



Working Paper  
2024:7

# The use of digital technology in higher education

A literature review



Fride Flobakk-Sitter and Lone Wanderås Fossum



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# Preface

The literature review study presented in this working paper is part of a larger research project on the pedagogical use of digital technology in higher education (DIGITEK-HU). The project is conducted by NIFU in collaboration with the University of Oslo and Inland Norway University of Applied Sciences, commissioned by the Norwegian Directorate for higher education and skills (HK-dir), the Norwegian Agency for Shared Services in Education and Research (Sikt) and the Norwegian Agency for Quality Assurance in Education (NOKUT).

The research project DIGITEK-HU consists of numerous work packages, one being the literature review presented in this working paper. Lene Korseberg has been the project manager for the research project, whereas Frida Flobakk-Sitter has been the work package manager for the literature review. Flobakk-Sitter has conducted the literature review in collaboration with Lone Wanderås Fossum, and both have contributed to the writing of the following working paper. Lene Korseberg and Elisabeth Hovdhaugen ensured the quality of the working paper.

We would like to thank HK-dir, Sikt, and NOKUT for an exciting project.

Oslo, 24. april 2024

Elisabeth Hovdhaugen  
Deputy Head of Research



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# Summary

This working paper presents a literature review on the use of digital technology in higher education. We pay particular attention to students and teachers' pedagogical and didactic use and perception of digital technology in ordinary educational settings. This literature review is a separate work package in the larger research project *DIGITEK-HU*. The project focuses on the use of digital technologies in higher education, specifically how digitalisation affects teaching, learning, and assessment.

In this rapid and systematic review, we have conducted literature searches and screening procedures in line with the PRISMA framework. A total of 68 articles were included in the review. Digital technologies, segmented into categories like digital teaching formats, student-activation tools, simulation technologies, learning management systems, and collaboration tools, form the backbone of this review.

## Many studies focus on digital tools, but the results vary

Our findings show that many studies focus on digital tools, whereas pedagogical and didactical aspects are less apparent. Several studies report on the effects of digital tools and online learning, but results vary. Some indicate that the use of digital technology in higher education can increase students' engagement, motivation, educational flexibility, and opportunities. Others show that students and lecturers do not prefer online learning activities, since they lack face-to-face interaction.

## Advantages and disadvantages of using digital technologies

Despite varied applications, a consistent theme emerges across the reviewed articles: while digital tools have significantly enriched the educational landscape by enhancing accessibility, engagement, and personalized learning experiences, they are not without their challenges. Issues such as the digital divide, data privacy, and the necessity for robust faculty training and enhanced digital competence are recurrent.

## Factors that contribute to good digital education

Many studies investigate factors contributing to high-quality online education, emphasising the importance of designing flexible learning environments with user-friendly technology. The studies also stress the importance of providing opportunities for interaction and cooperation between students and the teacher. Findings further show that the successful implementation of such activities is linked to the teacher's technical pedagogical knowledge. Whether digital technology help improve learning and teaching also seem dependent on the level of technology acceptance among the students themselves. It is also an advantage if the use of digital tools is linked to learning theory and its purpose made explicit to the students.

## The importance of in-person education

The research literature indicates that many students are satisfied with the use of digital technology in higher education. At the same time, research clearly shows that students do not want to give up in-person education. Central arguments for this, is based in the importance of in-person and authentic learning experiences. The importance of social interaction between students and between students and teachers is also highlighted. Social interaction is often perceived as easier face-to-face and considered as an important driver of discussion, problem-solving, critical thinking, and deeper learning. Much research thus shows that many students and teachers prefer to use digital technology as a *preparation* for, or as a *supplement* to, in-person teaching and learning activities. However, they are more reluctant to use digital technology as a *replacement* for in-person teaching formats.

## Multiple factors shape how digital technology is implemented, perceived and used in higher education

While digital technologies promise to revolutionize higher education, we argue that their full potential is contingent upon a balanced, thoughtful integration into pedagogical designs in higher education. This includes considerations of different actors' arguments for implementing technologies in higher education, and how technology is embedded in a pedagogical design. It is also important to move beyond the mere *intended* design, considering the actual educational activities. This includes contemplation of how technologies contribute to shape teaching and learning activities, providing both opportunities and limitations. At the same time, it is important to consider how teachers and students perceive and make use of technologies in their own and, perhaps, unanticipated way. This emphasise that teaching and learning are complex processes, that are influenced by more than just learning tools and pedagogical designs.

# 1 Introduction

Digital technology has become increasingly integrated into teaching and learning in higher education. With the COVID-19 pandemic, we saw an increase in the use of digital technologies in the sector, as teachers and students all over the world were forced to shift to online learning and remote teaching formats (Akram et al. 2021). Much research has covered the extraordinary teaching and learning settings during the pandemic. However, a question remains as to how digital technology is used in ordinary teaching and learning situations and, perhaps more importantly, how teachers and students perceive their use.

The following study presents and discusses central findings from a rapid review of relevant international research on the use of digital technology in higher education. The aim of the review was to move beyond the mere implementation of digital technology in the sector, focusing instead on students and teachers' educational, didactic, or pedagogical use of digital technology and their perceptions of this use. We paid particular attention to the use of technology in ordinary educational settings, and not in times of crisis (like the COVID-19 pandemic). By adopting this perspective, we hope to shed light on certain important aspects of the digital transformation of higher education.

## 1.1 Background for the study

This study is part of the larger research project *DIGITEK-HU*, on the use of digital technologies in higher education, focusing on how digitalisation affects teaching, learning, and assessments. The project is led by the Nordic Institute for Studies of Innovation, Research and Education (NIFU), in collaboration with the University of Oslo and Inland Norway University of Applied Sciences. The project is instigated and funded by the Norwegian Directorate for higher education and skills (HK-dir), in collaboration with the Norwegian Agency for Shared Services in Education and Research (Sikt) and the Norwegian Agency for Quality Assurance in Education (NOKUT).

The purpose of *DIGITEK-HU* is to obtain new knowledge about digital technology in higher education, addressing how technology is used by teachers and

students. A central aim of the project is to nuance the research on different digital practices, teachers and students' knowledge work, and educational quality.

The following study is a central part of the overarching project, as it is a literature review of relevant international research on the use of digital technology in higher education. Accordingly, the study is meant to inform the other working packages in the project.

## 1.2 Definitions and delimitations

As this review is part of a larger project, it follows some pre-set definitions and delimitations for the project at large. In all projects under *DIGITEK-HU*, 'digital technology' has been given a broad definition. It refers to all types of digital technologies and digital tools that can be used in teaching, instruction, and assessment activities in higher education. The project further focusses on teachers and students *pedagogical use* and their perception of digital technologies in educational and learning settings. In our rapid literature review we thus focus on students and/or teachers' pedagogical use of digital technologies in higher education teaching and learning settings more generally. For more knowledge on the use of digital technology in higher education, including more specific setting or contexts, the reader is referred to the other publications coming out of the *DIGITEK-HU* project (see for instance Fidjeland & Wiborg, 2023; Korseberg et al., 2023; Slette et al., 2023).

In our review, we further follow a pre-set categorisation of digital technologies since these categories run through the whole project. The categorisation of digital technologies are as follows:

- Digital teaching formats
- Student-activation tools
- Simulation tools
- Learning management systems
- Collaboration tools between students

'Digital teaching formats' refer to teaching in digital formats, such as pre-recorded instructional videos, and live-streamed lectures and so on. 'Student-activation tools' refer to digital tools that encourage student engagement and interaction with the teacher. Examples include interactive quizzes and games (like Kahoot, Quizlet, and Mentimeter). 'Simulation tools' indicate digital tools that simulate practical situations or scenarios, for instance seen with the use of augmented reality (AR) or virtual reality (VR) technology. 'Learning management systems' (LMS) indicate digital learning platforms, such as Canvas and Blackboard, whereas 'Collaboration tools between students' refer to digital tools meant for collaborative work between students, such as Google Drive/Docs, GitHub, and Discord.

These five technological categories did not shape our literature search, nor did they define the search strings used (see chapter 2). They did not, therefore, define *how* we searched for research literature in this study. However, we found that the identified studies in our rapid literature review could be categorised in one (or more) of these categories. Accordingly, the five categories shaped how we grouped the identified research literature in the presentation (chapter 3).

### 1.3 Structure for this working paper

Chapter 2 presents the methodological approach for our study, followed by two chapters presenting the findings from the literature review: Chapter 3 presents the included research in our study, categorised in line with different digital tools. Some of the research falls into more than one of the categories applied and will therefore be presented multiple times<sup>1</sup>. In chapter 4 we present findings across the research literature and investigate whether there is agreement between the findings from the various studies. Finally, chapter 5 provides a discussion of the findings and a concluding summary.

The working paper also contains two appendices. Appendix 1 consists of a table that gives an overview of all the 68 included studies. Appendix 2 contains syntheses for each individual research article included in our study. According, the second appendix is rather extensive, as it provides the readers with the opportunity to read a detailed synthesis of each included study<sup>2</sup>. In appendix 2, the articles are grouped in the thematic categories, as presented in the rapid systematic review.

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<sup>1</sup> This applies to 19 of the included studies.

<sup>2</sup> The syntheses are written in order to illuminate this working papers' topic and framing, and they are therefore not a copy of each article's abstract.

## 2 Materials and methods

The study follows the methodological approach for a rapid and systematic review (also called *rapid review* or *rapid evidence assessment*), which is an accelerated approach to conducting literature reviews. The method is considered less time-consuming than traditional systematic reviews, as it may use fewer databases and less time-consuming quality assessment of the included research. Nevertheless, rapid reviews are systematic and transparent as a systematic review. As such, it avoids bias in the inclusion, assessment, and synthesis of studies (Schünemann and Moja 2015). Despite potential limitations in depth of analysis, rapid reviews are beneficial for informing decision-making processes, policy development, and healthcare interventions within limited time frames, provided it maintains transparency and documentation in its implementation (Tricco et al., 2015; Tricco et al., 2016). Rapid reviews are also suitable when conducting literature reviews as part of a larger research project, which is the case for the following literature review.

### 2.1 Search and databases

Based on the selected theme and scope for this review (see chapter 1), we established an overview of criteria for what types of literature to include in the review. The searches targeted peer-reviewed articles published in English between the years 2018 and 2022. Attention was placed on students and teachers' educational, didactic, or pedagogical use of digital technology in ordinary educational settings in higher education. As such, the search excluded articles focusing on the use of digital technology in times of crisis, most notably the COVID-19 pandemic<sup>3</sup>. We narrowed the search further, by only including studies from European countries<sup>4</sup>. The selection criteria, in the form of inclusion and exclusion criteria, is presented in table 2.1.

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<sup>3</sup> This was one of the predetermined decisions for the review.

<sup>4</sup> Seeing that this literature review is part of a larger Norwegian research project, we focus on European research literature, since European HEIs have relatively similar educational contexts and educational systems.

