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Sharpen critical thinking skills to boost future works. The case of engineers from freehand drawing to digital processes.

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# Education Applications & Developments VIII



**Editor: Mafalda Carmo**

**Advances in Education and Educational Trends**

*Education Applications & Developments VIII*  
Advances in Education and Educational Trends Series

Edited by: Mafalda Carmo



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## FOREWORD

inScience Press is delighted to publish this book entitled *Education Applications & Developments VIII* as part of the Advances in Education and Educational Trends books series. These series comprise the work of authors and editors to address global research in the Education area.

In this eighth volume, a dedicated set of authors explore the Education field, contributing to the frontlines of knowledge. Success depends on the participation of those who wish to find creative solutions and believe their potential to change the world, altogether to increase public engagement and cooperation from communities. Part of our mission is to serve society with these initiatives and promote knowledge, therefore it requires the reinforcement of research efforts, education and science and cooperation between the most diverse studies and backgrounds.

The contents of this 8<sup>th</sup> edition bring us to the most broadening issues in contemporary research on Education. This book explores four major areas within the broad spectrum of Education, corresponding to four sections: “Teachers and Students”, “Projects and Trends”, “Teachers and Learning”, and “Organizational Issues”. Each section comprises chapters that have emerged from extended and peer reviewed selected papers, originally published last year in the proceedings of the International Conference on Education and New Developments (END) conference series (<http://end-educationconference.org/>). This meeting occurs annually always with successful outcomes. Original papers have been selected and the authors were invited to extend and to submit them to a new evaluation’s process. Afterwards the authors of the accepted chapters were requested to make the necessary corrections and improve the final submitted chapters. This process has resulted in the final publication of 44 high quality chapters organized into 4 sections. The following sections and chapters’ abstracts provide some information on this book’s contents.

**Section 1**, entitled “Teachers and Students”, provides studies within educational programs and pedagogy for both teachers and students.

Chapter 1: *Reframing teacher education to the realities in some South African societies*; by Newlin Marongwe, & Grasia Chisango. This chapter argues for the need to reframe the nature of the Bachelor of Education (B.Ed.) degree to the realities of some South African societies. The curriculum must be relevant and factoring in the changed reality in some South African societies. The B.Ed. should keep pace with the societal changes. The chapter was guided by a situated learning theory. The chapter adopted a qualitative approach and a case study design. The study purposively selected 3 universities, 9 lecturers and 15 teacher trainees as participants. Data were collected through use of interviews and focus group discussions. Thematic frames were used to analyse data that were discussed concurrently with the findings. The study established a mismatch between how the teachers are trained and the

actual reality in schools. The implication drawn was that failure to move with speed to reconfigure the training of teacher education increases frustration and tension between teachers and learners. The chapter concludes that teacher education programme needs an urgent revamp to keep pace with techno learners and rapid social developments. John Dewey in Draves and Coates (2011, p. 11) agrees, “if we teach today’s students as we taught yesterday’s, we rob them of tomorrow”.

*Chapter 2: The impact of teachers’ subject matter knowledge on students’ learning of rational numbers and proportion;* by Natalia Karlsson, & Wiggo Kilborn. This study examines the impact of teachers’ subject matter knowledge on students’ learning. The mathematical content deals with rational number as fractions and proportion. The study includes pre- and post-tests from 99 students, classroom observations, students’ written solutions and interviews with 48 selected students after the post-tests. Findings from this study show that the impact of teachers’ subject matter knowledge and ability to identify the objects of learning, and apply this in teaching, strongly influenced the development of students’ conceptual learning about fractions and proportion.

*Chapter 3: Reflecting on a PALAR co-teaching journey in teacher education;* by Brigitte Lenong. Co-teaching at universities encourages student participation, opens chances for feedback, and promotes critical thinking. Co-teaching is a model that involves two or more professionals working together to plan, instruct, and monitor progress of a heterogeneous or blended group of students in and outside the classroom, to achieve learning objectives. The authors – lecturers in teacher education at a university of technology – embarked on PALAR (participatory action learning action research) in planning, instruction, and assessment, by working together as team partners in a process that stretched over more than two years. In this chapter we reflect on our collaboration. The process involved continuous action learning through experience, enhanced by co-reflection and critical questioning; furthermore, we undertook intentional action research with the primary goal of improving practice through successive cycles of plan–act–evaluate–reflect, and which lead to practice modification. We found that participating, collaborating, building relationships, communicating, and trusting, and the transformational nature of PALAR, are crucial to the process of enhancing learning. The findings imply that PALAR can provide lecturers with a rich learning experience. This chapter adds to the body of knowledge by demonstrating how the PALAR approach can be used in co-teaching for teacher education.

*Chapter 4: Time allotted for nighttime sleep and the presence of fatigue in pupils from three high schools in Botoşani County;* by Adriana Albu, Alexandra Ioana Crăcană, Elena-Cristina Gavriluță, & Florin Dima. Fatigue is a physiological phenomenon that occurs after sustained effort and disappears through active and passive rest. The studied group consists of 246 pupils from the 9th and 11th grades from three high schools in Botoşani county – a theoretical high school, a national college and sports high school. Most pupils say they sleep for 6-7 hours (37.80%)

or 7-8 hours (33.73%). Fatigue is often present in 46.34% of cases. When they wake up in the morning, 44.30% of pupils feel tired. The majority of pupils from the 11th grade feel tired at the end of the week, while those from the 9th grade feel tired at the beginning of the week. During the day, fatigue appears mostly in the middle of the school day (36.17%) with insignificant differences between grades or schools, but significant when correlating night sleep with the time of day when fatigue appears ( $p < 0.01$ ). Napping is rarely present in the majority of pupils (46.74%). Most of the surveyed pupils have headaches or eye pain when fatigue occurs. Fatigue is present especially in pupils who recognize a short time spent sleeping at night. Recovery through sleep during the day is rarely present.

Chapter 5: *Towards a generalization: what students learn about multiplication*; by Natalia Karlsson, & Wiggo Kilborn. This chapter examines and analyzes students' learning about aspects of the concept of multiplication with a focus on perceptions and representations, and how they apply this to handling multiplicative situations and patterns in the multiplication tables. The analysis has been performed in the context of the generalization process related to teaching activities, with a focus on students' perception of multiplication. The theoretical approach is based on Davydov's (1990) view of theoretical generalization as a perception-conception-elementary concept (PCE model). The current mathematical content was classified according to: (1) multiplicative structures (Vergnaud, 1983); and (2) basic laws of algebra (van der Waerden, 1971). The relationship between students' learning and the teaching process was studied in order to identify students' learning in action. The study comprises two teachers and 40 students in two classes in grade 3 and was followed up two years later in grade 5 with one teacher and 25 students. The findings of this study can provide knowledge about students' learning about multiplication using structures and multiplication tables in a conceptual context.

Chapter 6: *Online technologies in teaching and learning. Lessons learnt while teaching during COVID-19 pandemic in Romania: Towards a "dual" education system*; by Alina Florentina Grigorescu (Pîrvu), & Cezar Scarlat. The education – as processes and systems, teachers and students – was affected by corona-virus pandemic, across the world. Since pandemic imposed rigorous social distancing, the education process has migrated to online environment, supported by appropriate technologies, with multi-sided effects on students, teachers, and technology producers. Thus, amid its profound negative impact, corona-virus pandemic functioned as an accelerator of using new online teaching technologies. The authors' scope of work encompassed a variety of education levels (from elementary to higher education) in Romanian educational environment. This chapter aims at summarizing major lessons learned by the authors' direct experiences of teaching under pandemic in two different education settings (international school, university) – with the general objective to formulate recommendations to: (i) teachers; (ii) students; (iii) education policymakers; as well as specific objectives: to identify similarities and significant differences among students by age and level of education; and eventually

formulate recommendations for technology producers. Essentially qualitative, the research methodology included secondary research (literature survey) and primary research methods (observation, interview and survey) – based on the authors' direct experience, yet teaching both local and international students. This study contributes at filling a literature gap, and opening further research paths in the field of online education.

Chapter 7: *Digital capital and safety in socialization process. An Italian case study*; by Ida Cortoni. The process of digital acceleration, which in the last few years of the pandemic crisis has affected formal socialization contexts such as schools and families, has led to a critical reflection on the new responsibilities and skills of the digital citizen, in order to preserve his autonomy in the management of virtual dynamics while respecting certain ethical principles at the basis of navigation. These principles underpin the implementation of a digital culture in which the use of devices is guided by a sense of responsibility and respect for otherness. The new digital skills of the citizen go beyond specific access techniques and focus mainly on conscious digital behaviour at the basis of safeguarding various forms of individual and social well-being. Through the illustration of the main results of a national survey promoted by Sapienza University of Rome in 2020, the paper intends to provide a reflection on the degree of diffusion of digital awareness among Italian adolescents and on the impact of school and family digital capital in the development and implementation of such skills.

