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Development of an Agile Blended Learning Framework for Engineering Higher Educational Instutions post Covid-19.

Amberlynn Bonello[1], Emmanuel Francalanza[1], Joseph Zammit[1], Antonio Maffei[2]*, Fredrik Enoksson[2], Eleonora Boffa[2], Fabiana Pirola[3], Giuditta Pezzotta[3], Roberto Sala[3], Paolo Claudio Priarone[4], Dario Antonelli[4], Paolo Minetola[4], Sandi Ljubić[5], Arian Skoki[5], Primož Podržaj[6] and Tena Žužek[6]

[1]Department of Industrial and Manufacturing Engineering, Faculty of Engineering, University of Malta, Malta;
[2]Department of Production Engineering, KTH Royal Institute of Technology, Stockholm, Sweden;
[3]Department of Management, Information and Production Engineering, University of Bergamo, Dalmine, Italy;
[4]Politecnico di Torino, Corso Duca degli Abruzzi 24, I 10129 Torino, Italy;
[5]University of Rijeka, Faculty of Engineering, Department of Computer Engineering, Rijeka 51000, Croatia
[6]Faculty of Mechanical Engineering, University of Ljubljana, Ljubljana, Slovenia.
E-pošta: maffei@kth.se

Abstract. *The incessant demand for the use of online tools in education and industry may strain the resiliency of Higher Education Institutes (HEIs) in terms of resource availability, employment; and assurance of access. These factors, combined with the need for HEIs to be agile in adapting to the new normality, are worth investigating following Covid-19. This entails comprehending the influence of the pandemic on the learning experience and the relevance of blended learning (BL) during Covid-19. This research work contributes a framework (ABL-HEIs) focusing on the agility, resilience, and readiness of HEIs to adopt BL in a post-Covid dynamic, adopting a case study of Faculties of Engineering in six European universities. The framework contributes a knowledge transfer roadmap through which an ABL-Resilience Index can be pursued. The majority of universities involved showed higher agility in the first year of the pandemic (2019-2020). In Phase 2 (2020-2021) most of the universities showed a similar level of resilience present between the universities.*

Keywords*— blended learning, agile, resilience, readiness, index, post-Covid, online, teaching*

1 Introduction to Blended Learning

Blended learning (BL) rose in importance and relevance during the Covid-19 pandemic. However, BL has been debated within the academic sphere for quite a long time, due to its unison (hence 'blending') of in-person teaching with online technologies, exploiting the advantages of both [1]. Creation and structuring of BL study units depends on criteria such as; "context", "pedagogical framework", "instructor competency" and "technical issues" [2]. Notwithstanding, BL's demand for online tools has impacted the resilience of higher educational institutions (HEIs) in terms of resource availability, and equitable and efficient access for students and educators alike. These, combined with the agility to adapt to new normalities, are worth investigating further. This necessity proliferated following the pandemic. Scholars already underscore the toll that the pandemic rendered on both students and professors. Overlooked factors such as motivation [3] and caring for "students traditionally minoritized" [4] or "under-privileged"[5] were identified. It is up to academic institutions to take into account the influence of the pandemic on the learning experience and the relevance of BL respectively.

Consequently, this research work aspires to provide a succinct account of experiences derived from Faculties of Engineering in six European universities. These acquired lessons shall prescribe the ABL - HEIs (Agile Blended Learning for Higher Educational Institutions) framework, which is supported by a practical ABL Resilience Index, enabling HEIs to quantitatively assess their didactic performance with respect to BL. Section II aspires to provide a concise state-of-the-art on BL in a post-Covid engineering education sphere, followed by the methodology in Section III. All results are elaborated in Section V.

2 Review of Literature

Covid-19 allowed academics to get a better understanding on the use of technology during BL. Distinct study units demand individual attention upon restructuring. Yu et al. simulate the time window in which online facilities should be implemented within an in-person safety system engineering lecture, so as to heighten attention span and maximise on the hybrid modality's advantages [6]. Guppy et al. predict the influence of the shift towards remote modality, with BL being the most voted by participants, followed by online courses. In spite of this, the authors [7] ascertain that there is yet no concrete evidence to sustain the concept of "University 4.0" [8]. Despite this drive, literature fails in delivering how this can be achieved. Novel hypothesis should assess the forecasted ratio of classes held on campus to those held remotely post-pandemic; the modality of teaching as well as how practical engineering skills would be best imparted under this new modality [8]. This is not easy, and Yu et al. conform that to test pilot-project study units, real-time teaching would have to be disturbed. Vergara et al. [9] and Asgari et al. [5] have unveiled the benefits of virtual engineering laboratories utilising Virtual Reality (VR).