**Table 2.1 Table of the selection criteria for the review.**

	Include	Exclude
<b>Population</b>	Students and teachers' experience and use of digital technology	Other groups
<b>Theme</b>	Educational, didactic or pedagogical use of digital technology in a teaching situation	
<b>Situation</b>	Ordinary situations	Time of crisis, e.g., covid-19 pandemic
<b>Type of studies</b>	Empirical studies Reviews	Theoretical studies
<b>Geographical</b>	Europe	Outside of Europe
<b>Time</b>	2018-2022	Before 2018
<b>Language</b>	English, Norwegian, Swedish, Danish	Other languages
<b>Document type</b>	Peer-reviewed articles	Other types of documents

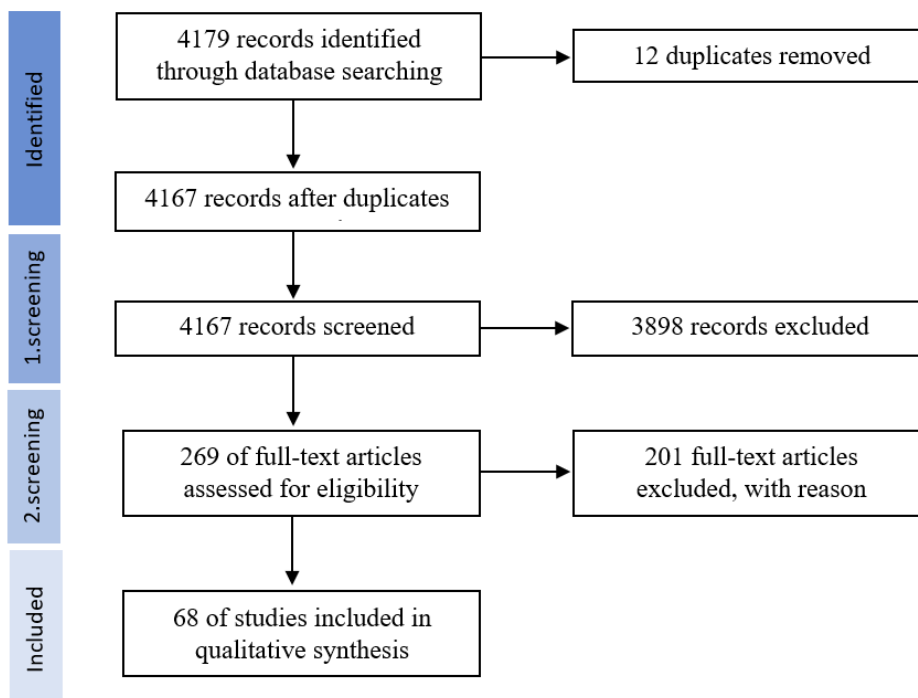
The rapid review was carried out from November 2022 to March 2023. Systematic literature searches were conducted in the databases Web of Science and ERIC. Web of Science is one of the largest and most used research databases in the world, while ERIC is a reference database of research publications in education. The two databases were selected to both complement each other and evaluate the scope of the literature searches. Several test searches were carried out to verify terms used in the search string and see whether they identified relevant results. Analysis of the search results identified other terms that we decided to include in the search string. The purpose was to search broadly rather than narrowly within the limitations that were predetermined, in order to obtain as many articles as possible. Similar search strings were used in both databases, with smaller adaptations.

## 2.2 Selection

The literature searches identified 4179 articles, 12 of which were duplicates which were removed. In line with the PRISMA framework<sup>5</sup>, a two-step screening procedure was conducted. Titles and abstracts of the remaining 4167 unique studies were screened by use of pre-determined inclusion and exclusion criteria (see table 2.1). Following this, 269 relevant articles were read in full text to determine their eligibility. A total of 201 studies were excluded<sup>6</sup> and, finally, 68 articles were included in the review. The list of the included studies can be found in Appendix 1. Figure 2.1 shows the PRISMA flow diagram illustrating the steps of our rapid systematic review.

<sup>5</sup> Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

<sup>6</sup> Most of the excluded studies were excluded on the basis that they did not address a *pedagogical* use of technology (68 out of 201). Other studies were excluded on the basis that they, for example, did not meet our criteria for population, language, geography, or publication type (42 out of 201), that they addressed the wrong context, such as the COVID-19 pandemic (29 out of 201), or that they only described specific digital tools or programs (24 out of 201).



**Figure 2.1 PRISMA flow diagram illustrating the steps of our rapid systematic review (PRISMA model adapted from Moher et al., 2009).**

The 68 included studies were coded, and relevant data were extracted from each article. Following this, a thematic analysis was used to identify common themes and patterns across the literature. The studies were, as previously mentioned, categorised in line with the following categories of digital tools: ‘digital teaching formats’, ‘student-activation tools’, ‘simulation tools’, ‘learning management systems’, and ‘collaboration tools between students. Some studies addressed several forms of technologies and were thus categorised in studies including ‘several/other’ (see Appendix 1). A synthesis of each study was written (see Appendix 2), and these constitute the foundation for indicating certain findings across the literature material (as presented in chapter 3 and 4).

## 2.3 Limitations

This rapid review is not without its limitations. The review has an encompassing scope, covering students and teachers’ use of several digital tools in higher education. To get a literature corpus that was manageable within a limited timeframe, we have used certain selection criteria which have limited the breadth and scope of our review. For instance, searches were conducted in only two databases: Web of Science and ERIC. The use of additional databases may have resulted in a larger number of included studies and a more comprehensive picture of the use of digital



technology in higher education. Nevertheless, the chosen databases were assessed as the most appropriate sources for this study.

Moreover, in our searches, we used the general term 'digital technology', in order to cover a variety of digital tools – which were in line with the overarching research project *DIGITEK-HU*. As such, we aimed to find patterns across the literature regardless of the digital tools being used. Searches for a specific digital tool or a set of digital technologies would, in all probability, have yielded a more nuanced picture regarding specific technologies. At the same time, searches for specific digital tools would have introduced bias for these tools in the literature searches and, consequently, the search would not have detected the same scope as the present study.

In this study, we have also focused on the use of digital technologies in ordinary educational settings. Accordingly, studies exclusively focusing on higher education during the COVID-19 pandemic were excluded. Extending the review to include education during a crisis-like situation could provide insight into the pedagogical and didactic use of digital technology which may also be of relevance to post-pandemic educational settings.

### 3 Research on digital technology in higher education

Findings from our study show that there is much available research on the use of digital technology in higher education. The amount of research has increased significantly with the COVID-19 pandemic, as many have investigated how higher education institutions (HEIs) around the world adopted digital tools and switched to digital teaching formats during lockdown. Since the purpose of our review is to investigate the use of digital technology in normal educational settings, and not during a crisis, COVID-19-related research was excluded from our dataset. Nevertheless, it is worth noting that the pandemic has accelerated the use of, and attention to, digital technology in higher education, even in the aftermath of the pandemic.

Our review also shows that much of the research on digital technology in higher education focuses on technology or digital tools, rather than learning activities. For instance, much research pays attention to the use of digital technology by investigating how certain digital tools can help increase students' engagement, motivation, or results. Many studies also look at students and/or teachers' attitudes, acceptance, perceived benefits, or barriers to digital tools. Fewer studies focus on the learning activity associated with the use of digital technology, by taking a more in-depth didactic and pedagogical approach.

Because of this technology-centred focus in the research literature, we have chosen to group and analyse the literature material according to the following categories:

- Digital teaching formats (23 studies)
- Student-activation tools (10 studies)
- Simulation tools (8 studies)
- Learning management systems (7 studies)
- Collaboration tools between students (1 study)
- Several forms of technologies/other (19 studies)

In the following, a synthesis of key findings from the included research contributions is presented and grouped according to these categories. Studies addressing

several forms of technologies may be referred to in their respective sections and can thus appear under several categories. Detailed synthesis of each of the 68 included articles are presented in appendix 2.

### **3.1 Digital teaching formats**

The use of digital technology in higher education is often associated with teaching in a digital format. The extent to which digital teaching formats are used in a course varies, from fully online courses, to blended or flipped classrooms where students have lessons in both digital and physical formats. A total of 23 studies on digital teaching formats were included in our review. In the literature data, mainly pre-recorded teaching videos and streaming of lectures are discussed.

#### **Pre-recorded teaching video**

Using pre-recorded instructional videos are a relatively common form of digital teaching, either in fully online courses or as learning materials in preparation for face-to-face lectures. The research literature shows that teaching videos are effective tools for introducing students to academic concepts, increasing students' understanding, and introducing them to the practical use of relevant equipment, for example before in-person laboratory sessions. This use can also close the gap between theory and practice (Barisone et al. 2019; Perez-Navarro, Garcia, and Conesa 2021; Smith and Francis 2022). The research also shows that students often rewatch the videos several times in connection with assignments or exams. The videos are perceived as an additional resource and are often used in combination with other available learning materials. At the same time, videos are not considered suitable to fully replace text documents (McGuinness and Fulton 2019; Perez-Navarro, Garcia, and Conesa 2021).

The research shows that students generally have a positive attitude towards teaching videos; they perceive that videos are easy to use, that they are effective, that they are relevant and accurate, and they think the videos often are of high quality. Students also highlight the advantage of videos being easily accessible and that they can be viewed multiple times. This increases flexibility, as well as students' motivation to learn independently and at their own pace. For example, high-achieving students may jump forward in parts they already understand, while low-achieving students may rewatch the teaching video to achieve a better grasp of the content (cf. Navio-Marco et al. 2022; Price and Walker 2021; Sing 2020).

However, the research literature also provides a more nuanced picture. Studies show that a significant proportion of students do not perceive teaching videos to be useful and choose not to use them (cf. Harrison 2020; Mozhenko et al. 2022).

For instance, students report disadvantages related to poor audio and unstable internet access, which interfered with their learning (McGuinness and Fulton 2019). Some students report that the number of instructional videos to watch in advance of in-person teaching sessions often can be overwhelming and lead to cognitive overload (Smith and Francis 2022). Educators also report on disadvantages connected with their use, as many find it expensive and time-consuming to create teaching videos (Harrison 2020; Perez-Navarro, Garcia, and Conesa 2021).

The research literature also addresses factors in pre-recorded teaching videos that are central to students' learning and their perception of them. Studies show that sound quality is important (McGuinness and Fulton 2019). The length of the videos is also highlighted a central factor, but the research literature reports different findings on this matter. Smith and Francis (2022) argue that length is negatively correlated with student engagement, and therefore the optimal video length should be around 10-20 minutes. Harrison (2020), on the other hand, argues that the ideal length varies, although many students believe that longer videos are beneficial for their learning. According to Harrison, decisions related to the length of a video should be made on an educational, rather than on a technological, basis. When it comes to the production quality of videos, research shows that they do not need to be advanced. It is the quality of the instructor's presentation, as opposed to the quality of the technology or video production itself, that is considered to have the greatest impact on student learning. Students are more concerned with the teachers' tone of voice, body language, ability to communicate clearly, and ability to entertain (Harrison 2020; Smith and Francis 2022). Research also shows that students value elements of human interaction in teaching videos, such as clips of the teacher speaking (Perez-Navarro, Garcia, and Conesa 2021).