Chapter 8: *Promoting epistemic virtues across the curriculum to educate 21<sup>st</sup> century citizens*; by Monica Tombolato. In our Knowledge Society, the ease of access to information due to advanced and user-friendly technologies often gives us the illusion to know more than we do. This "epistemic disease" is a danger to both democracy and public health. The educational system must therefore encourage good epistemic habits consistent with responsible citizenship. From a didactic perspective, this requires updating the curriculum in light of the educational challenge of the 21<sup>st</sup> century: training students to be virtuous epistemic agents by fostering their epistemic cognition. In this article, I intend to provide teachers with some useful operational guidance to achieve this goal. To this end, the epistemological concept of the virtuous epistemic agent is converted into a didactically fertile construct in two steps: first, observable knowledge-friendly behaviors are identified that can be regarded as clues to the habitus of the virtuous epistemic agent; then some procedural principles are formulated to help teachers design instructional activities that foster students' commitment to enacting those kinds of behaviors.

Chapter 9: *Written feedback messages: challenges and possibilities to support students' learning*; by Verónica Yáñez-Monje, Mariana Aillon-Neumann, & Cecilia Maldonado-Elevancini. This chapter presents two inquiries. The first corresponds to a part of a doctoral research regarding written forms of feedback. The study involves four teachers from three different primary schools in London. The main sources of data comprised teacher's interviews and the excerpts of written comments from their

students' books. Analysis suggested that feedback focused on correcting basics errors, seeking further actions on the task at hand and contrasting the work with learning objective and success criteria. These findings encouraged a collaborative research work to undertake a second study by using the same methodological approach in another context, namely, Chile. The participants were 60 primary school teachers enrolled in a professional development programme. They selected pupils' writing assignments to provide written feedback for them. Data show that the teachers faced difficulties at the initial stages as their comments were evaluative, centred on what was missing, with little room for students' self-assessment. The participants greatly improved their elaborated comments by being more descriptive and stressing the task's features. Both studies provide insightful data in terms of the problematic nature of teachers' written feedback that might hinder pupils' possibilities to achieve a broader understanding of quality.

Chapter 10: *Collaborative learning environments - Learning with Tiny Articles as a participatory learning network*; by André Seyfarth, Miriam Hilgner, & Bärbel Kühner-Stier. Over the past years, the nature of teaching has fundamentally changed. The learning process is challenged by a more uncertain and complex world. First grade students face a difficult starting point. Confidence in one's own learning process, between learners and teachers, and the strengthening of one's own peer group need to be intensively promoted. In order to develop critical thinking as individuals in a heterogeneous community and to make fears and uncertainties accessible to a scientific discourse, a new teaching concept for bachelor students in Human Sciences was designed. To encourage collaboration and interdisciplinary thinking, a novel format of simplified peer-reviewed publications was developed, called Tiny Articles. Inspired from the research cycle, we implemented different phases of critical thinking, reflections and writing episodes. This created eventually a virtual "common brain". This accumulation of knowledge, ideas, and reflections was shared with lecturers and opened up discussions about learning difficulties or problems. Learning with Tiny Articles is presented as a successful way of networked learning and working in mixed teams.

Chapter 11: *Developing Universal Design for Learning within higher and further education: the benefits of educator peer triads*; by Shaun Ferns, Irene McGinn, Nigel Vahey, Helen Williams, & Nicola Duffy. Universal Design for Learning (UDL) consists of a set of principles for curriculum development that aims to afford diverse learners equal opportunities to learn by providing more flexible and thus inclusive methods of teaching, learning and assessment. This chapter is focused on the present authors' collective learnings as a 'triad', a peer learning group of university educators participating in the Digital Badge for Universal Design in Teaching and Learning, accredited by Ireland's National Forum for the Enhancement of Teaching and Learning. We place particular emphasis upon our triad's (peer learning group) experiences implementing a UDL re-design of teaching and assessment as part of the Digital Badge. Our reflective analysis explores in detail how each lecturer's teaching, learning and assessment practices evolved as a function of systematically

incorporating various key practical elements of the UDL approach. Particular emphasis is placed upon describing how this UDL-based peer learning triad encouraged us as lecturers to adopt a more collaborative approach both with each other and with students.

Chapter 12: *The student's academic aspirations, predispositions and educational support*; by Josef Malach, Dana Vicherková, Martin Kolář, & Kateřina Malachová. This chapter presents the results of empirical research aiming to classify the students of the research group by their subjective view of their study ambitions and assumptions and analyse the relationship between them. Teachers' and schools' incentives to guide students towards technological thinking and deepen the school's interest in the field of study were examined as elements of academic support. The students' views on both of these variables were related to the perception of their educational aspirations. Academic aspiration expresses the anticipated level of performance or position the students wish to achieve. Study predispositions are a set of knowledge, competencies, cognitive abilities, talents, study ambitions and motivations. The research sample consists of 907 technical secondary school students in the Czech Republic. Descriptive data showed, that more than half of the respondents believe they have suitable prerequisites for studying and aspire to the status of a good student. Only 3% lack these prerequisites and have no ambition to be good students. Students with higher aspirations more frequently believe that they have sufficient prerequisites for studying and perceive school support to deepen their interest in the field. However, educational aspirations are separate from students' opinions about the teacher's efforts to develop technical thinking.

Chapter 13: *Opinion survey of teachers of dyslexic schoolchildren regarding learning skills*; by Bianca Rodrigues dos Santos, Giseli Donadon Germano & Simone Aparecida Capellini. The aim of this study was to characterize the opinion of teachers of students with dyslexia in a specific questionnaire on learning skills. 74 teachers of Brazilian schoolchildren with dyslexia participated, aged from 9 years to 10 years and 11 months from the 3rd to the 5th year of Elementary School I. The teachers answered the Learning Skills Questionnaire, composed of items: attention skills; visual processing skills; auditory processing skills; logical-mathematical reasoning skills; motor skills; behavioral skills. The questionnaire was filled out by teachers, with responses scored on a scale from 0 to 4 points (Likert Scale). Data for this study were collected from March 2019 to March 2020, before the start of the COVID-19 pandemic in Brazil. The results were analyzed statistically indicating that teachers answered “rarely” and “sometimes” for all categories, except for category behavioral, which most answers were “never”. There was also an indication of “I don't know” for all categories, suggesting that teachers’ lack of knowledge regarding behaviors aspects of dyslexic’s schoolchildren. The results allowed us to conclude that teachers still need of information about how schoolchildren with dyslexia learn to read, since the results “rarely” and “sometimes” were presented in all categories of academic learning.



Chapter 14: *The application of knowledge management in the teaching of translation in universities*; by Shiyang Liu, & Liu Liu. With the development of information technology, the universities are faced with an increasing need to integrate the knowledge management in their translation teaching, to form students' integral translation abilities and better the teaching efficiency. This research first makes a literature review on the knowledge management and the translation teaching. Then, we discuss the traditional translation teaching in universities and formulates the teaching model of knowledge management for translators', which includes the curriculum design, the search, identification and acquisition of information, the organization of information and the creation of personal knowledge bank, as well as the application of knowledge bank in the practical translation tasks.

Chapter 15: *Schoolchildren's performance on cognitive-linguistic skills during the context of a pandemic*; by Caroline Fernandes Brasil, Mariana Taborda Stolf, & Simone Aparecida Capellini. Aim: to characterize the performance of cognitive-linguistic skills of schoolchildren in early literacy during the pandemic. Twenty-two Brazilian schoolchildren participated in this preliminary study, distributed in GI, composed by ten schoolchildren for 1st grade and GII, composed by twelve schoolchildren for 2nd grade, submitted to the application of the Cognitive-Linguistic Skills Assessment Protocol. Results: schoolchildren from GI and GII showed average performance for writing the name, sequential alphabet recognition, and visual memory of shape. The GI presented a refusal response for the subtests of word, nonword and, picture dictation, word repetition and visual sequential memory of shapes and poor performance for alphabet recognition in random order and average performance for alphabet recognition in sequence. GII showed lower performance for the subtests of word, nonword and, picture dictation and superior performance for alphabet recognition in random order, alphabet in sequence and visual sequential memory of shapes. Discussion: the appropriation of the letter-sound relationship mechanism raises questions, since it evidenced the difficulty of all schoolchildren in cognitive-linguistic skills necessary for the full development of reading and writing. Conclusion: schoolchildren in the 1st and 2nd grade showed lower performance in cognitive-linguistic skills important for learning reading and writing.

Chapter 16: *Designing a curriculum for supporting the transition to adult life of young adults with intellectual disabilities*; by Ivan Traina. Individuals with intellectual disabilities (ID) are faced with significant barriers relating to the transition to adult life and employment. The proposed chapter's purpose consists of presenting the results emerged by the project of research E-IDEAS (Empowerment of youth with Intellectual Disabilities through Educational and training curricula for Acquiring employment Skills). In particular, the curriculum developed for supporting the acquisition of independent living and employment skills and the consequent transition to adult life of young persons with ID. Starting from a systematic analysis of literature on the topic, the chapter highlight the elements emerged that were used to develop the curriculum. Besides the search findings that

led to curriculum elaboration, it includes the description of the methodology adopted, learning contents, as well as teaching strategies and tools utilized. Lastly, the results achieved by participants who attended the curriculum are presented, its assessment discussed, and future research directions defined.

