical courses, and expanded the teaching space of practical courses. This approach and the insights can be applied and transferred to other design contexts for related practice.

Funding

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Critique Assemblages in Response to Emergency Hybrid Studio Pedagogy

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Studio education focuses on active learning and assessment that is embedded in students' exploration of ill-structured problems. Critique is a central component of this experience, providing a means of sensemaking, assessment, and socialization. These critique sessions encompass multiple types of interactions among students and instructors at multiple levels of formality. In most design programs, these practices have been situated in a physical studio environment—until they were disrupted by the COVID-19 pandemic. As a group of educators and design students, we used this disruption as an opportunity to reimagine means of critique engagement. In this paper, we document the creation, piloting, and evaluation of new critique assemblages—each of which bring together a group of technology tools, means and norms of engagement, and channels of participation. We report both on the extension of existing critique types such as desk crits, group crits, and formal presentation crits, describing both the instructional goals of the new critique assemblages and the students' experience of these assemblages. Building on these outcomes, we reflect upon opportunities to engage with new hybrid critique approaches once residential instruction can resume and identify patterns of socialization and wellbeing that have emerged through these assemblages that foster critical reflection on studio practices.

Keywords: critique; studio pedagogy; hybrid educational practices

Introduction

Studio education focuses on active learning and assessment that is embedded in students' exploration of ill-structured problems (Boling et al., 2016). Critique is a central component of this experience, providing a means of sensemaking, assessment, and socialization (Dannels et al., 2008; 2013; McDonald & Michela, 2019), encompassing multiple types of interactions among students and instructors at multiple levels of formality and with differing levels and types of participants. Critique practices have a long tradition as one of the core components of studio practice—part of what Shulman (2005) has termed a "signature pedagogy." However, critique practices have been adapted over time, across design disciplines, and through a range of technological supports (Easterday et al., 2017; Gray, 2019; Jones et al., 2019; Kvan, 2001; Maher et al., 1996).

While there are important virtual examples of critique, such as the virtual studios at the Open University (Jones et al., 2019) and Marshalsey and Sclater's (2020) response to COVID-19 with "distributed studios," the majority of critique practices have been historically situated in a physical studio environment. The pandemic disrupted these practices but provided an opportunity to reimagine means of critique engagement. While we recognize that the urgent pivot to online instruction in Spring 2020 due to the COVID-19 pandemic, and as such we cannot claim that our efforts constitute a deep and considered development of a technology-enhanced online learning environment, instead agreeing with Hodges et al. (2020) that our efforts began as an attempt to pivot to emergency remote teaching, the critique assemblages we have built during the pandemic have served as important reflective tools, serving as a stimulus for reconsidering the role of critique practices in both the physical and virtual studio environment, and we frame our contribution to the design education literature in this spirit.

In this paper, we document these early pilots of different "assemblages" of critique supports, with varying numbers of participants, means of engagement, channels of participation, and opportunities for reflection and deliberation across two different user experience (UX) design courses as these courses moved to hybrid or fully virtual environments. By critique assemblage, we refer to not only the technologies used to support the critique and the social practices that are enacted and supported by these technologies, but also the praxis of engagement and the norms that are performed, strengthened, or in tension through the assemblage. The purpose of this paper is to characterize these critique assemblages and the ways they enabled hybrid and virtual critique interactions and connect the critique interactions to broader historical notions of critique activity in the design studio. We seek to answer the following two research questions in this paper:

- What critique assemblages were used to pivot from residential studio instruction to online or hybrid instruction?
- What are the affordances of these assemblages and how were they experienced and participated in by students and instructors?

Related Work

Over the past two decades, scholars have documented the communicative characteristics of critique, however, this knowledge is largely constrained to a particular physical arrangement with a familiar set of interlocutors (e.g., Dannels & Martin, 2008; Oh et al., 2012). In the sections that follow, we will briefly outline prior work relating to modes of critique, the interest of critical scholars in building studio experiences that are more equitable, and existing approaches to supporting critique practices through technology.

Critique and Studio Education

Critique is used to teach disciplinary knowledge and techniques “just-in-time” (Uluoğlu, 2000), facilitate provision of feedback on student projects (Gray, 2019), inspire reflection on how what is learned can be applied to future efforts (Choi & Rhoades, 2020), and engage students in disciplinary modes of communication (Dannels et al., 2008; Hokanson, 2012; McDonald & Michela, 2019). Critique is increasingly common in online spaces adjacent to creative work (Kou & Gray, 2017; Luther et al., 2015), however, most studio courses rely heavily on physical engagement with critique in a physical setting (e.g., Schön, 1985). Thus, our approach builds upon what is known about critique in physical and digital environments, leveraging pilot work on increasing participation through multiple parallel modalities of critique (Easterday et al., 2017; Gray, 2019). Design education scholars have described types of critique practices along multiple dimensions. Blythman, Orr, and Blair (2007) articulated a range of critique types in architecture education by differing levels of formality and purpose. Oh et al. (2012) later articulated this diversity in relation to levels of formality, degree of privacy or public access, and number of participants. Across both Oh et al. (2012) and Hokanson’s (2012) analyses of critique types, four main categories emerge: the **desk crit** (low in formality and number of participants), the **group crit** (slightly higher in formality with more public access), the **interim review** (higher formality with more participants), and the **public critique** or **jury** (highly formal and high stakes with high public access). In this paper, we will rely on this typology, focusing on desk crits, group crits, and final presentation crits (somewhere between an interim review and jury).

Critical Views of Studio and Student Autonomy

Despite the widespread use of the studio approach in design education, numerous scholars have critiqued the power structures implicit in studio and critique practices, particularly in relation to student autonomy, power relations, and crunch culture (Anthony, 1991; 2007; Dutton, 1991; Gray & Smith, 2016). A strand of research has described the power dynamics between students and instructors in the studio environment, with Crysler (1995) noting that “faculty have tremendous power over students” in the studio program leading to “sexist and discriminatory behavior” as well as “verbal abuse, foul languages, and destructive comments at the end-of-year juries” in the context of architecture education. Other critical scholars such as Dutton (1991), Webster (2006, 2008), Gray (2013), and Blythman et al. (2007) have critiqued a variety of patterns of abuse that are often considered a part of studio’s “hidden curriculum”—harmful norms that are implicitly supported and performed through the rituals of studio. These critique structures are impacted negatively both by the common interpretation of Schön’s model of knowledge building, which was highly individualistic, focusing on the interactions between the individual student and a single expert tutor, without considering “all people learn all the time”, according to a critique by Webster (2008). In addition to these concerns, Willenbrock (1991) and Dutton (1991) underscored the need to critically engage with these power imbalances and abuses, with Dutton calling for educators to “encourage students to voice their difference from normative values and histories to better understand the relations of power that construct their social subjectivity.” In our work, we seek to connect these critical discourses with the concerns of power latent in the performance of the crit.

Technology-Supported Modes of Critique

Increasingly, technology is being used to support the aims of critique practices—both in the studio (e.g., Easterday et al., 2017; Gray, 2019; Gray & Howard, 2015) and using crowdsourced implementations to support creativity support among novices (Cheng et al., 2020; Luther et al., 2015). In this paper, we focus on efforts to extend the support of critique practices in the context of studio education, building on the ad hoc uses of technology reported in Gray and colleagues' work and the purpose-build system described by Easterday and colleagues. In Easterday et al.'s (2017) system, the crowd critique model was intended to provide a wide range of functionality, including "quick invite tools; formative framing; a public, near-synchronous social media interface; critique scaffolds; "like" system; community hashtags; analysis tools and to do lists; along with social practices including: prep/write-first/write-last script and critique training." In contrast, the system described by Gray (2019) emerged organically through the efforts of fellow students with the goal of building "critique capacity," using off-the-shelf tools such as Google Docs to "provides multiple channels for interaction and learning during presentations and shows how learner engagement might be productively—and substantially—increased within the time and physical constraints of the critique." In this paper, we will be focusing our attention on the creation of assemblages of *existing* tools rather than a purpose-built system, describing how we formed connections among these tools to support practices similar to those performed in a residential studio environment.

Methods

In this study, we used an auto-ethnographic approach to identify instructional decisions relating to hybrid critique practices to identify characteristics of critique assemblages. In conjunction with these data, we also collected data from course critique experiences using these assemblages and conducted a small interview study to elicit student experiences of these critique events.