Whilst this new concept is advocated for, Vergara et al. comment on how students still deem in-person laboratories as imperative throughout their education [9]. Before the pandemic, Hung et al. allude to an "Online Learning Readiness Scale" (OLRS), representing the students' preparedness towards an online learning approach [3], which excludes HEIs and is not oriented towards BL. This contrasts to Akkoyunlu and Soylu who develop a scale of fifty criteria to assess lecturers' perspective on BL [10]. However, this BLS once again revolves around students; as opposed to the agility and resilience of HEIs within a holistic HEI contest, underscoring the necessity for such improvements. The limitations introduced in the precursory section showcase the need for a post-pandemic measurement tool that elicits an HEI's readiness to switching to BL in the case of unforeseen circumstances, its agility in doing so and whether the present institutional structure is resilient enough to take onboard BL. Thus, this paper will present a framework that shall encompass a novel scale to assess these three gaps; HEI's agility, resilience and readiness to take onboard BL in a post-Covid dimension.

3 Methodology

Prior art focused on students, lecturers and both [4], [5], [6], with no prior work exploring internal documentation related to Covid-19 management in HEIs. Reviewing such credible material is strongly recommended due to its reputability in reflecting the course of action adopted by HEIs and how lecturers and students were advised to transition online. This study shall adopt the methodology in Fig. 1, commencing with a call for descriptive documents from six universities from Italy, Croatia, Sweden, Slovenia and Malta (labelled UNI1 to UNI6) within a shared database. Documents comprised university correspondence, government guidelines and results of internally conducted questionnaires. A total of one-hundred and forty-seven documents (147) associated to Covid-19 were gathered between the universities. Three major phases representative of the different stages of Covid-19 were outlined. Phase 1 embodies the initial reaction to Covid-19 (2019 - 2020), Phase 2 revolves around management in the midst of Covid-19 (2020 - 2021), with Phase 3 looking beyond Covid-19 and paving the way from 2021 onwards. All data was thoroughly analysed, with some of the major outcomes outlined in this section. These themes shall pave the way for the ABL-HEIs framework and corresponding index.

3.1 Documentation findings from the universities

- Introduction of novel online learning platforms

More than one online learning platform catered for remote learning. Three of the six universities referred to the Zoom platform as indispensable for BL, claiming how the use of Zoom features was dependent on the personal preferences and knowledge of each individual lecturer.

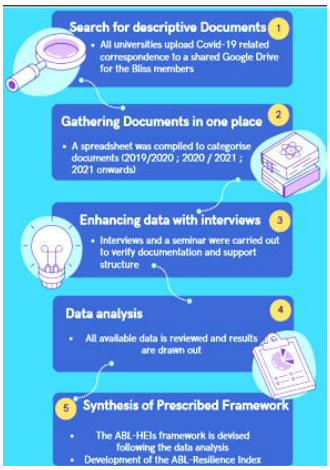

Fig. 1. Pictorial representation of proposed Research Methodology.

A future platform should be developed; uniting all of the advantages of each platform into one, with lecturers being made aware of functions such as 'breakout rooms' in Zoom and how these can be aligned to study objectives. Despite support measures being an asset during the initial Covid stages; it would have been of much more value had the curriculum always been designed to adapt easily to unforeseen circumstances by upholding BL (intentionally).