## **Recording and streaming of lecture**

Another digital teaching format is the recording of lectures, where the recording is made available digitally either in real time (live streaming) or after the lecture. The research literature gives a nuanced picture also of this form of digital education, highlighting both the advantages and disadvantages of recorded lectures. On the one hand, research indicates that streamed lectures contribute positively, by increasing the teacher's awareness, planning, and execution of the lecture (Joseph-Richard et al. 2018; Morris, Swinnerton and Coop 2019). Lecture recordings are also well received by students since they increase flexibility, inclusion, engagement, and motivation. Research also shows that students benefit from the recordings in terms of note taking, more thorough understanding and clarification of the topic discussed, and as preparation for tests and exams. Against this backdrop,

students often have high expectations for the availability and quality of lecture recordings (Joseph-Richard et al. 2018; Morris, Swinnerton and Coop 2019).

On the other hand, research included as part of this study shows that teachers are less positive toward recorded lectures, believing that it diminishes the value of the lecture. Recorded and streamed lectures are considered to have a negative impact on the teaching style, destroying spontaneity, impairing interaction, and leading to caution as the teacher feels constantly monitored. Many teachers also believe that streaming lectures reduces student learning and leads to lower attendance in physical lectures (Joseph-Richard et al. 2018; Morris, Swinnerton and Coop 2019).

The research literature is, however, unclear about the streaming of lecturers and students' attendance. One of the studies in our data shows that more than 80 per cent of the students participated in lectures that were recorded and streamed. Lectures where no recordings were made, on the other hand, had significantly higher participation (Morris, Swinnerton and Coop 2019). Another study shows that the offer of real-time recording had small effects on students' attendance in lectures, and the students thus appeared to prefer physical attendance (Cacault et al. 2021). The same study found that students use the streaming service only rarely, about 10 per cent of the times they have access. This contrasts with findings from other studies, which shows that students made extensive use of the lecture recordings (Morris, Swinnerton and Coop 2019). Research also addresses which student groups benefit from streamed lecturers. According to Cacault and colleagues (2021), watching live-streamed lectures lowers performance for already underperforming students, but it increases performance for already high-achieving students.

Overall, the research provides a somewhat nuanced picture related to the use and usefulness of digital lecture recordings. Some researchers point out that lecture capture and recordings enhance lecturers' self-awareness, their planning, and conscious performance. At the same time, it is also emphasized that the format crushes spontaneity, impairs interactions, and leads to more bland and instrumental lectures (Joseph-Richard et al. 2018). Others refer to the large difference between students and teachers' perceptions of the value of lecture recordings, arguing for a clearer debate since lecture recordings are increasing in higher education (Morris, Swinnerton and Coop 2019).

## **3.2 Student activation tools**

Another form of digital technology used in higher education is student-activation tools between students and teachers. A total of 10 studies on student activation

tools are included in our review. In our data material, interactive quizzes and games are particularly addressed.

## **Interactive quizzes and games**

The use of interactive quizzes and games, through gaming platforms such as Kahoot and Quizlet, has become a popular way to break up a teaching session and to activate and engage students. Research findings show how its use may increase students' active participation, improve their perception of certain concepts, and motivate them to learn in more interactive and stimulating environments. Studies also show that students often have a positive attitude toward the use of quizzes and games in teaching (Campillo-Ferrer, Miralles-Martínez and Sánchez-Ibáñez 2020; Hutain and Michinov 2022; Mader and Bry 2019; Raes and Depaepe 2020).

However, studies also emphasize that the effect of interactive games in education seems to depend on its use and the context in which it happens. In small courses with small groups, group-based interactive games seem to have a positive impact on student participation and engagement. In these cases, students also found that games and quizzes were enjoyable. In larger classes with randomly divided groups, group-based interactive games often failed to create engagement among the students. In these cases, students preferred to answer the quiz alone, rather than through collaboration with the group (Mader and Bry 2019). Research also shows that younger students often have better learning outcomes from interactive games than older students (Hernández-Lara, Serradell-López and Fitó-Bertran 2019). This is consistent with previous research indicating a negative correlation between age and technology acceptance, where younger generations often are more frequent users of, and more adapted to, new technologies (de Vries 2005). Research also shows that there is a significant difference between female and male students, with male students reporting that they prefer digital student-activation games to a larger extent (Mio, Ventura-Medina and João 2019).

When it comes to the learning outcomes brought about by quizzes and games, this appears to depend on a variety of factors. First, student's acceptance of these digital tools is reported as being essential for their contribution to learning and teaching (Raes and Depaepe 2020). Furthermore, research shows that the added benefit of student-activation tools depends on their use and context. It is not the integration of digital quizzes and games in education per se that increases student engagement. Rather, it is how teachers use these digital tools that determines whether students become more or less engaged through their use (Hernández-Lara, Serradell-López and Fitó-Bertran 2019; Hutain and Michinov 2022; Mader and Bry 2019). The research literature also points out that the use of student-activation tools should be linked to learning theory and made explicit for the

students. If digital tools are used to promote reflection, critical thinking, feedback, and improve deeper learning, it can support more pedagogical and didactical use of technologies in higher education (Hyll, Schvarcz and Manninen 2019).

### **3.3 Simulation tools**

Various digital simulation tools can be useful in teaching in higher education, as they can provide realistic portrayals of objects or practice-related situations. A total of 8 studies on simulation tools were included in our review. In our literature data, 3D technology, AR, and VR technology are discussed.

#### **3D technology**

The research literature shows how different forms of 3D technology can replace two-dimensional illustrations and images in teaching – shown here in studies on 3D visualization of brain anatomy (Jacquesson et al. 2020) and virtual dissection (Kazoka, Pilmane and Edelmers 2021). Findings from these studies show that students were satisfied with the use of 3D technology in their teaching, and that they perceived the use of simulation tools to increase their knowledge and skills. The studies also show that the use of 3D visualization gave the students increased opportunities to study the anatomy and structures of the human body, as well as develop a better understanding of the relationship between theoretical and clinical studies in medicine. The authors emphasize that this, in turn, can improve students' anatomical knowledge and clinical competence, and improve their results (Jacquesson et al. 2020; Kazoka, Pilmane and Edelmers 2021).

The research also highlights the disadvantages of the use of 3D technology in higher education. This is partly related to the advanced and resource-intensive rigging of such technological equipment (Jacquesson et al. 2020). Furthermore, it is emphasized that digital images and visualizations make it possible for students to learn some of the learning material at home via a computer, but this will never replace physical and practical teaching – for example, related to anatomy teaching, dissection, and the training of practical skills. The authors, therefore, point out the importance of using both traditional and progressive technological tools in teaching (Kazoka, Pilmane and Edelmers 2021).

#### **AR and VR technology**

Other forms of simulation tools can be found in the use of augmented reality (AR) and virtual reality (VR) technology. Both AR and VR are used in higher education to provide training that is otherwise risky, costly, or difficult to implement. The

technology is for instance used for more lifelike 3D models in biochemistry (Reeves et al. 2021), virtual labs and equipment (de Vries and May 2019; Herodotou et al. 2020; Schnieder, Williams and Ghosh 2022), and virtual crime scene investigations (Mayne and Green 2020).

Although the research literature points out that the technology can bring with it certain technical challenges, such as time-consuming rigging (de Vries and May 2019; Sprenger and Schwaninger 2021), the main message is that the use of simulation tools may be enriching and useful for teaching. Studies show that AR and VR simulation gave the students a better understanding of theory, that they were an aid in practicing skills, and helped students connect theory and practice. The simulation tools also helped them visualize complex structures, processes, practical laboratory procedures, or techniques (de Vries and May 2019; Mayne and Green 2020; Schnieder, Williams and Ghosh 2022). The technology also offered more cost-effective hands-on experiences, giving students opportunities to collaborate or work alone on a variety of scenarios (Mayne and Green 2020). The extent to which simulation tools increased students' results varied, from a moderate increase (Reeves et al. 2021) to a slightly higher increase in test scores (Schnieder, Williams and Ghosh 2022). It is, however, stressed that the content, length, and practical application of the individual virtual simulation cases will vary, and they may thus have a different impact on students' learning outcomes (de Vries and May 2019).

Findings from the included studies also report generally positive feedback from students on the use of AR and VR in education. The research highlights the engaging nature and interactivity of the simulation tools, better collaboration through shared user experience (Mayne and Green 2020; Reeves et al. 2021; Schnieder, Williams and Ghosh 2022), and increased study activity and motivation among students (de Vries and May 2019). Students also emphasised the advantage of simulation tools in allowing them to complete learning tasks anytime, anywhere, and at a pace suitable for each individual student (Schnieder, Williams and Ghosh 2022).

However, the study by Schnieder and colleagues (2022) shows that the students did not want to use the virtual laboratory as a substitute for physical laboratory exercises, and most chose to carry out both physical and virtual laboratory exercises – even though this entailed a double workload. Similar findings can be seen in a study comparing the use of virtual microscopes in blended learning and fully online teaching (Herodotou et al. 2020). This study found no differences in learning outcomes from the two teaching methods. On the other hand, blended learning approaches, with both web-based learning information and physical teaching, appeared to better facilitate student engagement and satisfaction with the use of virtual microscopes. The students were also more engaged and satisfied



with the mixed teaching method. They reported better systematic use of the virtual technology, they got a more comprehensive use of both virtual and physical microscopes, and they received better and more continuous guidance and support from the teacher. The authors point out that the use of virtual microscopes in purely web-based courses does not currently support students' learning engagement and satisfaction to the extent envisaged. Similar conclusions are found elsewhere in the research literature, where it is emphasized that AR and VR technology should be used as a supplement and to enrich teaching, rather than as a replacement of traditional educational activities (de Vries and May 2019; Gorucu-Coskuner, Atik and Tanner 2020; Reeves et al. 2021).

### 3.4 Learning Management Systems

A total of 7 studies on learning management systems were included in our review. Learning Management Systems (LMS) or digital learning platforms are web-based systems for accessing, organizing, and facilitating learning content. Such platforms are often used for one-way communication from the teacher to students, but users can also communicate among themselves through forums or chat functions. There are several different learning management systems, like Canvas and Moodle, as well as systems linked to massive open online courses, called MOOCs.

The research literature points out that learning management systems offer important resources in higher education, for example by making learning information digitally available. Students can thus prepare in advance for a physical educational session, as well as return to the learning material afterwards. Furthermore, the research shows how teachers use digital learning platforms as an organising tool, for example by checking how many students are enrolled in a course, planning seminar topics, and uploading learning material. Digital platforms are used to a lesser extent to promote student-centred and technology-based learning (Bond et al. 2018). This is also emphasized in a study by Pikhart and Klímová (2020). Their research shows that learning platforms are not considered an attractive tool for students, as they often favour more active participation and better opportunities for collaboration and interaction with each other.