Chapter 17: *The relationship between parents' education and students' self-assessment of their own study prerequisites and aspirations*; by Josef Malach, Dana Vicherková, & Martin Kolář. In this chapter, we explore the importance of self-assessment for students in achieving success in their studies. Self-assessment involves evaluating one's own learning processes and outcomes. However, we focus on secondary school students' self-assessment of their study predispositions, aspirations, and motivation for success. This includes their knowledge, competencies, abilities, talents, and educational goals. Academic success encompasses various factors such as learning objectives, skills acquisition, satisfaction, persistence, and post-college performance. The study investigates the influence of parents' education on their children's careers. The authors examined the self-assessment of educational prerequisites and aspirations of 900 secondary school students aged 15-18 years. The results show that more than half of the respondents believe they have the necessary technical study prerequisites. However, self-assessment of study predispositions is not related to gender or field of study. The study also found that students' aspirations to succeed are related to their mother's education, not their fathers'. Overall, self-assessment is a crucial tool for students to achieve success in their studies. By evaluating their study predispositions and aspirations, students can set educational goals for themselves and work towards achieving them. The study also highlights the importance of parental education in influencing their children's educational aspirations.

Chapter 18: *Active foreign language learning practices in higher education: the perspective of actors*; by Véronique Delplancq, Ana Maria Costa Lopes, José Pereira, & Susana Fidalgo. The digital age and Generation Z are key features within the current panorama of teaching-learning practices in higher education and drive innovative student-centred strategies, oriented towards the reality of the labour market. The article describes an experience of pedagogical activation carried out through project-based learning using digital tools, with undergraduate Media Studies students of the School of Education in Viseu (Portugal), towards the acquisition of skills in French and English, during the academic year 2021-2022. The objective was to renew teaching practices, so as to foster greater student motivation on the part of forthcoming media professionals, by enhancing their competences and confidence with concern to spoken and written interaction within the context of foreign languages for specific purposes. The dynamics of learning combined with authentic contexts and digital tools, encourages teachers to rethink their methodology and objectives, in order to be more innovative. One accounts for the chosen strategy and the various steps followed, evaluates the path of both students and teachers, analyses the benefits, the drawbacks and the impact in terms of acquired skills and concludes with reflections for forthcoming work projects.

Chapter 19: *Exploring assessment types, instruments and methods of assessing knowledge, skills and values in higher education*; by Eric M. Chweu, Sibongile Simelane-Mnisi, & Andile Mji. This study aimed to explore the assessment types, instruments and methods of assessing knowledge, skills and values in higher education. The challenge was that lecturers could not comprehend, differentiate and apply assessment types, instruments and methods when assessing. The lecturers indicated that this could be attributed to the lack of assessment policy, strategy, awareness campaigns, workshops, orientation and framework that stipulates the use of assessment types, instruments and methods. The researchers have not come across literature that addressed the aforementioned. Participants were 10 lecturers who were purposively sampled and interviewed from seven Faculties at the University of Technology in South Africa. The question was: “To what extent are the assessment types, instruments and methods used by lectures to assess students’ knowledge, skills and values? A qualitative case study method was used to answer this question. Semi-structured interviews and document analysis were used for collection. Atlas. ti. was used for analysis. It was found that examinations, assignments, tests, presentations and discussions were interpreted by lecturers as assessment types and methods. Assessment types were not explicit in the module descriptors. Lecturers must develop assessments that are relevant, progressive and just in time.

Chapter 20: *Class singing by pre-service generalists: individual leading and co-teaching*; by Annamaria Savona. This study contributes to filling the gaps in how pre-service generalist teachers develop skills to lead class singing. In this chapter, I present the case study of two generalists who co-led class singing in their second-year internship while they taught individually in their first- and third-year internships. The comparison of the co-led lesson with the individual lessons shows significant differences in how the two generalists led the singing and managed the class. The focus of this study is on their use of audio devices and musical instruments. I filmed the internship lessons over the course of their three-year teacher training and analysed the moments when the trainees used audio devices and musical instruments. The analysis of the individual lessons shows changes in the in-situ practice of the two generalists using an audio device, guitar and body percussion. The analysis of the co-led lesson shows how the trainees collaborated on classroom management from a didactic and musical point of view.

**Section 2**, entitled “Projects and Trends”, presents chapters concerning, as the title indicates, education viewed as the center for innovation, technology and projects, concerning new learning and teaching models.

Chapter 21: *The perfect match for education for sustainable development: human needs versus sustainable altruism?*; by Erika Quendler, Matthew James Lamb, & Nouredin Driouech. Altruistically speaking, humanity has now reached a point where it has recognized that it has a responsibility to achieve a development that is sustainable, to wit the United Nations Sustainable Development Goals (SDGs).

This notwithstanding, as an intrinsically selfish creature, humanity also has a need to fulfil its own needs. This concept is set out by Maslow. Education is undeniably a linchpin in marrying these two concepts, aiming to meet the challenges and the needs of both today's and future generations. Whether and how these needs are met for any learner affects the learner's motivation to learn and the educator's motivation to teach. Therefore, it is paramount to reflect on the type of education that best "cultivates and guides the sustainable humanity" of the learners. This is the challenge facing today's Anthropocene society. Hence, this conceptual chapter attempts to distil a number of tangibles from the marriage of the SDGs with Maslow's hierarchy of human needs. One of the concrete outcomes is a series of features which aim to frame any realignment and transformation process for education for sustainable development (ESD). Finally, this chapter should fuel research and steer governance.

Chapter 22: *Reflections shaped by the COVID-19 pandemic for medical education in China, and globally*; by Liying Wei, & Pamela Brett-MacLean. The unprecedented global disruption introduced by the ongoing COVID-19 pandemic has highlighted the need to consider how to best prepare our learners to respond to the wide, interconnected array of global health challenges we face at this historical juncture. In 2019-20, when Professor Wei was a visiting professor at the University of Alberta, we began an East-West dialogue regarding the contributions of the medical/ health humanities to medical education. Following the emergence of the pandemic, we explored a broad literature base as they considered opportunities for reforming medical education to better prepare physicians to address complex global health circumstances and crises. Proposed directions for reorienting medical education include emphasizing systems science and public health competencies, promoting relationally-oriented identity formation and developing humanistic qualities and adaptive leadership ability through both systems-focused, humanities-informed curriculum and pedagogical processes. Ultimately, how successfully our learners respond to ongoing and emergent global health challenges will depend on how well we prepare them for the future. Recognizing increasing worldwide adoption of competency-based medical education, there is a pressing need to explore how to promote, and authentically assess, development of adaptive relational, collectivist competencies and capabilities.

Chapter 23: *Identifying the Ph.D. Students' needs for career enhancement skills*; by Alexandra Kosvyra, Dimitrios Filos, Tara Cusack, & Ioanna Chouvarda. To date, it is observed that an increasing number of Ph.D. graduates follow a career outside academia. The EU-funded CHAMELEONS project aimed to identify and fulfill the needs of Ph.D. students towards pursuing a career in digital and connected health industry. The CHAMELEONS overall goal was to develop innovative educational interventions offered by higher education to build more adaptable, entrepreneurial and employable graduates in both academic and non-academic environments. Thus, a range of courses or educational material provided by CHAMELEONS consortium members, or available in open platforms were identified, organized and offered to 15 students, of diverse background, enrolled in the program through a

State-of-the-Art (SotA) toolkit. Two questionnaires were provided to attain information on: (i) background and skills the students recognized as underdeveloped, (ii) students' preferences in terms of interest, reasons, and motivation of selection and skills they aim to acquire using SotA toolkit. Students selected courses not actually improving hard skills needed for their research, but soft skills in the business and career management direction, focusing mostly on creativity, innovation, and communication. Finally, the students mentioned that the drive for their selection was based on self-awareness tools which identified the underdeveloped skills required for a successful career.

Chapter 24: *School social work intervention with students at socio-educational risk: practices to promote equity in times of Covid 19*; by Sidalina Almeida. The Covid 19 pandemic, by electing distance learning, intensified the risks of dropout and failure of students with a more fragile relationship with the school, accentuating social inequalities and other inequalities and not allowing the multiplicity of their needs to be satisfied, in the sense of its integral development. The Portuguese government wanted to respond to the problems of absenteeism and school dropout, child poverty, intra-family violence, and mental illness, which were aggravated by the pandemic, giving guidance to managers, teachers, and technicians to reinvent the role of the school in times of physical distance, quarantine, and isolation. In this reinvention, the intervention strategies of the social workers were highlighted in the identification, and monitoring of risk/danger situations to which children and young people were subject and, in the articulation with the competent authorities and the community institutions, in promoting the right to education and social protection. Focusing on a qualitative approach, through interviews with social workers who are part of multidisciplinary teams in school clusters, in the metropolitan area of Porto in northern Portugal, we sought to know how they perceive their functions and professional practices, and their potential in making the right to education effective for combating inequalities.