Study Context

We focus this study on the experiences of students and instructors in three User Experience (UX) Design studios taught during the Spring 2020 and Fall 2020 semesters. These studios included a first-year undergraduate experience that began in a residential mode and was then disrupted due to the pandemic mid-semester (n=45), a second-year undergraduate experience that was conducted using a hybrid synchronous approach (n=42), and a first-year graduate experience also conducted with a hybrid synchronous approach (n=12). The residential studio model used prior to the pandemic included multiple critique events, including desk critiques with project team groups, group critiques that utilized the physical space to pin up and post in-progress work for feedback, and formal presentations that included opportunities for multimodal interaction using Slack. During the pivot to online instruction due to the pandemic in March 2020, we shifted Spring 2020 courses completely online for the latter half of the semester, relying upon Slack, WebEx, and Mural to communicate and share design work. During the Fall 2020 semester, we used a hybrid synchronous approach to allow a portion of students to attend class in person (socially distanced and masked) with the remaining students joining via a synchronous Zoom session. All group critiques and formal presentations critiques were conducted only synchronously online, with no residential participation.

Data Collection

Data sources to document the creation and student experiences of the critique assemblages included critique session recordings, instructor and student reflections, student surveys, and student interviews. As a team of authors, we intentionally included multiple perspectives in relation to the designed critique events. The last author was the instructor or co-instructor for all three UX studios, the first and second authors were students in the graduate studio offered in Fall 2020 while one of them worked on data analysis for this project, and the third author previously experienced the two undergraduate studios when they were offered prior to the pandemic in residential form. In this way, we were able to triangulate multiple perspectives relating to the previous physical construction and performance of the crit, adaptation needed to address emergency hybrid requirements, and emergent student experiences of these critique events. While we have multiple points of data through which to triangulate these student experiences and critique assemblage qualities, our focus in this paper is on the properties of the critique assemblages (supported by video recordings, JSON output of Slack critique events, and Mural or Miro virtual whiteboard PDFs) and the student experience of these assemblages (supported by interviews with undergraduate and graduate students during the Fall 2020 semester), and we do not always differentiate between these experiences of the critique assemblages by course or semester. Instead, the critique assemblages which we describe in this paper can be considered as the outcomes of iterative construction, student engagement, and subsequent alteration with a primary focus on the undergraduate studios (due to their larger enrollment). Critique sessions that we evaluate within this framing include: 12 group critiques, weekly desk critiques on demand, and 11 final presentation critiques. The undergraduate students that experienced these critiques enrolled as a cohort in the UX studio in Spring 2020 and Fall 2020; the graduate students matriculated in Fall 2020 and were only represented in that portion of the dataset. As part of the interview study, the student authors conducted 30-45 minute interviews with five undergraduate and five graduate students using a semi-structured interview protocol that focused on their experience of critique sessions during the Fall 2020 semester, including the relative value of the feedback from these sessions and an invitation to identify portions of these learning experiences that they wished to change.

Data Analysis

We conducted two primary forms of analytic activities to support our project aims as a means of triangulating across data sources while seeking to build trustworthiness in relation to our reflective outcomes. First, we engaged in regular reflection sessions to externalize our decision-making processes, including expectations regarding critique outcomes and key affordances of the assemblages we created. During these virtual meetings, conducted throughout the Fall 2020 and Spring 2021 semester, we discussed challenges relating to our "pandemic pedagogy," discussed student responses to previous versions of critique assemblages, and identified new potential productive areas for experimentation. Second, we used a reflexive thematic analysis (Braun & Clarke, 2019) approach to analyze interview and reflection data, with a particular focus on connecting student experiences to particular critique types and outcomes. This analysis was also conducted over a period of months, with the student and instructor experiences informing the overall blueprint for each assemblage. Our goal in this analysis stage was to complicate and pluralize the critique experiences, helping us in identifying both instances where negative experiences led to positive overall outcomes and instances where students unexpectedly enjoyed critique experiences that were hastily created. Across these two analysis activities, we were better able to understand the decisions that led to the creation of the critique assemblages, and we built a shared awareness regarding how these critique experiences impacted the instructor and student experience.

Findings

Critique Assemblages

We created a variety of critique assemblages to pivot from residential studio instruction to synchronous hybrid instruction. These assemblages all represented a significant departure from physical critique practices used prior to the pandemic and included a rapidly changing suite of technology tools (Table 1), some of which had been previously used in a more limited sense prior to March 2020. Since 2015, the messaging platform Slack[1] had been extensively integrated into course and program experiences, facilitating conversations among students and alumni across multiple cohorts, creating spaces for team discussion in our project-based collaborative studios, and supporting residential critique practices in formal presentations through what Gray (2019) has previously called a "multimodal critique." In addition to interactions on Slack, all critique sessions prior to the pandemic were video recorded on GoPro cameras and distributed on the learning management system course site to encourage reflection on communication and design competencies.

Table 1. Summary of technological tools used to support different types of critique.

Critique Type	Zoom	Miro	Slack	Google Docs
Formal	•		•	•
Group	•	•		

[1] https://slack.com/

Desk •

In the following sub-sections, we will describe how three types of critique (Desk, Group, and Formal Presentation) previously existed in the in-person studio space and how each was adapted to accommodate pandemic-era restrictions and provide new modes of participation.

Desk Critique

Desk critiques entail one-on-one interactions between student teams and one or more instructors, with a focus on discussing in-progress design work. In residential UX studios, instructors would meet with student teams in the studio space during regular classroom instructional time. Because student teams were tasked with the same project prompt, these in-person critiques allowed for incidental learning by other student teams within earshot of an in-progress desk critique as well.

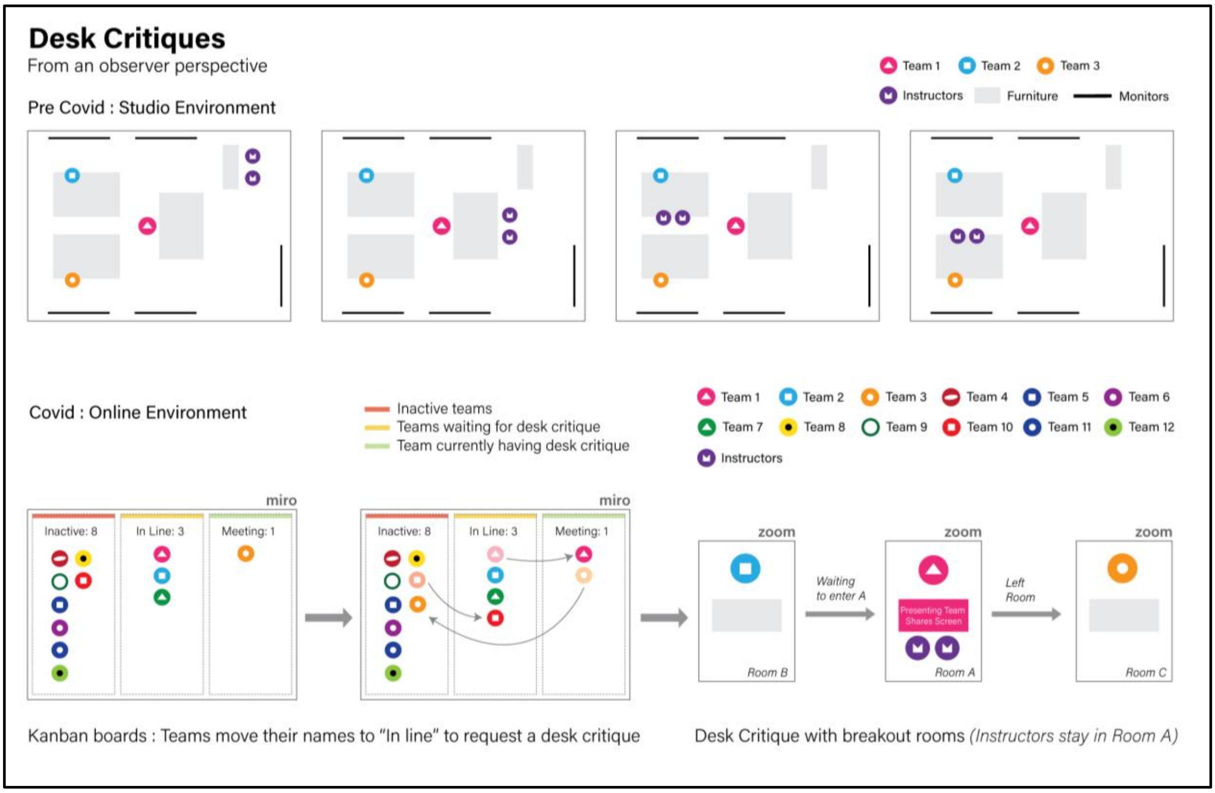

Figure 1. A desk critique assemblage that engaged students through Miro and Zoom.