- The BL learning curve and shift of study units

Difficulties adopting BL during Covid-19 were not solely technical but extended to psychological and social. Questionnaires carried out by some of the universities acknowledged that some students encountered lack of privacy and imbalance between leisure and study time. This reflects study units whose structure did not change enough to conform to the new norm. Another challenge pertained to study units with laboratory components. A third hurdle arose from remote examinations, with all universities alluding to how they had to deal with an unseen form of plagiarism and students helping each other remotely. All six universities were aware of this situation, and tried to devise ways to curb it. One HEI implemented random question allocation, strict timing per question, live remote oral exams and having students keep their laptop camera switched on during exam as a means of supervision. This method involved having a lecturer or an administrator supervise the students using video conferencing. Other universities frowned upon this approach, owing to adverse student privacy invasion and issues of data protection. This insight should be acknowledged when planning remote exams for BL study such that plagiarism is averted, without infringing data protection issues. Moving forward, educational study units should take into account that a level of unpredictability of events will always be present. A level of contingency is indispensable.

3.2 Prescribed Framework and development of the "ABL Resilience Index"

The framework ABL - HEIs (Agile Blended Learning for Higher Educational Institutions), Fig. 2, provides a knowledge transfer (KT) roadmap through which an ABL-Resilience Index can be pursued. ABL echoes the ability (ABiLity) of HEIs to showcase resilience in overcoming adverse situations. In Frame 0, HEIs analyse the present situation and hypothesise on how to be prepared for adverse situations, by reflecting on the experiences encountered during the pandemic. This helps in understanding BL's potential for scenarios such as another pandemic or emergencies. The level of KT offsetting due to national and global disruptive activities is also analysed. Frame 1 acknowledges that the HEIs' KT approach is subject to change based on the receivers (students) and transmitters (lecturers), different faculties and administrative staff. Frame 2 implements the ABL-Resilience Index. This index quantifies the preparedness and resilience of HEIs in engaging BL for a novel post-pandemic pedagogy, by addressing current limitations and challenges for future revision. In Frame 3, the ABL-Resilience Index score indicates what technology is necessary for an im-proved implementation of BL, as well as the main stakeholder for each need. Hence, the KT Transition embodies tools that ensure an HEI's ability to rapidly shift towards BL (agility and resilience are re-instilled here as well). Once the modifications are acknowledged, the final frame of the ABL-HEIs framework involves pooling together additional aspects that go beyond teaching ped-agogies, such as training of administration staff, lab technicians and lecturers; financial concerns and facilities, and undergoing changes to the necessary standard operating protocol (SOP).

The Index is intended to quantify the progress made by the universities during the pandemic. Data extracted from correspondence was recorded and assigned "ranking points". A scale similar to a Likert-scale was adopted for each activity, based on its correlation to BL. The closer the adherence to BL, the higher the score (from 0 = no aspects of BL, to 5 = activity successfully contributes to BL). Additional "points" were awarded to universities who carried out "Supplementary Actions". For instance, the action "Provision of licenses and reimbursements" granted an extra two points to universities who implemented this action in conjunction with the main action (in this case: "Support for online learning."); as shown in Fig. 3.

4 Discussion

The index scores for Phase 1 focus on the HEI's ability to be agile (time) in orienting the traditional teaching pedagogies to a more blended approach during the pandemic (reactive); but also the level of preparedness (in terms of resource availability) shown on the onset of the pandemic (proactive). This is also depicted in the ranking attributed, shown in Fig. 4.

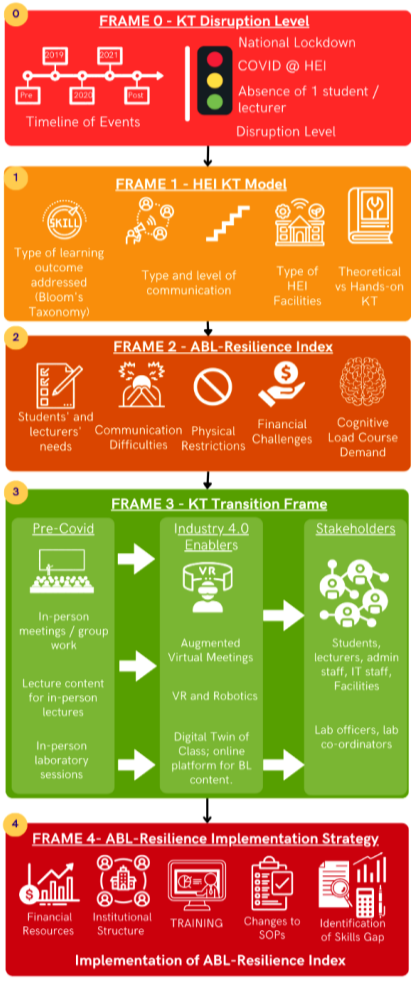

Fig. 2. ABL - HEIs (Agile Blended Learning for HEIs).