The research literature indicates that the use of learning management systems, for example in flipped classrooms, can save time and improve the experience of in-person education. Dombrowski and colleagues (2018) show that early use of learning management systems in the course of study is related to academic achievement later in the academic year. In their study, 66 per cent of the students reported that they frequently used the learning management system for their studies. This group also felt significantly better prepared for the practical teaching part of the course than students who used the learning management system to a

lesser extent. Similar results can be seen in a study by Broos and colleagues (2020), where the use of learning management systems resulted in an average of 6.4 per cent increase in students' final grades. However, the study could not demonstrate changes in the students' behaviour, nor an ability for deeper reflection, as a result of introducing learning management systems into the course.

Overall, the research literature shows that most students support the use of learning management systems (Broos et al. 2020; Dombrowski et al. 2018; Meum et al. 2021). Nevertheless, some disadvantages are identified when the systems are used in purely online courses – often seen in MOOCs – compared to courses that integrate digital teaching with forms of face-to-face teaching (Bralić and Divjak 2018; Vorbach, Poandl and Korajman 2019).

### **3.5 Collaboration tools between students**

Only one study in our literature material looks at digital collaboration tools between students. Ritella & Sansone (2020) qualitatively explore the emergent space-time configurations of interactive whiteboard (IWB) usage within a collaborative task in a university course. During the course, the students had an opportunity to use Interactive Whiteboard technology to support the collaborative learning process within small groups of 4-5 students.

The findings reveal that the interactive whiteboard was only partially integrated within the students' activity and most of the usage took place during the first phase of the course. The authors conclude that the usage of interactive whiteboards and the effectiveness of the emergent space-time configurations are both strictly dependent on the nature of the learning task and the pedagogical approach adopted. The interactive features of interactive whiteboard were appreciated by students but were not essential for the accomplishment of the knowledge creation task during the second and third phase of the course, when individual work was prioritized. The implication is, as noted by the authors, that teachers should consider digital features supporting students' knowledge creation, design learning, and students' engagement in collaborative task.

## 4 Findings across the research literature

In the following, we will highlight some key findings across the research literature. The findings indicate that digital technology has great potential to support students' learning processes and learning outcomes. The literature also highlights some disadvantages with the use of digital technology in higher education. It is shown that both students and teachers do not want digital technology to replace in-person education.

### 4.1 Advantages and disadvantages of digital technologies in higher education

In the research literature, many advantages of using digital technology in higher education are highlighted. It is for instance stressed that digital technology could increase students' engagement and motivation, strengthen teachers' autonomy, increase student-based learning, and improve resource utilization for students, educators, and the HEI (Dhillon and Murray 2021; Mei, Aas and Medgard 2019). The use of digital technology may also increase efficiency, flexibility, and opportunities for individual learning, as students can review the learning material at their own pace (Forde and O'Brien 2022; Sormunen et al. 2020).

Despite these potential benefits, the articles included as part of this study indicate that the extent to which the various technologies are used varies. This is often linked to the existence of various barriers to use, both among teachers and students. A central barrier identified in the literature is the lack of training or lack of confidence in using digital technology or tools in an educational setting. Research findings show that many educators also have little time to develop digital literacy skills and inadequate training within their HEI (Marcelo and Yot-Domnguez 2019; Mercader and Gairin 2020; Sormunen et al. 2020). The use of digital technology also leads to more technical issues, as well as more work related to the development and updating of digital course materials (Dhillon and Murray 2021; Grabinski et al. 2018). Another disadvantage, highlighted by several studies, is that

much digital technology has little interactivity and leave little or no room for interaction between the students themselves or between students and teacher (Forde and Obrien 2022; Vorbach, Poandl and Korajman 2019).

## 4.2 Effects of digital education vs. traditional education

Research shows that, on average, teachers in higher education use a variety of digital tools, rather than just one type (Dhillon and Murray 2021; Lohr et al. 2021). Digital tools are often used in combination with learning activities in in-person lectures (for example in blended learning or flipped classrooms), rather than in fully online courses (Pinto and Leite 2020).

In our literature material we find several studies that compare face-to-face education with digital education and/or blended learning – often to investigate which format ensures increased exam grades, and high learning outcomes, provides the most satisfied and engaged students, increases motivation, or leads to the highest study completion rate. Our systematic review shows that many of these studies refer to different, and to some extent contradictory, results.

Some research shows that the use of digital technology in higher education is generally positive, as it leads to increased engagement, participation in the learning process, and learning outcomes for students (Dunn and Kennedy 2022; Pinto and Leite 2020). Other studies indicate that it is students' participation in active, constructive, and interactive digital activities that is positively related to learning outcomes, not the use of digital technology per se (Wekerle, Daumiller, and Ingo 2022). Studies also show that digital teaching formats increase the efficiency and flexibility of teaching processes (Grabinski et al. 2018), and that students perceived an increase in expectations of independent learning with the introduction of digital teaching formats (Lomer and Palmer 2021).

Other studies find no correlation between the use of digital technologies in higher education and students' engagement or exam results (Pickering and Swinerton 2019). Findings indicate that it is especially the use of digital teaching charts, teaching recordings, reading of additional learning content, as well as the use of course blogs and discussion groups, that do not affect students' grades to any notable degree (Dunn and Kennedy 2022).

Research also shows that the use of digital technology in higher education leads to more work related to the development and updating of digital course materials, as well as time spent dealing with technical issues (Dhillon and Murray 2021; Grabinski et al. 2018). Studies also reveal that students generally display lower attention, engagement, and experience of flow in digital learning environments, compared with in-person settings. This relates to the importance of face-to-face

social interaction, an argument supported by much of the research literature examined here (e.g. Alvarez et al. 2022).

Several studies examine the effects of blended learning and flipped classroom formats compared with purely online courses on the one hand, and more traditional forms of teaching on the other. Studies show how students who were taught by blended learning methods, i.e. a combination of both digital learning resources and more traditional face-to-face teaching, performed better on exams than students with more traditional forms of teaching (Grønlien et al. 2021; Sing 2020). Findings also show that a blended form of teaching was advantageous for weaker performing students and could be linked to a lower probability of students failing exams compared to the fail rate in traditional teaching formats (Sing 2020). Compared to purely online courses, it appears that students who received blended learning also had better motivation, satisfaction, and knowledge of the subject (McCutcheon, O'Halloran, and Lohan 2018). Although other studies find no evidence that blended learning or flipped classrooms led to better exam scores, they nevertheless found that students became more engaged in such forms of learning – they appeared to find the course less difficult and more interesting compared with those students who followed a more traditional teaching format (Price and Walker 2021).

### **4.3 Factors that contribute to good digital education**

Many studies investigate factors that contribute to high-quality online education. They all emphasise the importance of designing flexible learning environments with user-friendly technology. The studies also stress the importance of students' ownership, expectations, and capacity for self-regulation when engaging them in digital learning formats (cf. Garrels and Zemliansky 2021; Nortvig et al. 2019; Theleen and van Breukelen 2022). Another key point is the importance of providing opportunities for interaction and cooperation between students and the teacher. Findings also indicate that teachers should have a clear presence in the digital learning arena (Nykvist et al. 2021; Regmi and Jones 2020). The use of active learning tasks is also highlighted as important, as this may contribute towards students' motivation and engagement. Findings further show that the successful implementation of such activities is linked to the teacher's technical pedagogical knowledge (Marcelo and Yot-Domnguez 2019; Lomer and Palmer 2021).

Whether digital technology help improve learning and teaching also seem dependent on the level of technology acceptance among the students themselves (Raes and Depaepe 2020). It is also an advantage if the use of digital tools is linked to learning theory and made explicit to the students (Hyll, Schvarcz and Manninen 2019).

## 4.4 The importance of in-person education

The research literature indicates that many students are satisfied with the use of digital technology in higher education. At the same time, research clearly shows that they do not want to give up in-person education. This tendency is seen across the various categories of digital tools examined here. For example, much research indicates advantages when digital teaching formats are incorporated into a course with face-to-face education (de Vries and May 2020; Kazoka, Pilmane and Edelmers 2021; Schnieder, Williams and Ghosh 2022). However, several disadvantages become apparent when the course is entirely online (Gorucu-Coskuner, Atik, and Taner 2020). We see the same with the use of digital simulation tools, like VR laboratories and 3D simulation. In these contexts, research emphasises the importance of such tools being used as a supplement to authentic and in-person teaching and training of practical skills, rather than as a replacement (Herodotou et al. 2020; Reeves et al. 2021).

Our review identifies two primary arguments as to why students and teachers prefer teaching that involves in-person components. First, the importance of in-person and authentic learning experiences is emphasized. This is often highlighted in courses that require practical training in laboratories or practice-related settings, common in for instance medicine, biology, or teacher education. Second, the importance of social interaction between students and between students and teachers is highlighted. Social interaction is often perceived as easier face-to-face and is considered an important driver of discussion, problem-solving, critical thinking, and deeper learning.

Much research thus shows that many students and teachers prefer to use digital technology as a *preparation* for, or as a *supplement* to, in-person teaching and learning activities. However, they are more reluctant to use digital technology as a *replacement* for traditional and in-person teaching formats (de Vries and May 2020; Hyll, Schvarcz and Manninen 2019). Instead, they prefer face-to-face teaching or blended learning formats with a combination of digital and authentic learning activities (Lomer and Palmer 2021; McGuinness and Fulton 2019). It is further stressed that the goal of in-person teaching should not be to repeat the content of the digital learning material, but rather to allow knowledge to be introduced and applied, as well as create interaction and discussion between students (Smith and Francis 2022).

# 5 Final reflections

## 5.1 Discussion

A key finding from our literature review is a lack of focus on pedagogical and didactic approaches to the use of digital technology in higher education. Many studies in our review focus on digital tools, rather than the learning activity itself. The lack of didactic and pedagogical grounding in the use of digital technology may help explain why some research find positive effects and other finds negative effects on the use of digital technology in higher education. As we have seen, some studies point to the benefits and positive effects of digital tools, from the use of student-activation quizzes to pre-recorded learning videos. Other studies refer to students and teachers' negative experiences or show how the use of digital technology has no or, in some cases, a negative effect on student participation, motivation, engagement, or learning outcomes. The common denominator for many of these studies is that they focus on the digital tool in question, rather than the learning activity. As such, many studies fail to consider that teaching and learning are complex processes, which are influenced by more than just learning tools and teaching formats – whether technology is used in fully online, blended, or in-person education.

However, it is not the integration of digital technology into a course per se that increases students' learning, engagement, and motivation. Rather, students and teachers' perceptions, and subsequently the effects, of digital tools will depend on how the technology is used, its content, and the context. For example, a challenge when designing digital teaching formats is that educators often try to replicate in-person teaching by building on digital tools (Garrels & Zemliansky 2021). As such, the educational content and format are replicated in order to fit the technology.