In order to adapt to a virtual setting, the instructor wanted to encourage the just-in-time and student-directed qualities of desk critiques as they had existed in the residential studio. This assemblage consisted of the following elements: 1) a virtual whiteboard to indicate a team's desire to receive a desk crit, and 2) video conferencing in breakout rooms to allow the instructor to privately meet with the students and have a discussion (Figure 1). Using Miro[2], a virtual whiteboard space, instructors created a Kanban-style board with project team names organized into three columns. During open studio time, project teams worked in breakout rooms on Zoom, and had the opportunity to move their respective team's name from the "Inactive" column to the "Request a desk crit" column. Multiple project teams could queue in the center column, and then the instructional team would sequentially join the relevant team breakout room in Zoom and move the team name to the "Currently meeting with" column. Once within the breakout room, the instructor(s) would engage the group in conversation, providing feedback on in-progress design ideas. Sharing of student screens was often a key component of this assemblage, where students could quickly share in-progress work with each other and the instructor.

While this assemblage allowed for one-on-one discussion between students within the single team and

[2] https://miro.com/

instructor(s), this assemblage did not afford any incidental learning or accidentally "overheard" qualities that would have been common in a residential studio. However, the Zoom format was also more equitable in the sense that all students had equal access to shared content and high-quality shared audio with limited background noise, as concentrated with the cacophony of the residential studio when up to 50 students were working and speaking at once.

Group Critique

Group critique underwent arguably the most significant change when instructors were forced to adapt to pandemic-era restrictions. Previously, group critique, often referenced by the memorable "gallery walk" component by interviewees who had experienced pre-COVID in-person critique, consisted of student teams presenting their in-progress work within the residential studio space using a variety of outputs including whiteboard drawings, sketchbooks, printouts of research, and physical prototypes. The gallery walk was accompanied by music as students and instructors traversed the studio space, looking at project outputs and taking notes that would seed conversation with each team in the question-and-answer portion of the crit. Once the gallery walk was complete, teams would present their work to the class and then engage in questions and receive feedback from their peers and instructors. Once feedback for one team had ended, another team would present and receive feedback, with the need for instructors and students to move physically through the studio space to engage with project outputs.

Instructors pivoted to the online collaborative whiteboard tool Miro as a means of supporting group critique sessions (Figure 2). Prior to a scheduled group critique, student teams would asynchronously upload pieces of their in-progress work to a dedicated Miro board using the program's built-in features. Once the synchronous class session began, teams briefly presented their work and core questions they wanted feedback on to other teams, leading to a virtual version of the "gallery walk" where students were asked to peruse this same Miro board and comment on other teams' work using a combination of Miro's features (e.g., sticky notes, text boxes). The instructors would typically play music during this time as well through Zoom. Once the allotted time expired, students had the opportunity to ask clarifying questions verbally via Zoom about feedback left on their project, provide verbal feedback on other teams' projects, and/or expand upon their own comments left on other teams' work.

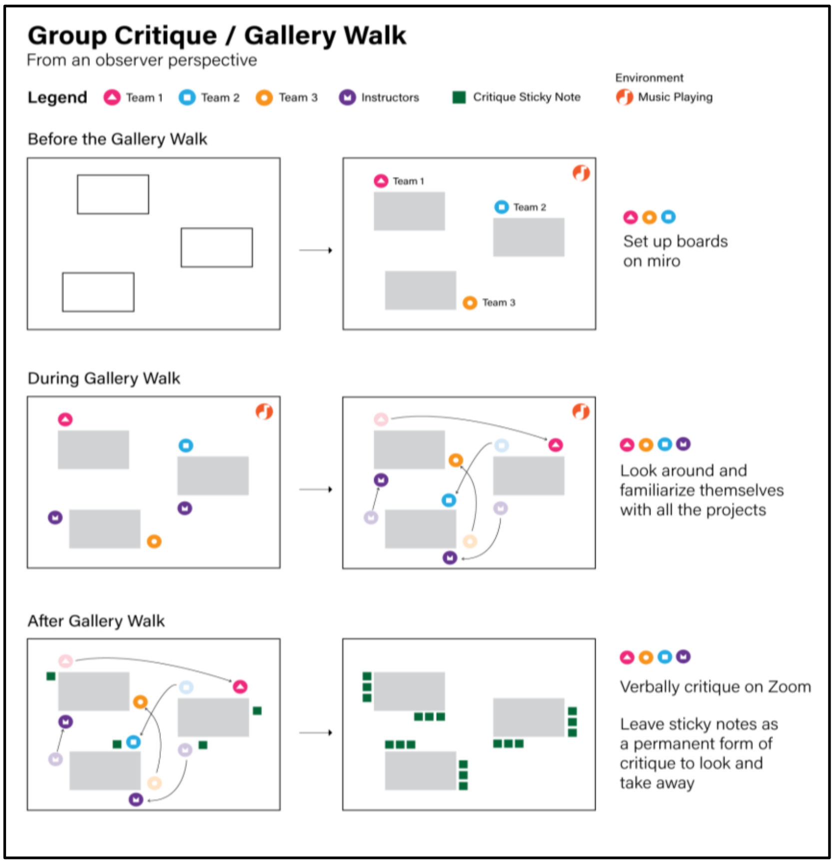

Figure 2. A group critique assemblage that engaged students through Miro and Zoom.

Unlike the in-person group critique sessions, this virtual critique assemblage provided significantly more equity in participation with fewer issues being heard or being able to provide feedback. From a logistical perspective, students did not have to physically post or dismantle their project outputs as they had in the residential studio, allowing Miro outputs to be added as a team well in advance of class, and allowing these outputs and subsequent feedback to remain persistent for them to revisit later in the project cycle. Importantly, the Miro-supported group critique also allowed for greater density of participation within a single project or across multiple projects. There was no vying for the best view of the physical artifacts, and indeed—dozens of students could easily view the same virtual outputs at the same time with the same level of fidelity and ability to engage by leaving feedback.

Formal Presentation Critique

Formal presentation critique sessions previously consisted of a team presenting their completed work using wall-mounted displays in the physical studio space. In addition to this visual interaction, instructors also created a dedicated channel on the channel-based messaging platform Slack for each formal presentation, often inviting upper-level students to join the critique session and provide feedback both during the presentation and during the verbal question-and-answer period. In addition, upper-level students often collaborated on a synthesis of critique using Google Docs to meet professional practices course requirements, with the document delivered to the lower-level students at the conclusion of the day's presentations.