Chapter 25: *Uses of artificial intelligence in intelligent tutoring system*; by Clément Aubeuf. This article aims to present the operation of an Intelligent Tutoring System exploiting artificial intelligence to personalize the learning of the learner and to automate certain tasks of the teacher. All the resources consulted and the educational objectives achieved by the learner will be processed using the TinCan API and the limitation of the amount of sensitive data sent to the cloud will be ensured by the use of peripheral artificial intelligence. We start by defining the concepts of artificial intelligence and Intelligent Tutoring System, then we focus on the implementation of machine learning in such a system and the advantages that this technique brings. Finally, we describe the limits of such a technology and the possible solutions to it.

Chapter 26: *What PhD students want from career-related modules: the CHAMELEONS project - An evaluation of three interdisciplinary, inter-sectoral and international modules*; by Tara Cusack, Jack Quinn, Ioanna Chouvarda, & Nicola Mountford. CHAMELEONS (Championing A Multi-Sectoral Education and Learning Experience to Open New Pathways for Doctoral Students, H2020-SwafS-2018-2020), is a programme of 3 EU-funded interdisciplinary, inter-sectoral and international modules that aimed to broaden the skills of PhD graduates improving their employability in academic and non-academic environments. Fifteen doctoral students from five European universities were recruited. This chapter represents evaluation conducted on all 3 modules. In terms of programme content, students perceived that real-time assessment, reflective learning, engagement with course coordinators and the opportunity to engage with practical research tools (Photovoice, Ecosystem Mapping and Walk My ID) all enhanced their learning. They suggested more group activities to enable them to better network with their doctoral colleagues as well as more practical activities. In terms of programme delivery students expressed a desire to have more physical face-to-face engagements while understanding the Covid-19 constraints. When given the opportunity to add freeform and unprompted comments, students almost without exception expressed their satisfaction with and appreciation for the modules. In terms of programme outcomes one student expressed an aspiration to be “more sure” of their skill set and marketability complimenting the focus on practical learning in the programme content review.

Chapter 27: *The e-readiness of student teachers for 21<sup>st</sup> century teaching: some reflections from a university of technology in South Africa*; by Paseka Patric Mollo. The COVID-19 pandemic and the hygienic measures of social distance brought impasses to education. Face-to-face activities are suspended, and this accelerated the use of Information Communications Technology (ICT) in most schools. Based on these changes, teacher education and training at universities should prepare prospective teachers that are able to function within digital and virtual classrooms. This study investigates the level to which student teachers were exposed to Technological Pedagogical Content Knowledge (TPACK) needed by them to function within such classrooms during and post-COVID-19 times. The study analyses, the Central University of Technology’s (CUT) final year Bachelor of Education student teachers’ e-readiness to integrate ICT and present lessons in these classrooms. A total of 60 student teachers were purposively selected for this study. Data was collected using online questionnaires. A 5-point Likert scale questionnaire was used to collect data from student teachers. Subsequently, results revealed that student teachers are aware of the importance of ICT and e-learning in schools. However, they acknowledge that they have limitations, and they are not fully ready in implementing ICT in digital & virtual classrooms. The study concludes by offering several theoretical and practical recommendations for the e-readiness of student teachers in such environments.

Chapter 28: *Employer, industry and policymaker views on doctorate education*; by Niamh Leniston, Joseph Coughlan, Tara Cusack & Nicola Mountford. As society undergoes green and digital transitions, various policymakers such as the European Commission expect universities to contribute to innovation and progress. As education's highest achieving graduates, the doctorate holder may be key in this era of innovation and problem-solving. As academic career prospects dwindle, and PhD graduates increasingly enter industry, academic research has highlighted that traditional PhD programmes may not provide the required skills and knowledge for the workforce today. To learn how best to address such issues, we consulted thirteen EU policy documents and industry-led reports; and interviewed thirteen employers to add their voice to the discussion. Findings align with previous reports of a lack of transferable skills, but also introduce new concerns such as the desire for adaptability, experience, and redefining skills with regards to self-presentation. We discuss interdisciplinarity and intersectorality as potential solutions to addressing these needs.

Chapter 29: *Relationship between oral reading fluency measures and visual attention span in Brazilian's schoolchildren in pandemic context. Reading fluency measures and Visual Attention Span*; by Giseli Donadon Germano, Lavínia Micaela Moreira, Ana Karolina Silva Deolindo, & Simone Aparecida Capellini. The aim of this study was to relate the measures of oral reading fluency and visual attention span in Brazilian students from the 4th grade of elementary school. Eleven students were submitted to three measures of oral reading fluency and the global visual attention span (VAS) for five characters. The reading correct word per minute measure was used with three texts that differed in complexity. The study was carried out after the adoption of remote teaching in the Pandemic. Spearman analysis was performed between fluency and VAS variables, with no significance. The results revealed a greater number of correct words per minute in the third reading time compared to the first two times, revealing that the real reading performance of 4th grade students is the average of 39 to 40 words per minute and average of fixation of 50% of the characters. These findings indicate academic losses due to low reading fluency rate, fewer characters per fixation and lack of relationship between the variables. These results pointed out to the decrease in reading practices during the Pandemic. As conclusion, there is a need for further studies about this theme.

Chapter 30: *Effects of a tutor based interactive-computerized intervention program for promoting comprehension skills in first grade at-risk Arabic students*; by Bahaa' Makhoul, Elite Olshtain, & Raphiq Ibrahim. The study investigated the effects of an interactive, individualized computer-based intervention program for advancing comprehension skills among children at risk of low literacy. Participants were forty Arabic-speaking first-grade students at literacy risk: 20 assigned to the intervention program, and 20 assigned as control group. In the intervention group, each student was paired with a tutor and was categorized in one of 4 sub-groups: high student and tutor motivation, low student and tutor motivation, high student motivation/low tutor motivation, and low student motivation/high tutor motivation. Students'

comprehension achievements and progress were measured before, during and after the program. Findings showed that the intervention program succeeded in advancing students' skills beyond motivation level, although the greatest improvement was found in the sub-group where both students and tutors had high motivation. Findings demonstrate the need for a specialized intervention to efficiently close the gap in comprehension skills among students at literacy risk and the importance of motivation of both students and tutors in the learning process.

Chapter 31: *Self-reported knowledge, experiences and predisposition towards interprofessional education and collaborative practice in faculty members from the centre-west region of Brazil: a qualitative study*; by Sebastião Benício da Costa Neto, & M. Graça Pereira. The mechanisms that facilitate interprofessional education and collaborative practice (IPECP) associated with the academic training project include the effective involvement of faculty members, a topic about which there is little available knowledge in Portuguese speaking countries. The goal of the present study was the understanding of self-reported knowledge, experiences, and willingness towards IPECP of health/related areas professors, from two universities in the centre-west region of Brazil. The intentional sample included 16 professors, members of the College and Teaching Structuring Cores (definition, management and update of undergraduate pedagogical projects), who answered a semi structured interview script and filled in a sociodemographic and professional profile questionnaire. The interviews were transcribed verbatim, validated by the participants and then submitted to a thematic content analysis, supported by NVivo, version 11. The results revealed six inductive thematic categories (Undergraduate Training Process, Professional Experience in IPECP, Mechanisms for IPECP, Openness to IPECP, Interprofessional Relations and Representation of IPECP), and 24 subcategories. In general, participants revealed to be open to IPECP, even though not all had knowledge of the mechanisms or technical, political, and ethical tools that favour the development of IPECP, in undergraduate degrees.

Chapter 32: *Science teachers' perceptions and practices on using mobile-based informal formative assessment for inquiry-based teaching in South African science classrooms*; by Noluthando Mdlalose, Umesh Ramnarain, & Mafor Penn. The proliferation of mobile technologies in different contexts contributes to the rapid and extensive implementation of mobile-based teaching and learning practices across the globe. Effective implementation of mobile-based informal formative assessment practices in science classrooms could yield to scientifically literate learners who are able to communicate, work collaboratively to construct knowledge and think critically. Data was collected from four purposively selected science teachers around Gauteng province, through questionnaire, classroom observations and stimulated-recall discussions. The findings from the questionnaire indicated that all four participating science teachers still enact formative assessment following the traditional and teacher-dominated approach. Numerous challenges such as insufficient classroom time, inadequate resources and unstable Wi-Fi connection hinders teachers from frequently practicing inquiry-based instructional strategies and



technology-enhanced formative assessment. Although these four science teachers have experienced numerous challenges, they have pointed out numerous benefits of implementing mobile-based formative assessment for inquiry-based learning. Benefits such as enhanced learner engagement, knowledge construction, participation, motivation, and comprehension of scientific concepts during the learning process were reported. However, certain changes such as flexible curriculum, adequate teaching and learning time and adequate and relevant teacher professional development must be implemented to ensure successful mobile technology-enhanced formative assessment for inquiry-based learning practices.