A central question ensuing from this is *what* digital tools offer in an educational setting. How does the digital tool in question contribute to the learning activity? Does it contribute to deeper learning or better understanding, or does it illustrate complex problems in a way not achieved by reading a book or explained by a teacher? Or, perhaps, is the use of digital technology a way to reach a larger group of students, without them being restricted by time or place? Different actors

involved in higher education may have different arguments for why digital technology should be incorporated and used. Some arguments are of an economic or administrative nature, others take a more pedagogical grounding. Other arguments, again, appear to stem from digital technology's enthralling nature.

For digital technology to have an added value to learning, one can argue that the attention to technology should come second, and discussions related to pedagogy and course design should be put first (Cousin 2005; Sankey, 2020). In other words, it is the educational objectives that should drive the choice of (digital) tools – and not the other way around. These arguments are far from new. Many researchers have called for more attention to the pedagogical and didactical anchoring when using digital technology in higher education. Already a decade ago, it was argued that too much emphasis was on sophisticated 'gadgetry' to enhance learning, with little regard for its consequences for the learning process (Carroll 2013). This view has been echoed by numerous scholars during the last decade (e.g., de Vries and May 2020; Hutain and Michinov 2022; Mader and Bry 2019; Nykvist et al. 2021; Regmi and Jones 2020; Wekerle, Daumiller and Ingo 2022).

The 'pedagogy first' argument is often emphasised by educators, supported by the metaphor of the 'pedagogical horse' driving the 'technological cart' (Cousin 2005; Tsui and Tavares 2021). Other authors argue that such standpoints indicate a technology–pedagogy dichotomy, where both pedagogy-led and technology-led positions decontextualise technology and are vulnerable to different forms of determinism, since they either assume technology as the driving force of change or as a set of neutral tools (Fawns 2022; Oliver 2011). A move beyond this technology-pedagogy dichotomy includes an assumption of the mutual shaping of technologies and pedagogy, where technologies, teaching methods, educational activities and purposes are entangled (Fawns, 2022).

As we can see, the relationship between technology and pedagogy can, in a crude categorisation, be grouped in three different ways: technology first, pedagogy first, or entangled. However, there is reason to suspect that technology often takes the front stage in many educational settings, whereas other considerations – like the pedagogical and didactical – fade in the background. Our review indicates that much research still focuses on digital tools and the technology itself, with little consideration for the learning process or the educational and didactical underpinnings of the technological use. As such, we argue that it is useful to shift the focus from technology-based thinking to pedagogy and design-based thinking, to promote learning and create high-quality educational activities in higher education. By arguing for this shift, we do not repel away from technology – far from it – nor do we argue that technology is a neutral set of tools. Technologies will inevitably influence teaching and learning activities, but teachers and students will also shape technologies and chose how they are used in educational settings.



When incorporating digital technology in a pedagogical design, we thus argue for the importance of considering multiple factors. This includes considerations of different actors' arguments for implementing technologies in higher education, and how technology is embedded in a pedagogical design. It is also important to move beyond the mere *intended* design, considering the actual educational activities. This includes contemplation of how technologies contribute to shape teaching and learning activities, providing both opportunities and limitations. At the same time, it is important to consider how teachers and students perceive and make use of technologies in their own and, perhaps, unanticipated way. Again, this emphasise that teaching and learning are complex processes, which are influenced by more than just learning tools and pedagogical designs.

## 5.2 Summary

Digital technology has great potential to support students' learning processes and learning outcomes, and many students are satisfied with the use of digital technology in higher education. Nevertheless, studies show that both students and teachers do not prefer fully online courses. Instead, they prefer in-person teaching or blended learning, where digital and face-to-face learning activities are combined. From the viewpoint of both students and teachers, digital technologies should thus primarily be seen as a *supplement* to, or preparation for, in-person teaching and learning activities, rather than as a *replacement* of face-to-face education.

Our findings further suggest that both teachers and students' pedagogical abilities, technological competence, and commitment may have a greater effect on learning than the introduction of a specific digital tool *per se*. The quality of digital technology in higher education should therefore be seen as context dependent – meaning that its added value will depend on how digital technology is used, which digital tools that are utilised, as well as the educational setting.

Rather than focusing on the *technical* use of digital technology, we call for more attention to, and further development of, the *didactic* and *pedagogical* use of digital technology in higher education. This requires increased digital skills and better training for educators, as well as a clearer focus on pedagogical approaches to its use. It also requires an understanding of how technology and pedagogy, with different actors and contexts, are entangled and mutually shape one another.

Digital technologies will continue to evolve and change, continuously offering new digital tools and impressive gadgets to higher education. How these technologies are embedded in, and mutually shaped by, education will partly depend on how teachers and students incorporate, use, and adapt to these technologies. This also means that we continuously need to reflect upon the complex relationship between technology and pedagogy in higher education.

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## Appendix 1: Table over the 68 included studies in the rapid systematic review

Authors	Year	Title/topic	Digital technology
Alvarez et al.	2022	Self-Reported Flow in Online Learning Environments for Teacher Education: A Quasi-Experimental Study Using a Counterbalanced Design	Digital teaching formats
Barisone et al.	2018	The effectiveness of web-based learning in supporting the development of nursing students' practical skills during clinical placements: A qualitative study	Digital teaching formats
Bedenlier et al.	2020	Facilitating student engagement through educational technology in higher education: A systematic review in the field of arts and humanities	Several forms of digital technology
Bond et al.	2081	Digital transformation in German higher education: student and teacher perceptions and usage of digital media	Learning Management Systems
Bralić & Divjak	2018	Integrating MOOCs in traditionally taught courses: achieving learning outcomes with blended learning	Learning Management Systems
Broos et al.	2020	Learning dashboards at scale: early warning and overall first year experiences	Learning Management Systems
Burvill et al.	2022	The digital explosion: It's impact on international student achievement	Student activation tools
Cacault et al.	2018	Distance learning in higher education: Evidence from a randomized experiment	Digital teaching formats
Campillo-Ferrer et al.	2019	Gamification in Higher Education: Impact on Student Motivation and the Acquisition of Social and Civic Key Competencies	Student activation tools
Costa et al.	2018	Higher education students' experiences of digital learning and (dis) empowerment	Several forms of digital technology
De Vires	2020	Virtual laboratory simulation in the education of laboratory technicians-motivation and study intensity	Simulation tools
Dhillon & Murray	2021	An Investigation of EAP Teachers' Views and Experiences of E-Learning Technology	Several forms of digital technology

<b>Dombrowski et al.</b>	2021	Flipped classroom frameworks improve efficacy in undergraduate practical courses – a quasi-randomized pilot study in otorhinolaryngology	Learning Management Systems
<b>Dunn &amp; Kennedy</b>	2022	Technology Enhanced Learning in higher education; motivations, engagement and academic achievement	Several forms of digital technology
<b>Fernandez-Batanero et al.</b>	2021	Impact of Educational Technology on Teacher Stress and Anxiety: A Literature Review	Several forms of digital technology
<b>Forde &amp; OBrien</b>	2022	A Literature Review of Barriers and Opportunities Presented by Digitally Enhanced Practical Skill Teaching and Learning in Health Science Education	Several forms of digital technology
<b>Garrels &amp; Zemliansky</b>	2021	Improving Student Engagement in Online Courses through Interactive and User-Centered Course Design: Practical Strategies	Digital teaching formats
<b>Gorucu-Coskuner et al.</b>	2019	Comparison of Live-Video and Video Demonstration Methods in Clinical Orthodontics Education	Simulation tools
<b>Grabinski et al.</b>	2018	Embedding E-Learning in Accounting Modules: The Educators' Perspective	Digital teaching formats
<b>Grønlien et al.</b>	2018	A blended learning teaching strategy strengthens the nursing students' performance and self-reported learning outcome achievement in an anatomy, physiology and biochemistry course - A quasi-experimental study	Digital teaching formats
<b>Harrison</b>	2021	How distance education students perceive the impact of teaching videos on their learning	Digital teaching formats
<b>Haugland et al.</b>	2020	Collaborative learning in small groups in an online course - a case study	Digital teaching formats
<b>Hernandez-Lara et al.</b>	2019	Students' perception of the impact of competences on learning: An analysis with business simulations	Student activation tools
<b>Herting et al.</b>	2020	Patterns of PowerPoint Use in Higher Education: a Comparison between the Natural, Medical, and Social Sciences	Student activation tools
<b>Herodotou et al.</b>	2019	Blended and online learning: a comparative study of virtual microscopy in Higher Education	Simulation tools
<b>Hutain &amp; Michinov</b>	2021	Improving student engagement during in-person classes by using functionalities of a digital learning environment	Student activation tools
<b>Hyll et al.</b>	2021	Exploring how medical students learn with the help of a digital presentation: a qualitative study	Student activation tools
<b>Jacquesson et al.</b>	2020	Stereoscopic three-dimensional visualization: interest for neuroanatomy teaching in medical school	Simulation tools

<b>Joseph-Richard et al.</b>	2018	Big brother or harbinger of best practice: Can lecture capture actually improve teaching?	Digital teaching formats
<b>Karay et al.</b>	2020	Progress testing anytime and anywhere – Does a mobile-learning approach enhance the utility of a large-scale formative assessment tool?	Digital teaching formats
<b>Kazoka et al.</b>	2020	Facilitating Student Understanding through Incorporating Digital Images and 3D-Printed Models in a Human Anatomy Course	Simulation tools
<b>Lohr et al.</b>	2021	On powerpointers, clickerers, and digital pros: Investigating the initiation of digital learning activities by teachers in higher education	Student activation tools
<b>Lomer &amp; Palmer</b>	2021	'I didn't know this was actually stuff that could help us, with actually learning': student perceptions of Active Blended Learning	Several forms of digital technology
<b>Mader &amp; Bry</b>	2019	Fun and Engagement in Lecture Halls Through Social Gamification	Student activation tools
<b>Magano et al.</b>	2020	Adoption and Use of Educational Technology Tools by Marketing Students	Several forms of digital technology
<b>Marcelo &amp; Yot-Dominguez</b>	2019	From chalk to keyboard in higher education classrooms: changes and coherence when integrating technological knowledge into pedagogical content knowledge	Several forms of digital technology
<b>Mayne &amp; Green</b>	2020	Virtual reality for teaching and learning in crime scene investigation	Simulation tools
<b>McCutcheon et al.</b>	2018	Online learning versus blended learning of clinical supervisee skills with pre-registration nursing students: A randomised controlled trial	Digital teaching formats
<b>McGuinness &amp; Fulton</b>	2019	Digital literacy in higher education: A case study of student engagement with e-tutorials using blended learning	Digital teaching formats
<b>Mei et al.</b>	2019	Teachers' use of digital learning tool for teaching in higher education Exploring teaching practice and sharing culture	Several forms of digital technology
<b>Mellar et al.</b>	2018	Addressing cheating in e-assessment using student authentication and authorship checking systems: teachers' perspectives	Digital teaching formats
<b>Mercader &amp; Gairin</b>	2020	University teachers' perception of barriers to the use of digital technologies: the importance of the academic discipline	Several forms of digital technology
<b>Meum et al.</b>	2021	Perceptions of digital technology in nursing education: A qualitative study	Learning Management Systems
<b>Mio et al.</b>	2019	Scenario-based eLearning to promote active learning in large cohorts: Students' perspective	Student activation tools