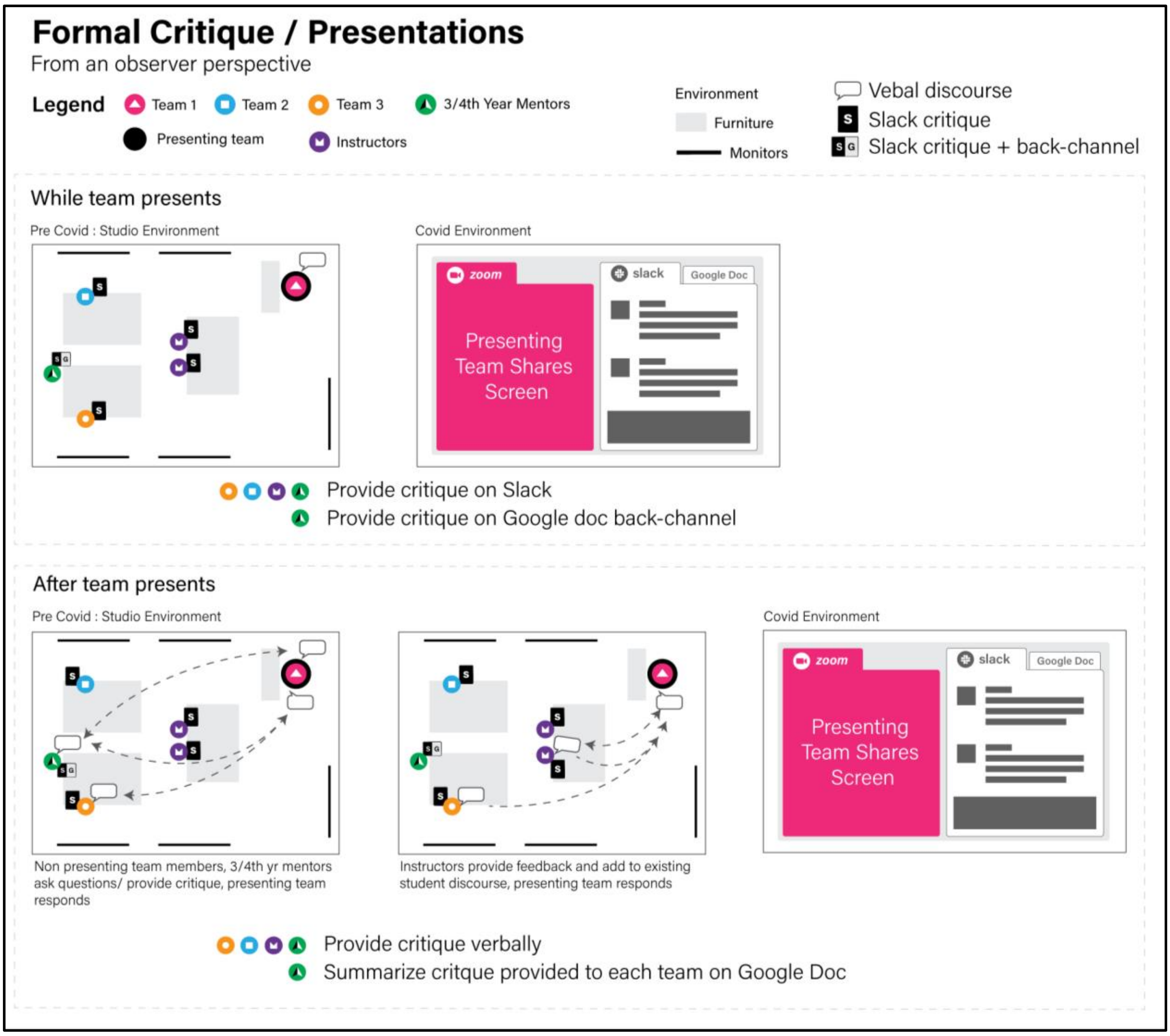

Figure 3. A formal critique assemblage that engaged students through Zoom, Slack, and Google Docs.

Aside from using Zoom to present final work, the formal presentation critique assemblage did not require the introduction of any other new technology. Using Zoom to support the final presentations surprisingly amplified the level of participation compared to the physical equivalent. While upper-level student participation was previously bound by the number of available seats in the studio, more students could join the Zoom call—and their presence increased the amount of critique being provided in Slack and Google Docs in ways that counterbalanced a small decline in engagement from other students due to "Zoom fatigue." In addition to the increased capacity for the critique event, there were also areas of growth and opportunity in relation to the use of video conferencing software. While early presentations included some technical glitches as students became accustomed to the need for screen sharing preferences and became confident in speaking as a team at a distance, these issues were quickly resolved, allowing for quick transition time among speakers as compared to an in-person critique. Because everyone was joining the same Zoom space, audio quality and the ability to hear and accurately respond to questions was also much higher as compared to the in-person critique equivalent. In addition, the recording and transcription functionality of Zoom in the cloud also allowed for the ability of students to effectively reflect upon their presentation behavior, with the capability to search for text in the automatically generated transcript. Thus, in some ways, this critique assemblage became more equitable and accessible—in ways that are still being discovered as we investigate longer-term patterns of development of critique competence.

Affordances and Student Experiences of Critique Assemblages

The critique assemblages that we created and piloted in Spring 2020 and Fall 2020 had a wide variety of affordances, some of which were known and anticipated, and all of which were experienced in similar yet unique ways by students and instructors.

Desk Critique

The specific mention of desk critique as a studio practice seldom appeared during our interviews with the UX students. However, when asked about prior critique experiences, one graduate student who had been part of the program as an undergraduate (and thus had experienced in-person desk critiques) mentioned how the desk critique is often the most beneficial because "you get more one-on-one—[the instructors] understand more of the project" but went on to mention how they could not recall engaging with this particular type of crit during the Fall 2020 semester. Based on results of a mid-semester survey to students in both UX studios to get feedback on a multitude of critique-related items, when students were asked about the frequency of desk critiques, 21 of the 38 undergraduates respondents wanted more of this type of critique, while 27 of these same students selected "always" when asked how often they applied feedback from desk critique to their projects. These survey results and a lack of reflection on desk crits in the graduate UX studio underscore some of the unique challenges in socializing practices which are intensely physical, embodied, and performative in the residential studio, and do not directly translate into the online space. The undergraduate UX students had learned patterns of engagement with desk crits during the Spring 2020 semester, and thus both had a conceptual image of what desk crits "looked like" and how they could be translated as more private conversations in Zoom breakout rooms. However, graduate students took longer to recognize both the value and the unique structure of desk crits in the online space.

While we have previously documented how desk critiques mostly took place via a combination of Zoom Breakout Rooms and scheduling in Miro, one graduate interviewee also discussed how an impromptu extended discussion between their team and an instructor in their team Slack channel acted as a desk crit of sorts. The interviewee explained how "[the instructor] had given [our team] a really good idea to explore, the unfortunate thing was we only had a week left and every contact we had basically just kept falling through" but believed if the team had "more time, [we] would have been able to really do something with it." This conversation—while disconnected from both the Zoom classroom and somewhat asynchronous, still provided the team with just-in-time feedback they could use to alter their project scope and outcomes. This range of experiences underscores the difficulty in effectively translating and socializing desk critiques in a single semester, particularly with students such as the graduate students who lacked a mental model for the purpose, value, and experience of engaging in these critiques. For undergraduate students that already had a mental model, this translation into the online Zoom space resulted in a new assemblage through which most of the physical practices relating to desk crits could be translated.

Group Critique

When talking about group critique experiences prior to COVID-19 (colloquially referred to only through one portion of the critique—the "gallery walk"), one undergraduate student stated how "[Miro was] very similar to what we started with, which was going with our project groups and working on the whiteboards and interacting with each other…[so it's] nice to see real time feedback, and collaboration, and all of those things." This use of Miro to support a group critique assemblage translated most literally from the residential version, with students feeling relieved that they had more time (and space) to post their materials, as opposed to at the beginning of class (Figure 4). In addition, this assemblage afforded both a sense of social presence (via collaborators' cursors in Miro) which reconstructed some of the studio "buzz" of an in-person gallery walk, while also affording quasi-permanence. After the crit concluded, students still had access both to their own materials and comments left by fellow students, but also access to other teams' materials and a comprehensive Zoom recording of the entire session with screen sharing to archive the entirety of the experience.

Figure 4. An example of a group critique Miro board with content from each team within each frame and comments surrounding the periphery of each frame from both students enrolled in the studio and upperclasspersons joining the session.

This assemblage of using Miro and Zoom to facilitate group critique was embraced by other interviewees as well, highlighting the ability to share, express, and communicate in-process design work with others. When discussing the final project of the semester, one graduate said "I think we found a good use of Miro...[and] hope we continue to share information, working together, and build up on that community...because I feel like that's the start of actually communicating and being able to express our thoughts in a more effective manner." However, this assemblage also introduced new challenges—most obvious to students that had previously experienced a more immersive in-person group crit. One undergraduate recalled how virtual learning came with challenges, noting how being online made it difficult "to give valuable, insightful feedback...because there is no dialogue happening…[because] we're all muted...and you just have to kind of work with what [teams] put in Miro. So it's a lot more difficult to get a fuller picture of what's going on." This lack of emergent discourse within the Miro environment did present a substantial limitation to interpersonal interaction, even while the overall quantity of critique feedback (measured in numbers of questions and notes) increased dramatically.