Supplementary Action taken:	Provision of Licenses and Reimbursements of licenses	Provision of IT equipment to students	Provision of IT equipment to teachers
	+ 2 points	+ 2 points	+ 2 points

Fig. 3. Extra points awarded through the "Supplementary Actions".

The scores for (Phase 2) assess the steadiness of HEIs in maintaining the measures implemented in Phase 1, and gauges improvement in comparison to Phase 1. This contributes towards HEIs' resilience.

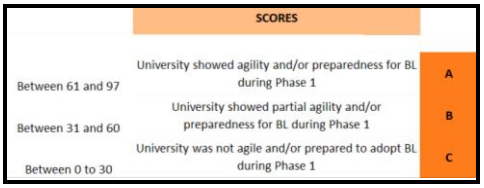

Fig. 4. Ranking Criteria (A,B and C) based on the scores for Phase 1.

Similar to the ranking criteria in Fig.4, the scores for Phase 2 were also ranked. HEIs obtaining a score between a 0 and 12 (rank C), indicated that the HEIdid not carry out any drastic changes between Phase 1 and Phase 2 or only modified minor aspects of the activities implemented in Phase 1. A Phase 2 score of between 25 and 31 (the highest score possible), implied that the HEI onboarded a majority of new activities in Phase 2 that were absent in Phase 1, or drastically modified most of the activities implemented in Phase 1. To summarise,

the greater the score in Phase 2, the greater the novelty and improvement in Phase 2. This is reflected in the third column, ΔP. To exemplify, despite UNI3 ranking lowest in Phase 1 (UNI3 was not agile nor prepared for the pandemic), its reasonably high score of 26 in Phase 2, and its lowest ΔP, implies major efforts being done to improve in Phase 2 and be resilient. Given that the Index should stay true to assessing the readiness and agility of HEIs, the scores were normalised equally, by taking each score for Phase 1 and Phase 2, dividing by the highest score per phase and converting into percentage form (%). For instance, with the maximum attainable score in Phase 1 being 97, a Phase 1 score of 46 contributes towards a normalised score of 47. Both Phase 1 and Phase 2 contributed to 50% each of the global score. The normalised scores and the absolute value for **ΔP** are shown in Table 1. The university with the highest normalised score for Phase 1 was UNI2, with UNI5 and UNI3 having the least normalised scores. This infers that the latter two were least prepared to adopt BL as the pandemic hit.

Tabela 1. Normalised Scores and difference between scores.

UNI	Phase 1	Phase 2	ΔP
1	47	29	18
2	56	13	43
3	28	26	2
4	47	35	12
5	38	23	16
6	47	26	22

UNI 4 and UNI 1, retained the initial momentum throughout both phases (trans-posed agility to resilience). UNI 2 emerged as a great contender for Phase 1, yet having the largest ΔP signified that potentially, the initial momentum was not retained. Overall, the majority of the universities were agile in their initial response towards the pandemic. This can be seen from the cluster of normalised scores (47,47,47,56) for four of the six universities. Two of the universities were less ready to counter the challenges brought by the pandemic. In Phase 2, most of the universities obtained scores similar to each other.

5 Conclusions

Covid-19 has set the scene for a wider adoption of BL due to increased teacher capability, coupled with the willingness of HEIs to integrate digital tools and innovative infrastructure in a fight-or-flight situation. This paper brought forward the joint efforts of six universities from Europe and has issued a two-fold contribution: a dedicated framework for assessing the agility of HEIs towards BL in the light of the pandemic, as well as an index for assessing readiness and agility of HEIs adopting BL. One question remains for numerous researchers and academics to answer: observing the consistency of readiness of HEIs in evolving on the acquired digital skills, and the shift of such skills towards addressing BL strategies for a post-pandemic learning environment.

6 Acknowledgments

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