<b>Morris et al.</b>	2019	Lecture recordings to support learning: A contested space between students and teachers	Digital teaching formats
<b>Mozhenko et al.</b>	2019	Multimedia Technologies in Modern Educational Practices: Audiovisual Context	Digital teaching formats
<b>Navio-Marco et al.</b>	2022	The student as a prosumer of educational audio-visual resources: a higher education hybrid learning experience	Digital teaching formats
<b>Nortvig et al.</b>	2019	A Literature Review of the Factors Influencing E-Learning and Blended Learning in Relation to Learning Outcome, Student Satisfaction and Engagement	Several forms of digital technology
<b>Nykvist et al.</b>	2021	Key Factors Needed for Developing a Higher Education Cross-Campus Learning Environment in a Nordic Context	Digital teaching formats
<b>Perez-Navarro et al.</b>	2021	Students' Behavior and Perceptions Regarding Complementary Videos for Introductory Physics Courses in an Online Environment	Digital teaching formats
<b>Pickering &amp; Swinnerton</b>	2020	Exploring the Dimensions of Medical Student Engagement with Technology-Enhanced Learning Resources and Assessing the Impact on Assessment Outcomes	Several forms of digital technology
<b>Pikhart &amp; Klimova</b>	2020	eLearning 4.0 as a Sustainability Strategy for Generation Z Language Learners: Applied Linguistics of Second Language Acquisition in Younger Adults	Learning Management Systems
<b>Pinto &amp; Leite</b>	2020	Digital technologies in support of students learning in Higher Education: literature review	Several forms of digital technology
<b>Price &amp; Walker</b>	2021	Improving the accessibility of foundation statistics for undergraduate business and management students using a flipped classroom	Digital teaching formats
<b>Raes &amp; De-paepe</b>	2020	A longitudinal study to understand students' acceptance of technological reform. When experiences exceed expectations	Student activation tools
<b>Reeves et al.</b>	2021	Use of augmented reality (AR) to aid bioscience education and enrich student experience	Simulation tools
<b>Regmi &amp; Jones</b>	2020	A systematic review of the factors - enablers and barriers - affecting e-learning in health sciences education	Several forms of digital technology
<b>Ritella &amp; Sansone</b>	2020	Transforming the space-time of learning through interactive whiteboards: the case of a knowledge creation collaborative task	Collaboration tools between students
<b>Saadeh et al.</b>	2020	To what extent do preclinical veterinary students in the UK utilize online resources to study physiology	Several forms of digital technology
<b>Schnieder et al.</b>	2021	Comparison of In-Person and Virtual Labs/Tutorials for Engineering Students Using Blended Learning Principles	Simulation tools

<b>Singh</b>	2020	“A little flip goes a long way” – The impact of a flipped classroom design on student performance and engagement in a first-year undergraduate economics classroom	Digital teaching formats
<b>Smith &amp; Francis</b>	2022	Engagement with video content in the blended classroom	Digital teaching formats
<b>Smyrnakis et al.</b>	2021	Webinars in general practice placement for final year medical students A mixed-method analysis	Digital teaching formats
<b>Sormunen et al.</b>	2020	Digital Learning Interventions in Higher Education A Scoping Review	Several forms of digital technology
<b>Sprenger &amp; Schwaninger</b>	2021	Technology acceptance of four digital learning technologies (classroom response system, classroom chat, e-lectures, and mobile virtual reality) after three months' usage	Digital teaching formats
<b>Theelen &amp; van Breukelen</b>	2022	The didactic and pedagogical design of e-learning in higher education: A systematic literature review	Several forms of digital technology
<b>Vorbach et al.</b>	2019	Digital entrepreneurship education: The role of MOOCs	Learning Management Systems
<b>Wekerle et al.</b>	2022	Using digital technology to promote higher education learning: The importance of different learning activities and their relations to learning outcomes	Several forms of digital technology

## Appendix 2: Synthesis of each included article

A synthesis of each included article is presented in the following. The articles are grouped in the thematic categories, as presented in the rapid systematic review.

### **Digital teaching formats (23 studies)**

**Alvarez, L., Carrupt, R., Audrin, C. & Gay, P. (2022). Self-Reported Flow in Online Learning Environments for Teacher Education: A Quasi-Experimental Study Using a Counterbalanced Design, in Education Sciences, Vol. 12, No. 351.**

Alvarez and colleagues (2022) notes that digitization in teacher education is currently being promoted, but the choice between face-to-face instruction and online learning environments remains challenging. The present study adopts a counterbalanced design to compare different dimensions of student experience of flow in face-to-face settings and online learning environments. Two groups of students in teacher-training programs ( $n = 37$ ) completed an EduFlow questionnaire at the end of the same interactive courses in the two different settings.

The results indicate globally lower attention and engagement in the online environment, suggesting that in-person instruction induces better cognitive absorption, greater time transformation, and a stronger autotelic experience. The authors note that it is possible to understand the better flow experience in the face-to-face environment compared to the distance learning environment as being related to the importance of direct social interactions. The findings also indicate that students seem to experience greater flow and retain their attention better in traditional, face-to-face classrooms, but online learning environments may promote time efficiency or scalability. The authors argue that if gamification or specific instructional design is added to the digital learning experience, it is possible that the reported flow would attain the levels in the face-to-face setting. They thus conclude that, more research is needed to identify the specific mechanisms regarding attention and motivation that can impact flow in these two environments. For

now, however, without a specific design for the distance online environment that promotes variability of learning experiences, it may be beneficial for the learners' experience of flow to remain in a face-to-face design.

**Barisone, M., Bagnasco, A., Aleo, G., Catania, G., Bona, M., Scaglia, S.G., Zanini, M., Timmins, F. & Sasso, L. (2018). The effectiveness of web-based learning in supporting the development of nursing students' practical skills during clinical placements: A qualitative study, in *Nurse Education in Practice*, Vol. 37, pp. 56-61.**

Barisone and colleagues (2018) note that web-based learning, on its own or in combination with traditional teaching methods, has become a consolidated practice in many countries, and has been described as a valid and effective method that supports practical learning in undergraduate nursing students. The aim of their study was to explore the perception and effectiveness of web-based learning in facilitating the development of clinical skills in undergraduate nursing students. A qualitative descriptive study was conducted including online videos in three nursing schools of a university in Northern Italy.

The results show that, thanks to its ease of use and unlimited access, web-based learning effectively supported students' clinical learning process by offering additional virtual visual support. Results also suggest that the use of web-based applications for learning technical-practical skills improve students' conceptual learning, ensuring high standards of care and patient safety, especially due to the increasing complexity of care. Web-based learning could be effectively used to reduce the gap between theory and practice, and even as an upgrade for already qualified nurses.

**Cacault, M.P., Hildebrand, C., Laurent-Lucchetti, J. & Pellizzari, M. (2018), Distance learning in higher education: Evidence from a randomized experiment, in *Journal of the European Economic Association*, pp. 2322-2372.**

Cacault and colleagues (2018) use a randomized experiment in a public Swiss university, studying the impact of online live streaming of lectures on student achievement and attendance. The authors find that attending lectures via live streaming lowers achievement for low-ability students and increases achievement for high-ability ones. They also find that students use the live streaming technology only occasionally, about 10 % of the times they have access. The results also show that offering live streaming reduces in-class attendance only mildly, and it thus has small effects on attendance in class. These findings have important implications for the effective design of education policies. The authors discuss possible mechanisms that could rationalise these findings. One such mechanisms that seems consistent with the data postulates that students use the streaming service



only when random events make the cost of attending in class particularly high. The result from the study suggests that students have a general preference for classroom attendance, hence the use of distance learning technologies, at least in the form of simply streaming traditional classroom lectures, is unlikely to solve problems of physical overcrowding. The authors further notes that it is hard to say whether other technologies would have different effects but, at a minimum, their results suggest caution with the idea that distant learning tools can be used to reduce class size.

**Garrels, V. & Zemliansky, P. (2021), Improving Student Engagement in Online Courses through Interactive and User-Centered Course Design: Practical Strategies, in Nordic Journal of Digital Literacy, Vol. 17, No. 1, pp. 112-122.**

Garrels and Zemilansky (2021) note that research suggests that many teachers in higher education struggle with designing high quality online courses. In this article, the authors present a set of practical teaching strategies, grounded in state-of-the-art research in online learning, and illustrated with practical examples from their own teaching. The authors argue that creating a successful online course is about designing a flexible learning environment for students, strategically blending synchronous and asynchronous means, providing active learning tasks that enhance student motivation and engagement, and creating multiple opportunities for students to interact with one another and with the teacher.

They further argue that, too frequently, beginning online teachers start by asking questions about specific technological tools and platforms, trying to replicate the face-to-face classroom online. However, preoccupations with technology must take a back seat to conversations about pedagogy and course design. Online courses allow teachers to transcend the confines of a physical classroom, and teachers are, therefore, not limited to real-time course delivery via video, though they should use it if it makes local sense. Teachers must also learn to recognize and employ the power of asynchronous learning, done through learning management systems and other asynchronous tools. Effective online learners and teachers thrive on engagement, flexibility and interactivity, and teachers must use a full range of methods and tools to achieve this.

The author further notes that, in order to facilitate the transition from technology-based to design-based thinking, researchers in education and other related fields should continue to study the impact of the design of online courses on student engagement, motivation, and learning. In particular, it may be relevant to explore experiences across different countries and educational systems and to investigate specific student and teacher populations.

**Grabinski, K., Kedzior, M., Krasodomska, J. & Herdan, A. (2018). Embedding E-Learning in Accounting Modules: The Educators' Perspective, in Education Sciences, Vol. 10, No. 97.**

The aim of Grabinski and colleagues (2018) paper is to investigate the benefits and drawbacks resulting from the implementation of e-learning in accounting modules among educators. The primary source of data was a questionnaire conducted among 79 accounting lecturers, employed by the leading Polish economic universities.

The results of the survey have shown that e-learning is not widely used by accounting academics in Poland. The most important benefits of the e-courses included the enhancement of efficiency and flexibility of the teaching process. The most serious difficulties were an extensive amount of work associated with designing and updating course materials and technical problems. The effectiveness of e-learning techniques in teaching accounting subjects is determined by the easiness of e-learning delivery, more regular learning process, greater development of students' social competences during e-learning classes, and a more effective process of verification of students' progress, in comparison with traditional classes. Furthermore, the study provides evidence that lecturers, who decided to use e-learning, perceive this way of teaching as more efficient, and at the same time more demanding, in comparison to traditional classes. The paper contributes to the understanding of the use of e-learning in accounting education and offers findings that might be useful for both policymakers and practitioners.