Formal Presentation Critique

Formal presentation critiques as an assemblage were the least impacted by the shift to online synchronous instruction. In previous years, students had already been socialized to using Slack and Google Docs to create conversation around final design work, and some students also used the provided recordings and Slack conversation to reflect on their progress and decide on how to improve their work. To understand this particular critique assemblage further, we analyze all of the Slack posts from the formal presentation critique sessions for both studios in order to determine levels of engagement throughout the Fall 2020 semester, using the same type of analysis to previous semester presentations for the same studio to provide a comparison between pre-pandemic in-person and synchronous online formal presentation crits.

Three formal critique sessions were conducted in the undergraduate UX studio during the Fall 2020 semester. Participation through the semester remained fairly consistent, peaking in the middle of the semester with 422 unique feedback instances compared to 327 early in the semester and 347 at the end of the semester, all across an approximately 150-minute crit session. An average of 365 instances of feedback occurred across all these formal presentation critique sessions, totaling 1096 critique statements. In the critique sessions from the 2019 Fall semester, we found 884 unique pieces of feedback across all three critiques, with an average of 294 critique statements per formal crit. These results demonstrate that critique interaction roughly scaled based on course enrollment (2019 n=33; 2020 n=39), even given the virtual conditions in 2020.

While student experiences of this critique assemblage were not as dramatically different, the affordance of interacting only online did provide the opportunity for different follow-on behaviors. One interviewee described how “right after the [formal presentation] critique, I talked to my teammate...about all the feedback, in our private project channel.” This ability to communicate privately and immediately following a presentation allowed team members to discuss the feedback they’d just received while it was fresh in their minds, instead of waiting until the end of the critique session. While not our direct object of study, Slack’s built-in emoji reactions often served as a way for students giving critique to agree with other peer’s feedback in ways that transcended both in-person and online final presentation critique sessions. For example, when a student posted feedback to the critique channel during or after a presentation, others would react with the “point up” emoji to indicate they had a similar question or thought. This emoji reaction was the most common reaction seen in our analysis of the Slack transcripts, with the “thumbs up” close behind. The ability to react to a person’s feedback could be viewed as engaging with the critique despite not verbally or non-verbally communicating feedback.

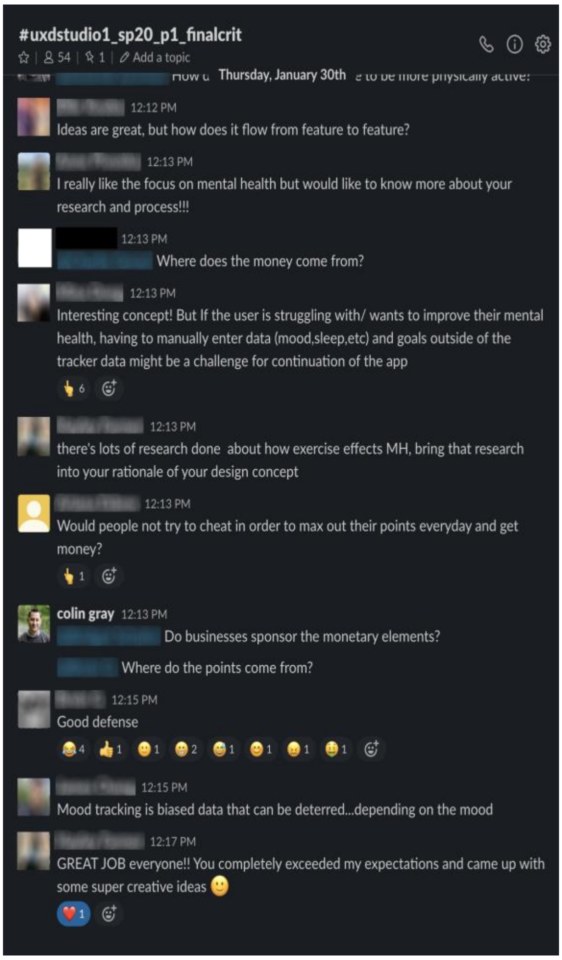

Figure 5. An example of a final presentation Slack critique channel, including questions and critical feedback alongside

supportive emoji to represent agreement or social support.

Another aspect of critique relating to engagement on Slack was the use of phatic comments. Despite being less common in the graduate studio—perhaps due to less opportunities for socialization in their first semester due to social distancing and unfamiliar course experiences—phatic expressions were frequently identified in all undergraduate formal presentation critique sessions. These expressions made up 21% of the total comments from our analysis of this course's Slack feedback, underscoring the utility of Slack as building affordances both for on-topic and off-topic banter as revealed by Gray and Howard (2015) in a previous study of technology enhanced critique environments. Examples of the use of phatic comments included students making a joke or commenting about something not directly related to the project being presented, often interspersed directly between critique comments much more germane to the design work being presented. These types of comments clearly played a role in the critique experience in ways that could be more fully explored in future work, particularly in relation to phatic expression and links to formal critique and as a form of socializing that then enables other critique practices.

Discussion

Based on these findings, we have identified opportunities and challenges to support and extend critique practices in studio education, across both virtual and residential modes. In this section, we will briefly outline opportunities to engage with deeper socio-technical and critical awareness once residential instruction can resume, identifying patterns of socialization and wellbeing that support students' autonomy and agency.

Permanent and Temporary Changes in Design Studio Critique Environments

We have constantly reflected while building and modifying these critique assemblages, considering the possibility of some of these tools may become a permanent element of our UX studios, or greatly impact our current engagement with technologies to support critique. While Slack was effectively used in pre-pandemic critique sessions, Miro was a new addition that has the potential to remain a fixture going forward, due to its affordances of persistence, legibility, and cross-pollination, all while removing accessibility barriers to full participation in the studio. However, this shift in material from the physical to digital space also presents new potential challenges in residential instruction, including a lack of felt embodied presence in the studio, leaving the studio "buzz" in a technology platform even while in-person engagement will be desired. One of the heuristics we are evaluating in the next generation of our teaching approaches—where we seek to teach studio at scale—is the role of technologies in supporting a range of student needs and accessibility profiles. In particular, we have become more aware of the limitations of engagement for neurodiverse students that now have access to full automated transcriptions of critique sessions, who may be negatively impacted when we return to residential instruction where audio quality and legibility varies more significantly. We have also considered how to support some of the increased privacy of the breakout room desk crits, while not sacrificing the "overhearing" qualities of this critique type. Finally, while we see value in extending the crit through technology tools, we are challenged to consider how these critique assemblages might better balance in person, embodied engagement alongside technological interaction, allowing students both to feel "present" and to be able to fully participate as a critic, a fellow designer, and as a colleague.

Socialization and Well-Being

The topics of socialization and well-being arose often during our interviews—building upon critical dimensions of the studio experience we had deeply considered as we built out this UX program in 2015. Many students understandably felt isolated due to the pandemic and had difficulty connecting with other members of their cohort, particularly those that were new to the graduate program who did not build relationships face-to-face prior to the pandemic. As one interviewee discussed, "we haven't really been able to get much face-to-face contact…[but] that's something we are trying to do more though...trying to reach out through social media or Slack, you know, the random channel just posting stuff." Slack played a pivotal role in the formal presentation critique environment while functioning as a social tool as well, providing a centralized location for those enrolled in the program to converse, in both private and public channels, and develop a rapport with each other despite the lack of in-person socialization opportunities during the pandemic.

However, this constant use of technology in the remote environment—while pragmatically necessary—brought challenges. Despite the "Zoom fatigue" felt by many, one interviewee didn't "necessarily think it [was] the technology that [was] hindering engagement...it [was] a person's want or drive to be participatory." When asked about their expectations for critique, the same interviewee thought the sessions would "be more conversational…[with] people feeling okay to voice their opinions." Through our analysis, we learned that students were more likely to provide written feedback via the use of Slack, rather than comment verbally via Zoom, even if they reported that they would prefer conversational, verbal engagement. This is a tension that was already known in the residential studios, but we now have a better understanding of how these social and technological components of the assemblages function and can use this knowledge both to scaffold students' socialization and ability to "speak up" while also recognizing the reality of cognitive fatigue.

Building on these experiences from 2020, we have continued to adapt our critique assemblages to meet the needs of even more students through hybrid instruction. While we do not claim to have addressed all of the issues mentioned above, we find the language of critique assemblages to better describe the complexity of critique—moving beyond notions of critique as primarily performative or knowledge-building. Instead, we have found our focus on critique to point to new opportunities to support students' wellbeing, identify threats at the "hidden curriculum" level, and continuously assess our roles as instructors in building equitable critique environments. Future work could address perceptions of critique experiences over time, and the role of these experiences in reproducing certain cultures of interactions that may be informed, or even inhibited, by particular combinations of technological tools.