Chapter 33: *Impact of teacher creativity styles on science teacher training in inquiry-based science education*; by Eva Trnová. The efficiency of teacher education is an essential issue in continuous professional development. The main areas affecting this efficiency are innovative educational methods, teacher training methods and personality characteristics, including creativity styles. The study is devoted to researching the roles of teacher creativity styles in science teacher training in implementing inquiry-based science education. The research was conducted in the frame of the European project PROFILES. Design-based research has been used as a research frame. Fifty Czech science teachers - participants in the PROFILES project were identified as innovators using Kirton Adaption-Innovation Inventory. A comparison of teachers' activities during training with characteristics of teachers-innovators was conducted. The research results confirmed teachers' innovative behaviour during the training of IBSE implementation. The main research finding is that the style of creativity (innovators) influenced the interest and process of teacher training. The research implies that it is necessary to accept the creative style of teacher-participants in training courses to be efficient.

**Section 3**, entitled “Teaching and Learning”, offers research about foundations in the education process itself, in various contexts, both for tutors and students.

Chapter 34: *Media, language and their impact on the development of young children's political awareness - Thoughts and preliminary research results of an interdisciplinary research project*; by Gudrun Marci-Boehncke, Matthias O. Rath, & Raphaela Tkotzyk. The interdisciplinary project PoJoMeC, funded by The Federal Agency for Civic Education (Bundeszentrale für politische Bildung) in Germany, examines the political awareness and understanding of preschool and elementary school children. Thereby the interdisciplinary approach takes place from the perspective of political didactics, literature and media didactics, and journalism. The main research goal is to survey how political awareness of young children is expressed. Therefore, we draw on qualitative approaches, in which we focus (a) on the children's explicit knowledge, and (b) concepts of rule-based behavior. The different levels of abstraction of these concepts are based on a modification of the ecological model of human development according to Uri Bronfenbrenner (1979). This article outlines, on one hand, an interdisciplinary investigation for a

viable concept of politics for research with children between the ages of 4 to 8 years. Therefore, we consider areas such as political didactics, literature and media studies, and philosophy, and introduce a research framework that does not start with terms and concepts but considers more fundamental forms of social perception. On the other hand, this chapter explains methodological approaches and evaluation methods and presents the preliminary results of a pretest with a sample of German preschool children.

Chapter 35: *Teaching towards joy and involvement with Western and Arab classical music*; by Shoshan Shmuelof, Eyad Hamza, & Michal Hefer. Listeners at concerts of classical music, both Western and Arab, are dwindling. Educational policy does not invest enough to preserve the gifts of previous generations. We will argue that what prevents teachers from introducing their pupils to this music is the absence of teaching methods that make listening to unfamiliar music challenging, engaging, and fun. This chapter introduces new pedagogy and a program of prepared concerts for teaching classical music in primary schools and preschools. One of the innovative methods of teaching is the "Musical Mirror" approach, based on the principle that movement gestures are the source of musical gestures and their use aids in the individual's cognitive and affective identification with the music. Conclusions drawn from the study are based on responses to questionnaires and interviews of practicing teachers, both those who are teaching Western and those who are teaching Arab music. The use of Musical Mirrors and Graphs raised teachers' confidence for teaching complex music because it deepens their understanding and generates excitement and identification with the music which they then transfer to their students. Furthermore, the concert program provides a professional framework with opportunities for collaborative learning both for themselves and their pupils.

Chapter 36: *Deeper conceptualization and anchoring of knowledge in second language learning*; by Marie J. Myers. There are increasing concerns around the teaching and learning of French, Canada's second official language, due to a lack of proficiency in the language by future teachers in the English-speaking provinces. The main question is around how to improve this situation and find specific answers for some of the major problems, especially to increase deep learning. To investigate this, instructor teaching notes were analyzed to uncover what was deemed most efficient, as for example noting how the instructor drew attention to knowledge to be mastered and how metacognitive strategies were implemented. Various categories were looked at including ways involving the affective domain, through emotions and using innovative ways to see if they provided a further impact for the crystallization of thoughts and anchoring of knowledge. Overall results show that students reported that they appreciated the corrective feedback the way it was dispensed. A variety of issues were also uncovered. Due to page limitations, in this chapter we present overarching aspects.

Chapter 37: *"My dance area - your dance area" - Metaphors of nursing trainee identity in the context of virtual communities of practice*; by Linda Hommel. Virtual Communities of Practice (vCOP) in the context of nursing education evolve their significance in the case of professional identity development. "What does it mean to be a nursing student?" is a central question in the nursing education context, in which the foundation for a professional identity is laid. Since communication in virtual communities of practice is predominantly text-based, there are often rich descriptions of one's own view as well as reflections on what has been experienced. Studies indicate, that linguistic peculiarities are evident in the expression of nurses in the form of frequent metaphorizations. Against this background, this research addresses the question of what metaphors nursing trainees use in the context of virtual communities of practice to describe their perceptions of being a nursing trainee. The goal of the study is to describe the core characteristics of nursing scholar identity and derive curricular consequences. Within the framework of a netnographic research design, data collection is done through field observations. In the context of data evaluation, Schmitt's metaphor analysis is used. Preliminary results show, that nursing trainees describe their identity in terms of metaphorical expressions, which manifest themselves in Being a Nursing Trainee and Being a Prospective Nurse.

Chapter 38: *Sharpen critical thinking skills to boost future works. The case of engineers from freehand drawing to digital processes*; by Francesca M. Ugliotti, Davide L. D. Aschieri, & Anna Osello. Learning never stops, and neither does teaching. Re-engaging critical thinking learned at an early age and boosting skills within the university setting play a critical role in shaping a generation of professionals capable of meeting the ever-changing challenges of the modern world. The experience is related to the Building Engineering degree program at the Politecnico di Torino, specifically in the first-year Building Drawing course, pointing out the relevance of the approach from the beginning of the curricular path. The discipline of Drawing, understood as a language of communication for the construction industry, is the element around which an active learning path with students is developed. The scheme adopted provided theoretical notions as the knowledge foundation, then methods and tools between tradition and innovation for representing and analyzing the projects with a critical attitude. Real-world (freehand sketching), digital (Computer-Aided Design vs Building Information Modelling), Augmented and Virtual (avatar in the metaverse) practices are presented to provide a synoptic picture of possibilities that the student may choose to self-consciously employ in further academic courses and their working life.

Chapter 39: *Teachers perspectives of virtual programs to promote student engagement in secondary education*; by Samantha F. Junkin. Households can be very distracting for students, simultaneously teachers are unable to walk around to see if students are engaged or distracted (Farah & Barnett, 2019). In addition, teachers can feel intimidated and overwhelmed by technology (Hertenstein, 2020; Schaffhauser, 2020). Teachers are struggling with virtual learning and have gotten little to no professional development on how to engage students in an online platform

(Schwartz, 2020; Williams, 2021). This study will dive into various virtual programs for promoting student engagement. This perspective will help provide professional development direction on which programs could be used to engage students in a virtual setting.

The participants included current teachers enrolled in a master's of education program in southeast Alabama. The participants learned about various free online programs and were able to implement those programs in their classrooms simultaneously. At the end of the semester, students took an online survey asking which programs were least to most helpful for engagement, easiest to implement, and programs they would like to know more about.

Chapter 40: *Examining the factors influencing English teaching and learning in rural settings throughout Europe and the United States*; by Diane Boothe. This chapter examines English learning environments and methods in rural settings in Europe and the United States, assessing their contributions to language learning, both written and spoken. Educational systems are compared and contrasted, including two different styles of English education structured in a comparative analysis using five focal areas. These focal areas are expanded to include the definition and structure of rural education, English language learning modalities, linguistic environment, educational outcomes, and indicators of success. The opportunity to investigate the experiences of teachers who are active in rural communities and focus on the multidimensional aspects of the education of multilingual learners provides valuable information that contributes to expert teaching and learning and bridges the gap between educating rural and urban populations of students. Embracing English language learning, new technologies, and initiating change through proactive educational strategies including a paradigm shift to incorporate a translanguaging pedagogy for emergent English speakers will lead to relevant and purposeful accomplishments in rural school settings.

Chapter 41: *Applying inquiry-based learning into practice: a case study of one rural South African physical sciences teacher*; by Nomzamo Xaba, & Aviwe Sondlo. The South African secondary school curriculum expects teachers to adjust their ways of teaching to include activities that involve learner participation. However, there is little to no support that is aimed at developing in-service teachers' effective inquiry-based practises from the Department of Basic Education (DBE). Therefore, this mixed-method research aimed to investigate whether Physical Sciences teachers' beliefs about inquiry-based learning transpired in their teaching. A quantitative method was used to determine the teachers' beliefs about inquiry and a qualitative method was used to analyse the selected teacher's classroom pedagogical practices and provide insights into whether their beliefs about inquiry translated into their teaching practices. An adopted version of the Science Curriculum Implementation Questionnaire (SCIQ) was used to determine the teachers' beliefs while an Electronic Quality of Inquiry Protocol (EQUIP) was used to evaluate the selected teacher's pedagogical practices. The findings of this study indicate that the Physical Sciences teachers in the Zululand District generally had a positive belief about

inquiry-based learning. However, the selected teacher's pedagogical practices did partially reflect their beliefs about inquiry. The qualitative method it was found that the selected teacher was centred within developing inquiry (Level 2).