**Grønlien, H.K., Christoffersen, T.E., Ringstad, Ø., Andreassen, M. & Lugo, R.G. (2018), A blended learning teaching strategy strengthens the nursing students' performance and self-reported learning outcome achievement in an anatomy, physiology and biochemistry course - A quasi-experimental study, in Nurse Education in Practice, Vol. 52, No. 103046.**

Grønlien and colleagues (2018) explore a blended learning teaching strategy in an anatomy, physiology, and biochemistry course for first year Bachelor nursing students. In the blended learning teaching strategy, short narrated online digital resources of bioscientific terms and concepts were integrated into the teaching design along with digital metacognitive evaluations of learning outcomes.

Results show that compared to students receiving traditional face-to-face teaching, the students with a blended learning approach performed better on their national exam with a small to medium effect size. Student course evaluations supported the blended learning delivery with small to medium effect sizes. The students reported that the digital resources supported their learning outcome achievement, that they better understood the teacher's expectations and that they were more satisfied with their virtual learning environment. The authors conclude

by noting how this study adds to the growing literature of blended learning effectiveness in higher education and suggests the use of digital resources as an enrichment of teaching and enhancement of students' study experience.

**Harrison, T. (2021). How distance education students perceive the impact of teaching videos on their learning, in *Open Learning*, Vol. 35, No. 3, pp. 260-276.**

Harrison (2021) notes that pedagogical research into teaching videos has been broadly positive and focussed on their benefits for students' experience as well as how specific features of films can enhance learning and attainment. Although these studies are useful, few consider the perceptions of the students who watch the films and the teachers who make them. This article focuses on a study conducted with distance learning students and teachers from one university in England to discover their attitudes to teaching videos. The exploratory study found that although a majority of distance students like and watch the videos, a significant proportion give good reasons for not doing so.

Further, and contrary to many previous studies, perception about the ideal length of videos varies and many students believe that longer videos are beneficial to their learning. This means that decisions about the length of the video should be made on a pedagogical as opposed to a technological basis. The quality of video production matters to some students whereas the quality of teacher presentation matters to most students. Students were most concerned with the teachers' tone, body language, ability to communicate clearly using varied expression and their ability to be entertaining.

The overall finding from the research is, it is the quality of the teacher, as opposed to the affordances that technology offers, that is perceived to have the most impact on student learning. Any positive effects from teaching videos might best be attributed to the teacher's style on video as well as the use students make of the videos rather than the technology per se. The findings are significant as the development of teaching videos can be expensive and they will help higher education teachers make wiser pedagogical decisions about when to use videos, and of what type.

**Haugland, M.J., Rosenberg, I. & Aasekjaer, K. (2020), Collaborative learning in small groups in an online course - a case study, in *BMC Medical Education*, Vol. 22:165.**

The aim of Haugland and colleagues (2020) study was to describe, explore and discuss how the students collaborated in small groups in an online course to learn. The course was a 15-ECTS-credit online course in philosophy of science, ethics, and research methods, offered online at a university in Norway. Collaborative

learning in combination with digital teaching tools was the preferred pedagogical approach in the online course. The authors performed focus groups and individual interviews, conducting a qualitative case study with a content analysis of the data collected.

The results revealed that the collaboration in small groups resulted in three different working processes, depending on the students' ability to be flexible and take responsibility for their own and common learning. The three different working processes that emerged from their data were i) joint responsibility – flexible organization; ii) individual responsibility – flexible organization; and iii) individual responsibility – unorganized. None of the groups changed their working process during their course, even though some experienced their strategy as inadequate. The authors concludes that their study show that despite similar factors such as context, assignments and student autonomy, the students chose different collaboration strategies to accomplish the online course learning objectives. Each group chose their own working process, but only the strategy i) joint responsibility – flexible organization, seemed to promote collaboration, discussion, and team work to complete the complex assignments in the online course. The authors further note that the result from the study may be helpful in designing and planning future online courses; hence online learning requires a focus on how students collaborate and learn online, to gain knowledge and understanding through group discussion.

**Joseph-Richard, P., Jessop, T., Okafor, G., Almpanis, T. & Price, D. (2018), Big brother or harbinger of best practice: Can lecture capture actually improve teaching?, in British Educational Research Journal, Vol. 44, No. 3.**

Joseph-Richard and colleagues (2018) use a mixed-method approach to explore the impact of lecture capture technology in higher education. Their data paints a mixed picture of what the authors call “the lecture capture’s Janus-faced reality”. On the one hand, it enhances lecturer self-awareness, planning and conscious ‘performance’. On the other hand, it crushes spontaneity, impairs interaction, and breeds wariness through constant surveillance. The authors note that the findings pose awkward questions as to whether lecture capture is making teaching blander and more instrumental, albeit neatly aligned to dimensions of the UK Professional Standards Framework. The authors provide contradictory evidence about lecture capture technology, embraced by students, yet tentatively adopted by most academics. The implications of the study are, as noted by the authors, not straightforward, except to proceed with caution, valuing the benefits but ensuring that learning is not dehumanised through blind acceptance at the moment we press the record button.

**Karay, Y., Reiss, B. & Schaubert, S. K. (2020). Progress testing anytime and anywhere – Does a mobile-learning approach enhance the utility of a large-scale formative assessment tool?, in *Medical Teacher*, Vol. 42, No. 10, pp. 1154-1162.**

Karay and colleagues (2020) explore whether a time- and location-independent variant of a formative progress test has an impact on the students' acceptance, its validity and reliability and if there is a difference in response processes between the two exam conditions. In the study, students were randomly assigned to two groups of which one took the test free of local or temporal fixations (the mobile group), while the other group took the test at the local testing center under causal examination conditions. Beside the generated test data, such as test score, time-on-test, and semester status, students also evaluated the settings.

The results show that, while there was no significant effect on the test score between the two groups, students in the mobile group spent more time on the test and were more likely to use the help of books or online resources. The results of the evaluation show that the acceptability among students is increased by a mobile version of the formative progress test. The authors conclude by suggesting that the acceptance and motivation to participate in formative test is enhanced by lifting local and temporal restrictions. The mobile version nonetheless does not have an impact on the students' performance.

**McCutcheon, K., O'Halloran, P. & Lohan, M. (2018). Online learning versus blended learning of clinical supervisee skills with pre-registration nursing students: A randomised controlled trial, in *International Journal of Nursing Studies*, Vol. 82, pp. 30-39.**

The purpose of McCutcheon and colleagues (2018) study was to test whether undergraduate nursing students who received clinical supervisee skills training via a blended learning approach would score higher in terms of motivation and attitudes towards clinical supervision, knowledge of clinical supervision and satisfaction of learning method, when compared to those students who received an online only teaching approach. In the study, a total of 122 pre-registration nurses enrolled at one United Kingdom university, randomly assigned to the online learning control group (n=60) or the blended learning intervention group (n=62). The blended learning intervention group participated in a face-to-face tutorial and the online clinical supervisee skills training app. The online learning control group participated in an online discussion forum and the same online clinical supervisee skills training app.

The results show that participants who received clinical supervisee skills training via a blended learning approach scored higher in terms of motivation and attitudes, compared to the online group. The blended learning group also scored

higher in terms of knowledge compared to the online group; and in terms of satisfaction compared to the online group. Qualitative data supported the results. The authors conclude by noting that blended learning provides added pedagogical value when compared to online learning in terms of teaching undergraduate nurses' clinical supervision skills.

**McGuinness, C. & Fulton, C. (2019). Digital literacy in higher education: A case study of student engagement with e-tutorials using blended learning, in Journal of Information Technology Education-Innovations in Practice, Vol. 18**

McGuinness and Fulton (2019) report on a case study project which had three goals; to develop a suite of original interactive digital skills e-tutorials to be embedded in undergraduate and postgraduate courses; to evaluate the students' experience and engagement with the e-tutorials over one semester; and to explore their general attitudes towards online and blended learning. A suite of nine interactive e-tutorials, addressing essential digital literacy skills for university students, was developed through instructor and student peer collaboration.

The findings show that the e-tutorials were perceived as valuable in reinforcing classroom learning, allowing respondents to revise concepts and materials covered in face-to-face classes, at their own pace and in their own time. Survey responses showed that the accessibility, ease-of-use, design and duration of the e-tutorials were deemed effective in terms of user engagement; however, several technological challenges were identified, such as browser incompatibility, uneven sound quality and general Internet connection issues, which disrupted their learning. Overall, students expressed enjoyment of the learning facilitated by the e-tutorials; however, rather than favoring online learning alone, they expressed a preference for a blended learning environment, with a combination of complementary learning approaches; survey respondents did not generally wish to forego face-to-face classes entirely.

**Mellar, H., Peytcheva-Forsyth, R., Kocdar, S., Karadeniz, A. & Yovkova, B. (2018), Addressing cheating in e-assessment using student authentication and authorship checking systems: teachers' perspectives, in International Journal for Educational Integrity, Vol. 14, No. 2.**

Mellar and colleagues (2018) investigate higher education teachers' perceptions of the prevalence and types of cheating in their courses with a focus on the possible changes that might come about as a result of an increased use of e-assessment, ways of addressing cheating, and how the use of student authentication and authorship checking systems might impact on assessment practice. Data was collected from four contexts at universities in Turkey and Bulgaria.

Results show that, in three of the four contexts, cheating was seen by teachers as a serious and growing problem. The exception was the distance education context where the teachers believed that the existing procedures were effective in controlling cheating. Most teachers in all four contexts expected cheating to become a greater problem with increased use of e-assessment. Student authentication was not seen as a major problem in any of the contexts, as this was felt to be well controlled through face-to-face proctored assessments, though the problem of assuring effective authentication was seen by many teachers as a barrier to increased use of e-assessment. Authorship checking was seen as a major issue in all contexts, as copying and pasting from the web, ghost writing and plagiarism were all reported as widely prevalent, and authorship checking was seen as becoming even more important with increased use of e-assessment. Teachers identified a third category of cheating behaviours, which was the accessing of information from other students, from written materials, and from the internet during assessments.

Teachers identified a number of approaches to address the problem of cheating: education, technology, assessment design, sanctions, policy, and surveillance. Whilst technology was not seen as the most important approach to prevention, student authentication and authorship checking systems were seen as relevant in terms of reducing reliance on face-to-face proctored examinations, and in improving the quality of assessment through supporting the employment of a wider range of assessment methods. The development of authorship checking based on computational linguistic approaches was an area of particular interest. Student authentication and authorship checking systems were not seen as being able to address the third category of cheating behaviours that the study identified.