Conclusion

In this paper, we describe a set of critique assemblages that bring together social and technological practices that allowed our studio pedagogy to be resilient during the online instructional response to the pandemic. Across desk, group, and formal critique types, we identify a set of technological tools that built on existing studio practices, and in many cases facilitated the identification of new affordances that may shape future residential studio experiences. We conclude with opportunities to consider wellbeing and socialization through critique engagement and strengthen student identity development in online and residential studio programs.

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The Leftovers of Participation

Identifying the Value of Interaction-based Design Experiences

Andrea Wilkinson and Steven Lenaers
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Falling under the theme of Design Learning Environments the workshop *The leftovers of participation* looks to identify learning environments that can be adapted to facilitate learning experiences through reflection. Drawing on experiences from interaction (with clients, users, communities, etc), places many of the experiences outside of the classroom. By identifying the impact of rich experiences, the value of these experiences can be qualified. In turn, existing educational structures can then be encouraged to open up to participation, looking for new environments, new forms of interaction and socially relevant involvement that not only support the community but aids in the holistic development of a student who is both citizen and changemaker.

Keywords: participation; reflective practice; research through design; designer experience; design anecdotes

Workshop Aims

Falling under the theme of Design Learning Environments (environments where students come into contact with and interact with participants) the workshop will look at the following topics:

- Environment:
  What sort of environments or types of participation delivers these meaningful learning experiences?
- Reflection:
  Where does reflection take place and in what form does it happen?
- Integration:
  How might these reflective practices be better integrated into design practice?
- Dissemination:
  What are best-practices for documenting and sharing these meaningful experiences?

The workshop will center primarily upon the experience of the participants. Prior to the workshop, those enrolled in the workshop will be interviewed via Zoom (or similar). The interview will be a discussion on design insights based on personal experience. The design facilitator will provide examples on the forehand to help prep the discussion. The discussion will look to gather experiences in which interaction with a participant (client, user) had a lasting impact. It will look to discuss the impact on the designer and identify how this insight matured and what reflective action preceded it. Those not able to meet digitally or who prefer to submit a written reflection are requested to submit a word document (maximum 2 pages) in which they respond to the following:

- Describe a memorable experience you had in the capacity of designer/researcher in which the working together with another individual continues to impact your way of working.
- Describe the context and purpose of the interaction
- Explain how this experience impacts your process or way of working
- When and how did you realise that this experience was ‘important’ or influential?
- If you work as a lecturer, explain how you express this experience to others or use it within the

classroom.

- The reflection can be supported by an image or illustration but this is not required. If submitting an image, please provide the relevant citation for use of the image.

These interviews will be bundled into one-page summaries utilising the participant's own voice and used in the workshop as a means to organise the groups and best utilse the time.

10 minutes: Introduction to the workshop, the facilitator, background story and the intention of the data generated in the workshop. Includes group formation: 4-5 participants.

5 minutes: Introduction of participants to group

The workshop will utilise a workshop technique called mapping. Mapping is a tool to facilitate "participants' exchanges and disagreements" (Schepers et al. 2013) in which a large-format document is created together by workshop participants and becomes a documentation of their working process (see Map-it.be) through the use of collaborative brainstorming with post-it notes and hand-written descriptions placed on the map.

20 minutes: Participants will share their own 3-5 minute story about how participation within design impacted them. They will identify who it was (name), What they were doing (the context) and why it was important (what they learned?) and place this within the mapping document.

20 minutes: Moving from personal experience to third person, the groups will identify the environments that facilitated these experiences. Each groups will read 3-4 interview transcripts (not their own) and on the mapping document, summarise per transcript:

- The experience
- The insight(s) or knowledge gained
- The questions needed to gain access to these insights
- The format that would be suit this sort of reflection (ie. journal, selfie-film…)

20 minutes: In a following section on the mapping document, groups will identify potential teaching and design environments where these experiences could take place and cluster together concepts on reflective practice.

- Learning environments that would offer students these experiences
- Potential groups of users, populations, contexts that could offer this sort of experience for students
- Design course modules that would cater to this sort of experience (ie. design thinking, intro to design research,…)
- Where/how reflection can be integrated into coursework
- Known challenges to reflection integration

10 minutes: Final group discussion where participants will be asked to think about dissemination:

- Who is reflection for?
- How might design anecdotes such as the collected interviews become a tool
- Who would be the audience?

5 minutes: Wrap up summary of the workshop. Collection of participant details for those interested in participating in further research on this topic or in receiving workshop material (audio files and/or transcripts). Participants will receive a sticker that says "ask me about….." and encouraged to fill out the sticker with the name of the person they identified in part 1 of the mapping. This offers the intention of being a conversation starter for the rest of the conference day.

Physical vs. Online:

The above workshop was initially created for face-to-face interaction within small groups. However, gathering the material on the forehand through informal interviews allows the facilitator to better get to know the participants of the workshop individually and better refine the workshop format. This works for both a physical workshop as well as an online or adapted one. An online adaption would be facilitated by the use of Miro for the mapping. Miro allows participants to work on a larger document in small groups much in the same way as mapping physically. This would require the inclusion of a platform that allows breakout rooms.

Expected outcomes of the workshop:

The resulting 'maps' will collectively form an initial critical analysis of 10-15 design reflections based on the workshop participants (designer/educator/researcher) experiences. Collecting and cataloguing these design experiences is an ongoing project about design reflection that looks to identify ways to best utilise and disseminate these narratives in ways that respond to the needs of both current and future design students.

Minimum and maximum numbers of participants:

Minimum 10, maximum 20

How the workshop will benefit the participants:

Workshop participants will get to know each other within a very informal and personal setting. This group work allows participants to build connections that can extend beyond the workshop and conference. Next to this, participants will be invited to participate in further research in this area contributing to publications or audio series on this topic.

How the workshop is relevant to the selected track's aims:

Participation within design involves interaction between design researchers and participants and is defined as: "a process of investigating, understanding, reflecting upon, establishing, developing, and supporting mutual learning between multiple participants in collective 'reflection-in-action'… the designers strive to learn the realities of the users' situation while the users strive to articulate their desired aims and learn appropriate technological means to obtain them" (Simonsen & Robertson 2012, p. 2).

The knowledge generated and documented within this participation is limited to the expectations of academics and journals as well as limited by the requirements outlined by the project the research is situated within. Within education, the knowledge is also limited by the requirements outlined in a brief: an object is created, a process has been followed. However, in acknowledging the relevance of each of these forms of knowledge, there is also the need to be aware of other forms of knowledge that is generated through these processes. They are most often not the focus of papers that are submitted to journals and they exist within the fringes of formal design processes, but they are powerful drivers of the way in which designers design.

This workshop focuses on these small moments of change or insight within these well orchestrated design routines. By turning to storytelling, this workshop will reflect on the "leftovers" or the "unused" anecdotes of interaction between designer-researchers and participants. Often dismissed, anecdotes are a means of "interrogating the research process itself" (Lury & Wakeford, 2012, p. 33). It will look at the impact these have on the individual and the potential for use within design education environments. In doing so, the workshop will create a collection of media resources that will challenge educators to create new learning environments that are focused not only on designed objects, services or interfaces, but rather on student experiences.

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Students and Teachers Becoming Co-Designers of Learning

A Virtual Learning Space for Creating, Organising and Sharing Media-Rich Documents

Gloria Gomez and Rodney Tamblyn
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This interactive workshop will introduce a virtual personal learning environment for creating, organising, and sharing media-rich documents. This environment was developed to address issues in online education around student engagement and enabling academic staff to author their own teaching content. Its implementation was informed by design-based research undertaken from an interaction design perspective with bridging design prototypes. Its educational foundations are drawn from the fields of study skills for academic success, good visual design that facilitates metacognition, and networked learning for promoting connection between people. The implementation of a same interface for students and teachers to use has broadened participation in the creation of resources, facilitated opportunities for interesting individual and collaborative study activities, and administrative tasks have been reduced. Inspired by the feature design, these changes in study behaviour have transformed students into co-designers of learning, and teachers into facilitators of learning. These pedagogical innovations have mainly taken place in online medical and health science higher education programmes. However, these could potentially happen in contemporary design education.