Chapter 42: *Reflections on didactical challenges in teaching computer programming*; by Marcin Fojcik, Martyna K. Fojcik, Sven-Olai Høyland, & Jon Øivind Hoem. One of the key challenges of modern society is the vast number of technological devices surrounding us. As a result, general ICT skills are essential for both work and personal time. In addition, ICT skills are widely used in the education of different subjects. The challenge is that while computer science (programming) is relatively well covered in the literature, computer science in other professions, including education for non-IT professionals, is not.

Teaching computer programming is particularly difficult in courses for students from outside computer science fields. The fundamental problem is: what computer skills should be taught and to what extent? It is usually impossible to teach all possible concepts in a course. In this case, the focus should be on programming terminology, key definitions, or perhaps - computational thinking and problem-solving skills? Another challenge may be using English or the national language and selecting examples based mainly on mathematics or practical experiences.

This chapter presents the experiences and reflections of authors from different universities, departments, and courses on teaching, using other pedagogical approaches, and programming theories comparing programming for computer science students and non-computer science students.

**Section 4**, entitled “Organizational Issues”, gives a glance on tools for implementing organizational learning and change in the education context.

Chapter 43: *Relationship between school climate and grade 9 learner achievement in science: comparing South Africa and Singapore*; by Marien Alet Graham. South Africa scored worst in scientific achievement at the high-grade level in the Trends in International Mathematics and Science Studies (TIMSS) 2019. Singapore, the TIMSS 2019 leader, and South Africa are compared. Quantitative positivist design was applied. Multi-level models showed that, for both countries, learners with a higher sense of belonging performed better. In Singapore, school buildings, grounds, and audio-visual tools for instruction were significant predictors; however, in South Africa, appropriate instructional materials and technologically skilled staff were. Singaporean learners at schools where principals claimed their audio-visual resources for instruction were not affected by shortage or inadequacy performed significantly worse than those in schools where principals said it is affected. Several explanations were offered for this surprising discovery, but Singapore education officials and stakeholders may need to investigate more. Thus, for Singapore, we urge additional investigation of the surprising outcome while, for South Africa, prioritising schools with insufficient instructional materials and training all teachers in technology. Stakeholders should also invest in school climate

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surveys and other interventions supporting a healthy school environment. Additional research is encouraged to establish the nature of the impact that a healthy school climate has on learner achievement through longitudinal studies where causation can be proven.

Chapter 44: *Perceived realities of rural primary school teachers in Malawi: applying Bronfenbrenner's ecological systems theory*; by Guðlaug Erlendsdóttir, & Peter Mtika. The ability of teachers to enhance the quality of education depends on the teachers' knowledge, skills, motivation and conducive working environment. This study examines teachers' experiences in four rural primary schools in Malawi, focusing on the impact of their working and living conditions on the quality of education. The study followed a qualitative research approach, collecting data through semi-structured interviews. Data were obtained from 24 teachers, four headteachers and four primary education advisors (PEA). Bronfenbrenner's ecological systems theory was applied to interpret data. The teachers, headteachers and PEAs are represented in the microsystem, their interactions comprise the mesosystem, their working and living conditions are represented in the exosystem, and the macrosystem consists of the customs and laws of society. The findings show that the microsystem, which involves teachers, headteachers and PEAs, appears somewhat active; teachers teach despite numerous challenges. However, interactions between units within that system are weak, resulting in limited mesosystemic interaction. Implications of the findings are discussed later in this chapter.

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**Section 3**  
**Teaching and Learning**



## Chapter # 38

### SHARPEN CRITICAL THINKING SKILLS TO BOOST FUTURE WORKS

#### The case of engineers from freehand drawing to digital processes

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#### ABSTRACT

Learning never stops, and neither does teaching. Re-engaging critical thinking learned at an early age and boosting skills within the university setting play a critical role in shaping a generation of professionals capable of meeting the ever-changing challenges of the modern world. The experience is related to the Building Engineering degree program at the Politecnico di Torino, specifically in the first-year Building Drawing course, pointing out the relevance of the approach from the beginning of the curricular path. The discipline of Drawing, understood as a language of communication for the construction industry, is the element around which an active learning path with students is developed. The scheme adopted provided theoretical notions as the knowledge foundation, then methods and tools between tradition and innovation for representing and analyzing the projects with a critical attitude. Real-world (freehand sketching), digital (Computer-Aided Design vs Building Information Modelling), Augmented and Virtual (avatar in the metaverse) practices are presented to provide a synoptic picture of possibilities that the student may choose to self-consciously employ in further academic courses and their working life.

*Keywords:* building drawing, critical thinking, mind map, building information modelling, virtual reality, avatar.

#### 1. INTRODUCTION

Nowadays, the modern world is faced with increasingly complex challenges related to globalization, climate change, and the resilience of our cities. On the other hand, the growing technological evolution is enabling broader and more exciting scenarios than ever. These factors are very prominent in the construction sector, which is going through a period of structural change to keep pace with the speed of the Industry 4.0 era.

The emergence related to the digitalization of processes and the introduction of new working collaborative tools, such as Building Information Modelling (BIM), required at the European level by Directive 2014/24/EU (European Parliament, 2014), has demanded from the market not only new skills at a technical level but, above all, a flexible engineering mindset capable of adapting to fast-changing contexts. This element takes on even more significant weight since, according to the World Economic Forum, 65% of children enrolled in primary school today will work in jobs that do not yet exist (World Economic Forum, 2020).

Education will therefore play a decisive role in the following years to bridge the gap between the new industry's demands and the training of young university graduates and ease the transition of workers into more sustainable job opportunities. Consequently, in this historical and cultural context, more than at any other time, there is a pressing need to introduce a revision of degree courses (Osello, Del Giudice, De Luca, & Ugliotti, 2022).

Moreover, distance learning associated with the Covid-19 epidemiological emergency measures experienced in the last few years has introduced new difficulties that have required additional investment to turn the limitations of the virtual environment into current and future opportunities for the students (Ugliotti, De Luca, Fonsati, Del Giudice, & Osello, 2021). Technology-enhanced learning leverages technology to maximize learning within an environment of high-quality course design that can offer students the options of time, place and pace, and emphasizes different learning styles (Huang et al., 2020).

This chapter addresses the particular case of the first-year Building Drawing course of the Building Engineering degree program at the Politecnico di Torino as a leading example of innovative and future-proof teaching practice.

## 2. BACKGROUND

Digital transformation increasingly requires digital and transversal skills by professionals, companies, public administrations, and citizens to benefit from new services. Hence, the development of critical thinking represents an essential skill in 21st-century learning within educational and professional settings. Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to action. Several interpretations can be found in the literature on the subject (Padmanabha, 2018; Paul & Elder, 2010). According to Dewey, critical thinking is a reflective thinking type that consists of turning a subject over in mind and giving it serious and consecutive consideration (Dewey, 1933). It is a purposeful, self-regulatory judgment that results in understanding, investigation, evaluation, and inference (Facione, Sanchez, Facione, & Gainen, 1995). For Ennis, it is meditative, and sensible thinking focused on deciding what to believe or do (Fisher, 2011). When individuals are capable of using their critical thinking skills to act on opportunities successfully, it can be expected that growth and benefits for the knowledge economy should follow, further developing the capabilities and potential of nation-states (Heard, Scoular, Duckworth, Ramalingam, & Teo, 2020).

Indeed it is the university's job to train students to be increasingly competitive and ready for a world of work subject to constant adaptation. Therefore, the focus moves from the selection and quantity of theoretical content to the learning style for the teaching method aimed at raising knowledge quality (Creemers et al., 2013; Biggs & Tang, 2011) and providing engagement opportunities. According to a recent trend, improving teaching practices requires treating them with the same methodological rigour as scientific disciplines. There is a need for a new synthesis of the instructional development literature (Stes, Min-Leliveld, Gijbels, & Van Petegem, 2009; Hattie, 2009; Samuel & Rahman, 2018). Evidence-Based Education (Pellegrini & Vivianet, 2020) adopts a practice based on the best available evidence. According to Hattie, it is necessary to make the learning-teaching process "visible" (Hattie, 2009, 2012): the objectives must be made explicit, the didactic proposals challenging, the feedback provided and sought, the subjects actively, passionately and enthusiastically involved. Learning is best achieved when the individual actively constructs knowledge and understanding (Sanrock, 2001). Individuals must actively participate in the teaching and learning process, thus discovering, reflecting and thinking critically about the knowledge they acquire (Richardson, 2003). Active learning (Brame, 2016) builds on constructivist learning theory (Piaget, 1964), which posits that people learn by connecting new ideas and experiences to what they already know. In light of existing research, teaching structures (Bonaiuti, 2014) are gradually incorporating active learning techniques such as

Participatory Teaching (Concina, 2019), Think Pair Share and Team-Based Learning (Lotti, 2021), Game and Role Playing, Problem-Based Learning, Peer Review, and Mind and Conceptual mapping. Further background and theoretical grounding are provided in the next section concerning the methodological approach used.

### **3. METHODOLOGY**

Now that the necessity to push for innovation in teaching and learning methods has been framed, how to critically and technically explore it? Which role do tools and procedures play in digitalization? This section aims to investigate the strategies that lead to consistent innovation in teaching processes and focuses on the broad theoretical reflection of the current strategies in innovating practices. Promoting innovation in terms of processes and tools in teaching courses is driven by specific and tailor-made strategies that aspire to change the traditional teaching approach profoundly. As mentioned before, preliminary experimentation on the Building Engineering degree program is applied to the Building Design course, which is intended to be the first characterizing teaching of the curriculum. The Building Drawing course tries to embody some of the principles expressed by the cognitivist matrix teaching (Maccario, 2015) and associate the theoretical suggestions with an operative strategy. In fact, the teacher's role (van Dijk, van Tartwijk, van der Schaaf, & Kluijtmans, 2020; Vighnarajah, Luan & Bakar, 2008) both in cognitivism and in the constructivism learning theory is to guide students through the problem-solving process, while allowing them to use their own mental capacities to find solutions. The model adopted seeks to combine teacher-centred teaching, i.e. the didactic approach, and student-centred learning, i.e. the student's active participation. The elaboration of information regarding the connection between topics and matters, individual restitution of results, and critical analysis of process and outcome are fundamental in pushing teaching methods beyond traditional and consolidated procedures. Therefore, the teaching approach of the course takes the following strategic principles into account: (i) supporting the reworking of knowledge, (ii) experimenting with mental strategies, (iii) employing the use of mental resources, (iii) increasing the self-efficiency level of the students.

#### **3.1. Reworking of knowledge**

First of all, innovative teaching methods should lean on supporting the reworking of knowledge (De Vecchi, Carmona-Magnaldi, & Della Casa, 1999). The teaching goal is no longer to accumulate knowledge but to structure it, build networks between concepts, and establish a connection between knowledge. What can benefit the development of an articulated network of concepts is addressing a teaching topic by suggesting the employment of several and different technologies to explore from different sides and grade the same object of study. Providing diversified tools and learning strategies can help push students to build critical thinking and cognitive connections. In this context, the Building Drawing course suggests employing several methodologies and techniques in the cross-sectional analysis of a specific object under study, as explained in the following.

#### **3.2. Experiment with mental strategies**

Secondly, teachers should encourage students to experiment with mental strategies to push a step beyond mere knowledge transmission. Knowledge is built through a personal work of re-elaborating concepts through which understanding takes place, and knowledge is established. During the Building Drawing course, students are encouraged to elaborate on a personal interpretation of the theoretical topics learned in class and build a concept or mind

map (Tavares, Meira, & Amaral, 2021). Maps are more than a mere graphical representation of concepts and their relationships: they are tools that can help us think better by improving our creative capacity and analytical and reasoning skills. This strategy is aimed at developing meta-cognitive and self-regulatory abilities. Students acquire generative behaviour according to the constructive mode of Michelene Chi's ICAP (Interactive, Constructive, Active or Passive engagement) active learning framework (Chi & Wylie 2014; Chi et al., 2018). In this way, they can generate additional information, which may contain parts of new knowledge compared to the material provided by the lecturer and go beyond what has been presented.

### **3.3. Employing the use of mental resources**

The teacher not only provides the strategies but also helps students employ the use of mental resources (Mazzoni, 2001). It is fundamental that an individual is guided to understand that resources must be dedicated during a study activity and, secondly, how many resources must be dedicated and for how long. It is strategic for a student to ask himself how much (cognitive) effort must be used to tackle a task. How to reach this objective? The teaching course's clear organization concerning topics, objectives, technologies employed, and expected outcomes helps provide a precise reference context. The task of a teacher is not only to organize the resources but also to help students by employing them at different levels at different times. The Building Drawing course is organized to put different organizational, cognitive and technical resources into action to accompany the subject in its growth as an autonomous individual and student. According to the Experiential Learning (Kolb, 1984) process, the "learn by doing" is used to engage students.

### **3.4. Increasing the self-efficacy level of the students**

The weaving of the strategies described must lead to the last point of discussion to consider the needed increase in the self-efficacy level of the students. This aspect represents a crucial and fundamental element because it focuses on nourishing the students' cognitive resources in evaluating themselves. It aspires to help students not so much to understand if they have done well or poorly but because they have achieved a specific result. It can positively affect self-efficacy as it helps to evaluate their performance to recognize functional processes and those that are harmful to increase the possibility of self-regulation and the confidence to better face future difficulties. Concerning this, the pedagogical strategy of Team-Based Learning (Parmelee, Michaelsen, Cook, & Hudes, 2012) provides support with problem-solving, group work, and peer review activities. Students evaluate each other on each other's contribution and intra-group dynamics, reinforcing the importance of both individual preparation and team participation. The Building Drawing course promotes a calendar organized in weekly steps of validations supported by the teacher and tutors at different levels and with different and complementary competencies to help students develop practical activities. Students are accompanied in developing their exercises by weekly reporting difficulties and achievements. They are put into proof to have defined a critical and personal reflection on the practical work.

#### 4. COURSE APPLICATIONS

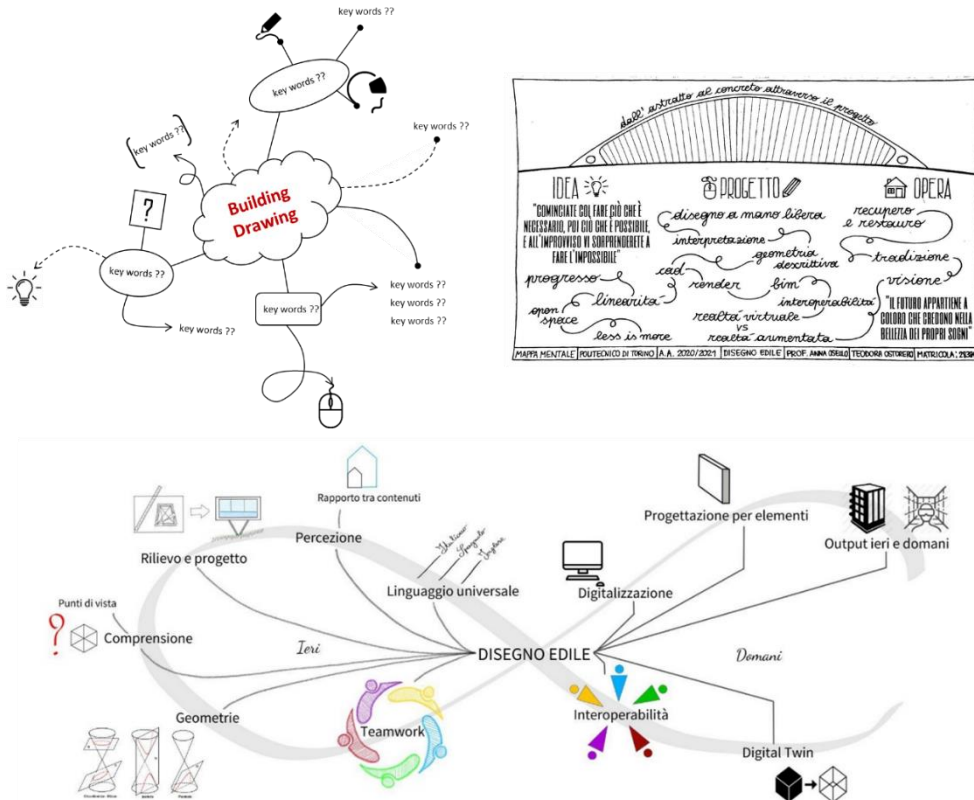
The Building Drawing course aims to set up the methodological elements of drawing as a communication language for the building engineer, providing tools and methods between tradition and innovation for representing both survey and project. The theoretical concepts concerning descriptive geometry are declined in practical exercises, freehand sketches, and technical drawing, including innovative visualization practices. Going into the details of the experience, an attempt was made to implement the strategic principles previously outlined in the teaching by providing an articulated plan of action. As the literature reflects, “Learning involves a combination of discussion, practice and production, working together to practice new skills and creating collaborative work by challenging each other and reaching agreement” (Laurillard, 2012).

In particular, an effort was made to design participatory teaching and interactive learning techniques concerning the theoretical modules. Active reflecting activities on specific topics are offered, asking students to ponder what they already know about a subject. As an example, the launch of the course is handled through a brainstorming activity on the meaning of Drawing, what it expresses and what it helps us communicate in engineering and architecture. At the end of the lectures, on the other hand, the teacher promotes an exercise in summarizing the concepts, highlighting the connection of the new information concerning their real life and how they will apply it to the world through a concrete application. This task also allows a continuous check of the skill gap or mismatch against market needs. Interaction with students is managed through audience response system (Wood & Shirazi, 2020) tools such as Padlet, Kahoot, and Google docs/forms.