Keywords: innovative pedagogical practices; media-rich documents, online learning communities; personal learning environment; students as co-designers of learning

Specific Aims of the Workshop

In this workshop and for the first time, design education researchers will be introduced to a virtual learning space called OB3 – Beautiful Study for Lifelong Learning. It is a personal learning environment that mainly focuses on the educational or learning activities of people rather than a course. It offers more autonomy than traditional learning management systems, and is particularly well suited for independent, lifelong, and self-directed styles of learning.

Since its inception back in 2010, this technology has been mostly used in online medical and health science higher education in Australia and New Zealand. So far, it has deeply transformed two distance higher education programmes in Ophthalmology (Gomez & Petsoglou, 2021) and Midwifery (Daellenbach, Davies, Kensington, & Tamblyn, 2014) for almost a decade. Some novel pedagogical practices undertaken in those programmes might be of interest to the design education researchers using approaches for promoting active learning such as flipped classroom, blended learning, problem-based, among others (Daellenbach et al., 2014; Gomez, Daellenbach, Kensington, Davies, & Petsoglou, 2017; Gomez & Petsoglou, 2021).

Case studies in these fields will be presented to spark conversations around challenges and opportunities in design education research and practice, as they relate to remote/online learning. With the ongoing changes in design education, the increasing number of design programmes around the world, and the democratization of the discipline, there might be an opportunity for OB3 to enhance the online study experience of designers teaching or studying formally, non-formally, and informally. The concept map shows the innovative pedagogical practices afforded by this technology (figure 1).

The GUI and Interaction Design

The R&D of this *learning space* was undertaken from an interaction design perspective and using a human-centred design method called Bridging Design Prototypes (Gomez & Petsoglou, 2021; Gomez & Tamblyn, 2012a, 2012b; Gomez et al., 2020). Feature design was informed by concepts drawn from university study skills (Bandura, 1986), visual design in metacognition (Kirsh, 2005), and network learning (Goodyear, Banks, Hodgson, & McConnell, 2004; Goodyear & Steeples, 1998). The design process produced a graphical user interface affording academic staff and students to interact with the same feature set to create, co-create and share media-rich documents with embedded discussions. This change in interaction design de-emphasises administration and emphasises support for the development of study activities that promote deep understanding. The innovative features enable an individual (teacher or student) with basic technological skills (i.e. users of MS Office, internet browsers, and email applications) to author media-rich documents, with the option of starting embedded discussions at any point inside the document. Within minutes through using the commands of cut, copy, and paste; drag and drop; and an in-context style palette, he/she can author, share and/or collaborate in content development of different kinds.

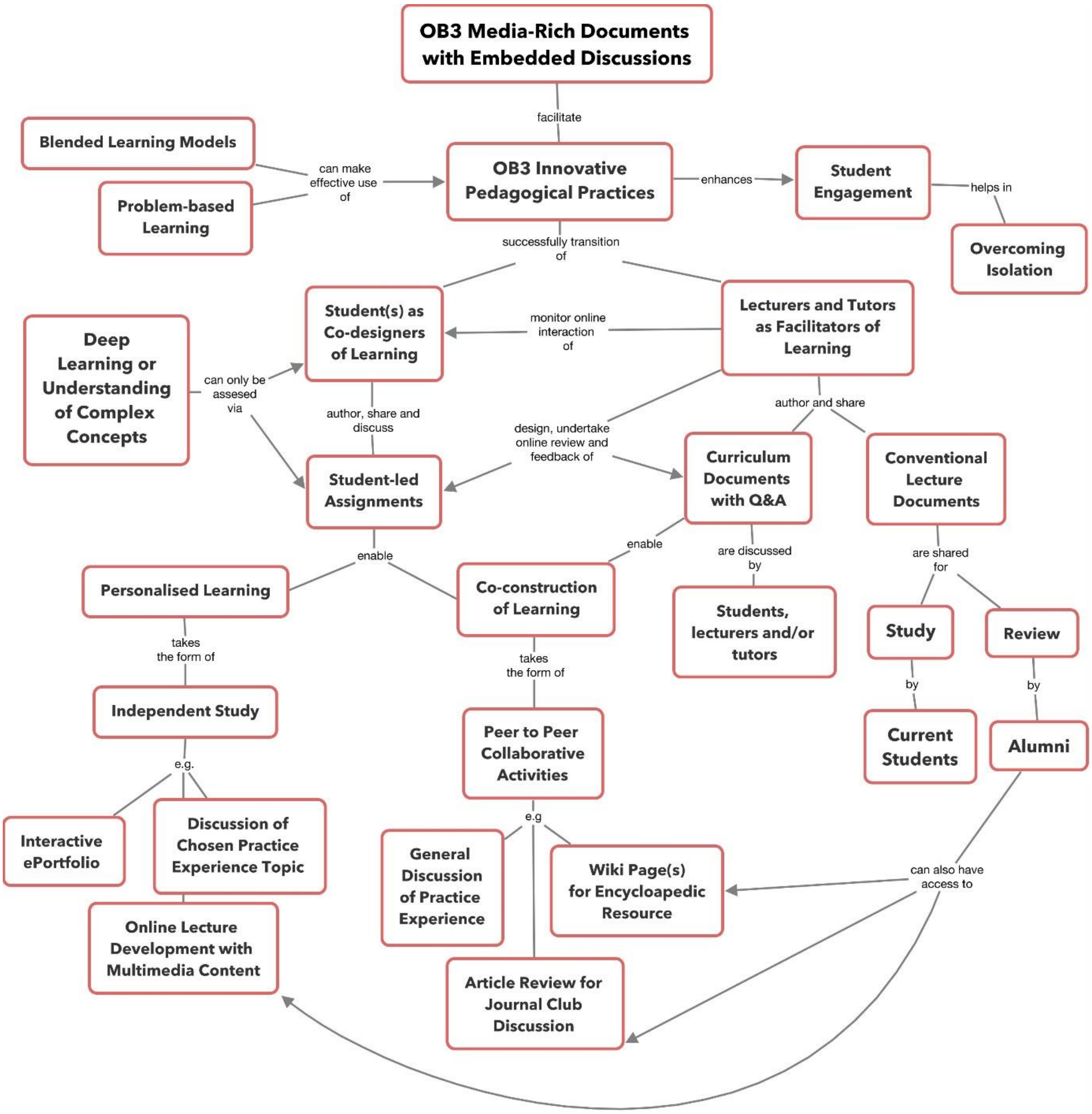

Figure 1. Concept map on the type of innovative pedagogical practices that OB3 users could develop

The changes in interaction design *guide people's behavior* in a manner that lifts learning performance in three ways. Firstly; academic staff can prepare curriculum content without the direct support of a technologist (e.g. course builder, multimedia consultant, learning designer). Secondly; students engage in asynchronous discussions with lecturers inside an OB3 document. Thirdly; students engage in authoring curriculum topics or reflective practice as part of individual and collaborative assignments.

A media-rich document could be created using text, embedded videos, audio-recordings, links to web pages, podcasts, etc. Very quickly people are able to create collections of media-rich documents on diverse topics, favourite podcast topics, curated lists of YouTube videos, movies, books etc. The collections can take the form of directories, glossaries or encyclopaedic resources. People could share them with the groups you create in formal, non-formal, and informal learning situations. Discussions could be started on any element (e.g. paragraph, image, tweet, embedded video or survey, etc.) inside the document.

Qualitative Research Evaluations

Qualitative research analyses using two frameworks have shown that the educational practices enabled by the creation, discussion, and sharing of these media-rich documents can be qualified as innovative pedagogical practices, according to the Creative Classroom Framework (S. Bocconi, P. Kampylis, G., & Y. Punie, 2012; S. Bocconi, P. G. Kampylis, & Y. Punie, 2012), and have enabled trends (e.g. deeper learning approaches and blended learning designs) and addressed challenges (e.g. students as co-designers of learning and rethinking the role of educators) identified by the NMC Horizon Reports (Adams Becker et al., 2017; Adams Becker, Cummins, Davis, & Yuhnke, 2016; Johnson et al., 2014; Johnson, Adams, & Cummins, 2011). A more detail description is available in Gomez and Petsoglou (2021, p. 9).

The personalised learning aspect makes it a game changing educational technology. It shifts the power from institutions to the individual educator or learner. It presents a situation in which an individual manages his/her own teaching or study activities to a greater extent. This finding is relevant because personalised learning has been identified as a difficult challenge to address in education with technology (Adams Becker et al., 2016).

Some users have expressed the following as their preferred features or activities with OB3: privacy, academic attribution (tracking authorship across the system/platform), inter-institutional teaching collaborations, discussions happening inside the media-rich document, co-creation for understanding with students.

Workshop Structure

The workshop will be run, delivered online, in a timeframe of 60 minutes. It is structured in five parts that are:

- Part 1 (10 min): Set up free accounts and introductions
- Part 2 (5 min): Present current use cases in other disciplines in which teachers and students have become co-designers of learning as described by Johnson and colleagues (2014)
- Part 3 (20 min): Interact, play and explore OB3 features. Attendees will learn to create a media-rich document, organise information in different media formats and share it with other participants
- Part 4 (20 min): Brainstorm about its potential uses and support to design education and its challenges. The brainstorming will be inspired by envisioned scenarios of use on how this tool could advance contemporary design education. In a group discussion we will envision scenarios and media-rich documents will be created with the ideas produced. This activity is further explained in section "how the workshop is relevant to the aims of track 09"
- Part 5: Wrap up activity (5 min)

Expected Outcomes and Benefits

The participants would have had a chance to:

- Create organise and share media-rich documents and start a personal or group collection
- Create activities for transforming students and teachers into co-designers of learning
- Explore through conversations with participants (guided by presenters) the potential role this technology could have for traditional and contemporary design education, and associated challenges

Participants

- Minimum and maximum numbers of participants: 1 to 25 participants.

How the Workshop is Relevant to the Aims of Track 09

Part 4 of the workshop (20 minutes) will be used to brainstorm and discuss potential scenarios of use in design education. The following "questions of interest" extracted from the CFP will guide discussions.

Contemporary Design Educational Concepts and Types of Spaces Do They Require

Could OB3 be a learning space for advancing contemporary design educational concepts, novel curriculums or practices? For example design thinking, inclusive design education, pluriversal design education, speculative design, sustainable design, transition design, decolonising design, co-design, design for learning, among others. This learning space could be used to prototype formal, non-formal or informal online learning situations around these concepts and topics worldwide. Collaborations between different types of designers following a similar goal could come together in spaces like this one to advance issues for example "diversity and inclusion in design education".

Identifying Hybrid or Virtual Counterparts of Physical Space for Design Learning

Case studies in other disciplines will be presented in which approaches such as flipped classroom, blended learning models have been used in connection with OB3. See figure 1.

Learning Space Capturing, Displaying, Archiving, Transferring and Instigating (New) Design Knowledge

OB3 enabling people to capture media has provided a way for academics and students to collaborate in the creation of resource collections (Gomez et al., 2017; Gomez & Petsoglou, 2021). The collections could take the form of journal or book club discussions, encyclopaedic resources, directories, glossaries, conventional lecture notes, documentation of practice experience, reflective practice portfolios, electronic note-taking (events attended, brainstorming activities, research notes). Video and audio collections to be used in user research. This technology could be considered a type of tool "that would facilitate the development process of [virtual] creative spaces" (Thoring, Desmet, & Badke-Schaub, 2019, p. 303).

Learning Spaces Providing Affordances to Guide People's Behaviour?

Boys (2010) wrote about a learning myth: "informal and formal learning are binary opposites" (p.3). OB3 appears to challenge such myth because individuals and groups can transition from informal to non-formal or formal learning. The GUI design addresses learning needs of individuals and not institutions. In doing so, learnings situations are created for addressing two wicked challenges in education, rethinking the role of the teacher (Adams Becker et al., 2017; Adams Becker et al., 2016) and students becoming co-designers of learning (Johnson et al., 2014). OB3 could be used to investigate Boys' statement, and also Temple's (2008) call for research:

> *We need a better understanding of the role of space in the dynamics of creating more productive higher education communities and its connections with learning and research. This should be the subject of further research. The literature throws almost no light on managerial decision-making about space issues affecting students or staff; this is a topic where further work would be useful (pp. 238-239).*

Disclaimer

The presenters would like to disclose that we are not only the researchers but also the owners of the educational technology that will be used in the workshop. Presenter 1 is also an honorary lecturer at a university, and her design research has informed this technology development. In this workshop we do not intend to market or sell it. We truly believe that it meets the criteria for track 09's CFP. Under the lead of presenter 1, we undertake "design-based research that develops and implements new learning environments and tools and studies their possible impact."

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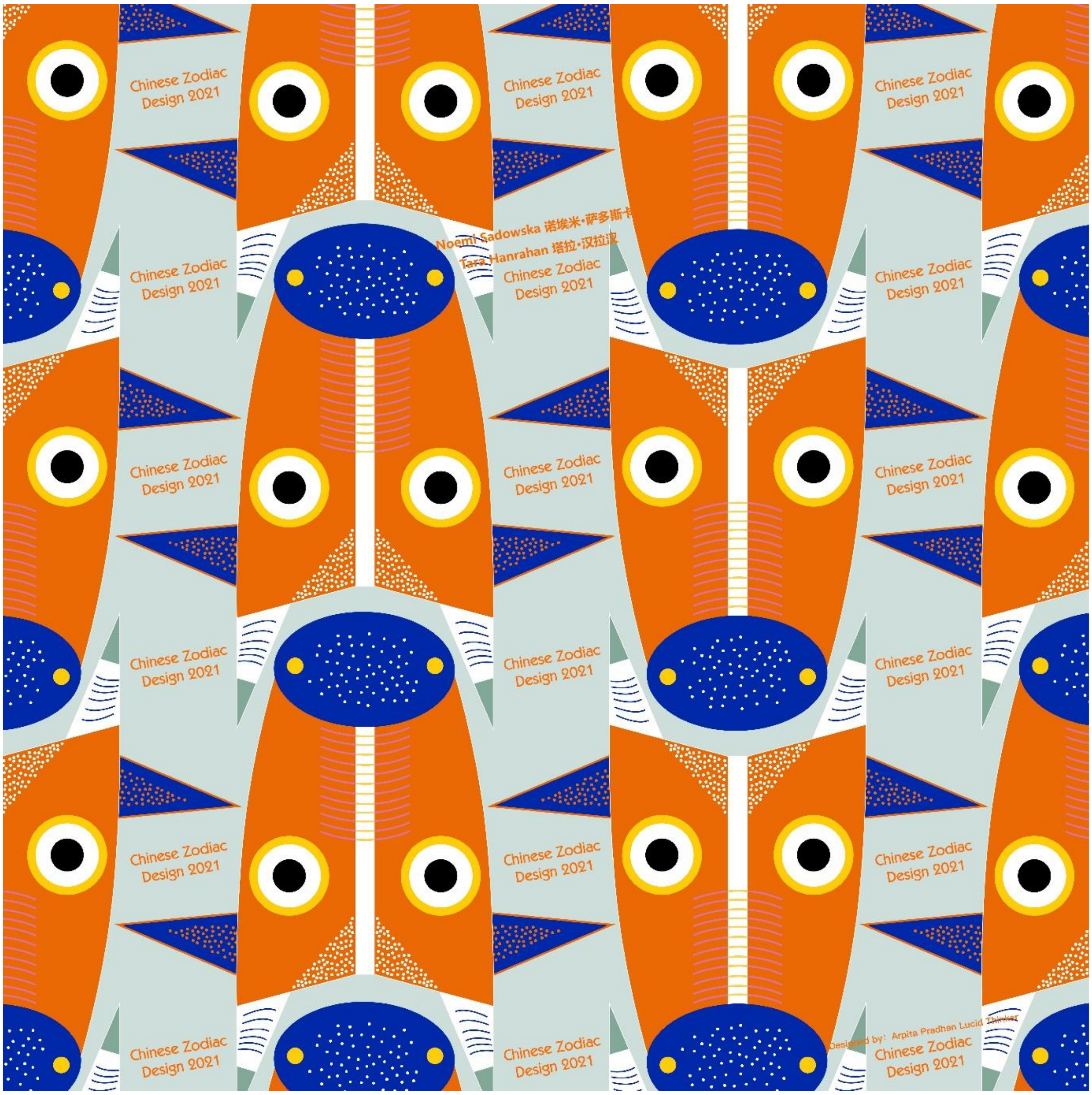

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