To further mark each lesson, students are targeted for a conceptualization activity by self-reflecting on arguments addressed in the course. In this framework, an operative strategy adopted is the development of a mind map to pick representative keywords collected from lesson to lesson, put them in order, and trace connections among the topics, reworking the relationships by using a graphical means. This personal global overview and interpretation of the topics of the teaching formulated by the student are used as the basis for the initial discussion of the oral final examination. Two examples from the Building Drawing course, a.a. 2020/2021, are shown in Figure 1.

The practical exercise involves individual work in the initial weeks of the course, which becomes group work in the predominant part of the course. This choice aims to foster the development of soft skills in university teaching from the early years through experimentation with teamworking, networking, and no less conflict resolution. These skills then become relevant in consideration to the future professional activity of the building engineer, who will always have to collaborate with various other stakeholders for any project’s success. As the students are in their first year, they are asked to reproduce an author’s project to begin to familiarise themselves with the theoretical content and govern the tools. The case study selected should be explored comprehensively by students through a gradual learning path of representation techniques. It involves the employment of freehand sketches, bi-dimensional and three-dimensional digital drawing, parametric design, and Augmented and Virtual Reality. The aim, therefore, is not to make a vertical focus but to investigate the potential and limitations of different instruments. While freehand drawing is well established in scientific social research as a tool for critical reflection, the adoption of advanced digital tools is still underestimated in terms of methodological approach.

Figure 1.  
Mental maps outcomes.



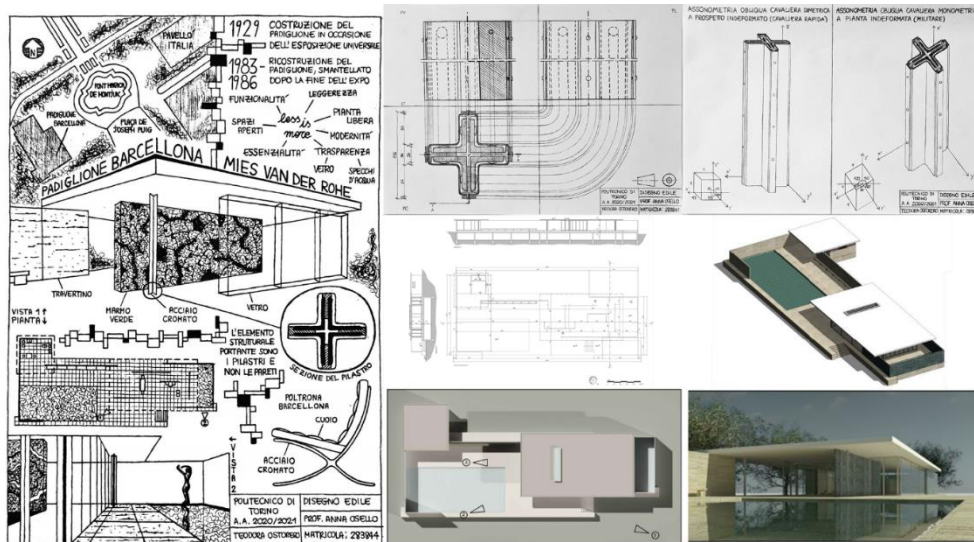
The tools represent a means better to control not only the design but especially the processes. In this sense, it is essential to transfer the method to the students to interface with the instruments rather than merely sharing commands referring to a specific software popular at the time. Using different but complementary operative solutions helps students analyze the object in different scales, perspectives, and technical means. The outcome is deeper learning of the whole object's characteristics, relationships between the parts, and connection with the surrounding. The students are asked to begin the process of investigating the building, starting with the creation of sketches. The anthological drawing is a personal, reasoned, critical reading where the most significant information about the artefact must be selected, drawn, and written down. The theoretical contents relating to orthogonal and axonometric projections are declined in the following practical exercises, always requested freehand, having as object a specific characterizing element of the author's project. Training on digital representation is indispensable nowadays. However, it is the job of university lecturers to select and transfer the most advanced methodologies that find application feedback in the professional and procurement world in addition to the more traditional and established practices. Over the past two decades, in fact, Building Information Modelling (Osello, 2012) understood as the process at the heart of the construction industry for exchanging information during the building life cycle has taken hold. Within this method, BIM tools enable the creation of parametric digital models beyond simple three-dimensional representation by



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setting up a database of information. This software category allows graphic and alphanumeric data to be transmitted to other applications and professionals through technological, procedural, and organizational interoperability concepts. Students must return drawings of the author's projects either through Autodesk AutoCAD, a Computer-Aided Design software universally used for drawing and design, or through Autodesk Revit, a model authoring software specific to the construction sector. This work aims to accustom them to the different demands that may come from the market. The approach and working procedure are entirely different, even though the final output of the design boards must provide the same depth. This activity, conducted on a small project so that it can be governed as best as possible, is intended to have students critically compare the different possibilities the software offers. The Engineer must govern the tools, optimizing the solutions according to the representation objectives. Figure 2 shows the example of the Mies van der Rohe Barcelona Pavilion case study from the Building Drawing course a.a. 2020/2021.

Figure 2.  
Gradual learning path of representation techniques.



In the last part of the course, theoretical lectures also glance toward using new Augmented and Virtual Reality technologies to present projects effectively. This aspect is also considered very important to complete the framework of the Building Drawing in the third millennium. Accordingly, applications are encouraged to experiment with this returning. The employment of Augmented Reality is required to provide additional layers of information during the presentation of the drawings at the examination. These may include images, videos, virtual tours made from the realized models, and websites.

Moreover, students experience immersive Virtual Reality for their project reviews using Iris ProspectVR software and HTC Vive and Oculus Rift hardware. As can be seen from Figure 3, the teacher becomes an avatar who can interact with students in cyberspace to verify the project, the correct construction of elements, and their assembly, dimensions, proportions, and construction nodes. User perception is amplified, and discussion becomes interactive among the participants because it is possible to take note of critical points by employing instruments for taking screenshots, writing comments, and highlighting errors

inside the model (Ugliotti, De Luca, Fonsati, Del Giudice, Osello, 2021). Being able to navigate the three-dimensional digital models from the inside at the same time certainly contributed in terms of collaboration and involvement of the students. This experience stems from the needs related to the recent pandemic, which has promoted further opportunities to innovate teaching by adopting tools that stimulate creativity. Given the initiative's effectiveness, it was considered to be a regular activity during the course. The purpose is primarily to evaluate their work from another point of view. In the second instance, students must acquire the elements to evaluate possible further application contexts in the professional field. Today is an interaction with the teacher; tomorrow could be the way to interact with other professional firms, the presentation of a project to a client, or the involvement of stakeholders within a service conference.

*Figure 3.*  
*Immersive Virtual Reality experience for project reviews.*



## 5. RESULTS AND CONCLUSION

Learning takes place through the organization of knowledge by the subject. A person learns when s/he can connect the information from outside to her/his own knowledge to build organized structures. The organization of knowledge leads to the construction of concepts or logical categories that are more and more comprehensive, articulated, and related through logical links. Therefore, the student must be helped to manage their own learning in an increasingly autonomous way, developing a strategic attitude. The chapter aims to illustrate how these theoretical reflections can become practical strategies to make teaching principles feasible. The Building Drawing course at Politecnico di Torino is the fieldwork where these teaching and learning objectives are put into action and are experimented into a practical context. The enrichment of the course offering is student-centered who can, on the one hand, benefit from advanced didactic experimentation proposing collaborative tools establishing interactive virtual learning environments and, on the other hand, can develop a strategic attitude and working method to approaching complex problems. The results obtained represent an initial proposal to evaluate the potential of the adopted technologies to support teaching and their impact on students' learning processes based on critical thinking. Through

the introduction of diversified active learning strategies in the course, it has been noticed an increasing involvement of students compared to previous years, both individually and in groups. At the end of the course, students have acquired the competence to critically interpret building form and geometry and the ability to choose the most appropriate representation to achieve a given goal. Student enrichment has been noted through student-teacher interaction improvement, the achievement of final products' quality related to the specific course, sometimes higher than required, and the application of these skills in subsequent student work.

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Sharpen critical thinking skills to boost future works. The case of engineers from freehand drawing to digital processes

## CONTRIBUTIONS

Abstract: all authors; Introduction: F.M.U, D.L.D.A; Background: F.M.U; Methodology: F.M.U; Course Applications: F.M.U, D.L.D.A; Results and Conclusion: all authors.

## KEY TERMS & DEFINITIONS

**Avatar:** graphical representation of a user within a virtual community who can move freely and interact with the virtual environment in which it is immersed.

**Building Drawing:** means representing thought and expressing a project (architectural or urban planning) by which a design hypothesis is shaped and through which the congruence between formal image and construction technologies and systems is verified.

**Building Information Modelling:** methodological process for specifying, creating, and managing digital information about a built asset.

**Critical thinking:** ability to analyze information, situations and experiences independently and objectively, distinguishing reality from personal impressions.

**Mind map:** a form of graphic representation of a thought or a subject devoted to creativity, memorization, and annotation in a personal key.

**Virtual Reality:** three-dimensional computer-built simulated Reality within which the user can immersively navigate, move and interact with the recreated digital world through special visors.

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