### **Morris, N.P., Swinnerton, B. & Coop, T. (2019), Lecture recordings to support learning: A contested space between students and teachers, in *Computer & Education***

Morris and colleagues (2019) note that research has demonstrated that blended learning offers at least equivalent learning outcomes for students, and enhances flexibility, inclusivity, engagement, and motivation. However, research shows that teaching staff are generally less positive about the value of lecture capture, believing it to diminish the value of the live lecture experience, reduce learning, and encourage student absenteeism from lectures. In this study, the authors used mixed methods and repeated cross-sectional data collection to investigate the use and value of lecture recordings from the perspective of students and teaching staff in a large campus-based university, employing a blended learning approach.

Their data show that students make significant use of lecture recordings, throughout the academic session, and place great value on recordings for

notetaking, more in-depth understanding or clarification, and assessment preparation. As a result, students have high expectations about the availability and quality of recordings. Teaching staff reported a range of reservations about the value of lecture recordings, including its impact on teaching style, and strong concerns about the negative impact of lecture recordings on students learning and attendance. The study further shows that over 80% of students attended recorded lectures, but lectures that weren't recorded had significantly higher attendance.

The authors conclude by noting how their research demonstrates a contested space between staff and students in relation to the use and value of lecture recordings, a contested space that will need to be debated and resolved as universities grow their use of blended learning. This study contributes significantly to this global debate by its use of a wide range of additional data sets to delve further and provide a more nuanced view of this space.

**Mozhenko, M., Donchyk, A., Yushchenko, A., Suchkov, D. & Yelenskyi, R. (2019). Multimedia Technologies in Modern Educational Practices: Audio-visual Context, in International Journal of Computer Science and Network Security, Vol. 22, No. 3**

Mozhenko and colleagues (2019) notes that, in modern educational practices, the issue of dependence on the experience of using multimedia by students and the adoption of technologies in education, the perception of their benefits and effectiveness in blended learning is little covered. The purpose of their paper lies in assessing the audiovisual context of multimedia technologies, its acceptance by students in practice on the example of using video lectures in blended learning. The study is based on an online survey of 120 students in Ukrainian universities who have assessed the experience level in using video lectures.

The results show that the majority of students use video lectures to a certain extent in their training. It has been revealed that most students agree with the relevance of video lectures, the accuracy of lectures, the brevity of lectures, the clarity of lectures, as well as the high quality of lecture videos. The authors estimate that 42,5 % believe that lecture videos are an effective tool towards supporting students in hybrid learning. 26,7% of students consider video lectures to be appropriate technologies for online/hybrid courses. In general, 37,5% of respondents find video lectures useful; however, 35% do not agree with this statement. 83,3% of students have rated the high level of ease of access to video. In total, 95% of students find lecture videos easy to use. The authors conclude that, in general, positive attitude of students to video lectures has been revealed.



**Navio-Marco, J., Ruiz-Gomez, L.M., Arguedas-Sanz, R. & Lopez-Martin, C. (2022). The student as a prosumer of educational audio-visual resources: a higher education hybrid learning experience, in Interactive Learning Environments.**

Navio-Marco and colleagues (2022) analyses whether there are patterns of behaviour and different perceptions associated with different groups of students in their role as producers and/or users in the field of active learning in hybrid university education systems. The research was conducted with a group of engineering students at one of the largest blended universities in Europe.

The results indicate higher level of involvement in, and appreciation of, the experience in content producers compared with mere content consumers. All the characteristics of the course associated with the production of content and the recording of the video were evaluated very favourably by the students, especially their usefulness for summarizing the basic concepts and the possibility of establishing content as part of the learning process. The students also emphasized the creation of collaborative learning environments through models in which information circulates at the same level generating user networks, and that learning through video content is perceived as more effective than that based exclusively on printed materials. Moreover, the results show that the students' environment and personal attitudes (such as their availability and degree of professional dedication) in relation to this type of education, the profile of which is often quite distinct from that of traditional learning, may differentiate their interest and appreciation of these activities, which are more creative and probably more demanding.

**Nykvist, S. S., De Caro-Barek, V., Stockert, R. & Lysne, D. A. (2021). Key Factors Needed for Developing a Higher Education Cross-Campus Learning Environment in a Nordic Context, in Frontiers in Education, Vol. 6, No. 763761**

Nykvist and colleagues (2021), reports on an exploratory case study that focuses on cross campus/ university collaboration and flexible learning opportunities for students studying a master's level degree in the area of Music, Communication and Technology within a Nordic context. They investigate what factors educators in a hybrid cross-campus learning environment identify as essential for providing a supportive learning experience for students. The findings from the study identify three themes that need to be considered when attempting to design and implement high quality learning opportunities for students studying a largely synchronous hybrid music, communications, and technology program. These themes were flexibility, trust and the human element, and ownership. The findings also highlight the need for a renewed focus on pedagogical approaches that can be adapted and continually revised to meet the changing needs of students in a synchronous hybrid learning space.

**Perez-Navarro, A., Garcia, V. & Conesa, J. (2021). Students' Behavior and Perceptions Regarding Complementary Videos for Introductory Physics Courses in an Online Environment, in Applied Sciences-Basel, Vol. 11, No. 523.**

Perez-Navarro and colleagues (2021) note that digital videos have an important and increasing presence in student learning. However, creating videos is a time-consuming activity for teachers, who are usually not experts in video creation. Therefore, it is important to know which kinds of videos are perceived as more useful by students and why. In this paper the authors analysed the perceptions and attitudes that online students (N=200) have regarding videos in an online physics course, specifically, videos where the teacher's hands appeared in writing on a blackboard and videos where the hands did not appear. The authors followed a qualitative methodology from a ground theory perspective and performed semi-structured interviews.

The results show that videos are perceived as an extra resource available in physics and students use them combined with the rest of the available resources. Videos are the resource that they prefer because they facilitate and accelerate understanding of the concepts of physics and offer high interactivity. An indicator that they consider videos useful is that they watched them several times. Nevertheless, they considered that videos cannot substitute text documents. The results also show that students valued human elements and found them in videos where the hands of the professor appear. But hands in the video also play the role of being an important element to attract attention, pointing to where the students should look, for example. Finally, results show that students consumed videos according to the course schedule, visualized the whole video the first time, and consumed it later according to further deliveries and exams.

**Price, C. & Walker, M. (2021). Improving the accessibility of foundation statistics for undergraduate business and management students using a flipped classroom, in Studies in Higher Education, Vol. 46, No. 2, pp. 245-257.**

Price and Walker (2021) undertake a quantitative study to investigate the accessibility of an undergraduate foundation statistics module for business and management students over four consecutive years, before and after the adoption of a flipped classroom teaching approach for a large cohort (~500 students per year). Students' module feedback questionnaires, exam scores, basic student demographics and online engagement and attendance data were analysed.

The results show no evidence that flipped classroom leads to improved exam performance, nor that it encourages increased attendance at face-to-face sessions. That said, it did not appear to hinder performance either. However, the findings suggest that within the flipped classroom, students perceive the subject to be less

difficult and more interesting, thus making the material feel more accessible. The authors note that this, by extension, enhances the student experience which is an important aim for institutions in an age of high student fees and university rankings. They also found it encouraging to observe for such a large cohort the positive shift in perceptions towards a subject which is often a source of anxiety for students. Findings from the study also revealed that perceptions of the flipped classroom differed according to gender, nationality and reported prior maths training, but the flipped classroom appears to enhance the student experience by making a traditionally difficult subject feel more accessible.

**Singh, N. (2020), "A little flip goes a long way" – The impact of a flipped classroom design on student performance and engagement in a first-year undergraduate economics classroom, in *Education Sciences*, 10, 319.**

Singh (2020) argue that many undergraduate economics students do not engage with traditional lecturers, and thus investigates a flipped classroom design. Traditional lecturers were substituted with micro-lectures and the remaining class time was devoted to active learning pedagogies including quizzes, group work and student presentations. The full lectures were recorded (using Panopto) and put up on the e-learning site Blackboard.

Key results from Singh's analysis revealed that the various classroom activities instituted in the flipped classroom format promoted greater peer interaction and encouraged students to become active learners in this process. The online video-based lecturers offered increased flexibility and motivated students to learn independently and at their own pace. Learners could skip, fast forward, pause, rewind, and skip any part of the online lecture, which would facilitate better management of the working memory. High-achieving students could fast forward through certain parts they clearly understood, whereas struggling students could watch the lecture multiple times.

The research also demonstrated that the flipped classroom format resulted in the better scores in the final exam, as well as in the overall assessment for the module. In addition to this, the flipped classroom design benefitted academically weaker students and was associated with lower odds of students failing in the final exam, as compared to a traditional lecture-based format. The author concludes by noting that the merits of a flipped classroom approach outweigh its potential drawbacks. However, a flipped classroom design cannot be implemented effectively as a "one size fits all" in all areas of higher education. It needs to be collaborated with other blended learning pedagogies to create an enabling classroom environment.

**Smith, D.P. & Francis, N. J. (2022). Engagement with video content in the blended classroom, in *Essays in Biochemistry*, Vol. 66, pp. 5-10.**

Smith and Francis (2022) notes how blended learning is becoming the expected norm for core content delivery in many institutions. Pre-recorded videos in the form of screencasts are the primary delivery method, with students being asked to engage with the content in this medium. Usage is only likely to increase into the future as delivery moves away from traditional lectures and seminars. In this perspective, the authors look at the use of video material as a means of content delivery and how to help students engage with it. It is for instance noted that the audio in pre-recorded videos is key; the same is the video length, since duration is negatively correlated with engagement. The authors note that the optimal length is approximately 10-20 minutes for educational material. The authors also note that there is no need for a video to be highly produced and show how evidence in the literature suggest that the rougher nature of screencasts can make them feel like a one-on-one tutorial, increasing connection with the students.

The authors show how one of the most well-utilised forms of active learning is flipped learning. In this model, students are introduced to the learning material, often through video prior to a session, with face-to-face time being used to conduct problem-solving activities designed to deepen understanding through discussion and application and has been shown to increase critical thinking skills. Peer interaction and individual attention here is key; the aim of these sessions is not to repeat the learning in the videos, instead allow the knowledge to be introduced, used, or applied and to build social interactions between students. However, many students have reported that the volume of material to be watched prior to a session(s) can be overwhelming due to cognitive overloading, and care should be taken to manage this cognitive load. The authors further notes that, in the same way that recorded material can be used to prepare students for active learning, videos have been shown to be a highly effective tool to introduce students to key laboratory concepts, including health and safety and the use of equipment. These videos are often used as a means of introducing students to laboratory equipment and their practical use and are embedded into pre-sessional materials.

**Smyrnakis, E., Vlachopoulos, N., Moirasgenti, M., Pourtoulidou, D. F., Bourtzinakou, A. A., Savvidou, E., Baimaki, A., Aman, S., Kokkali, S. & Benos, A. (2021), Webinars in general practice placement for final year medical students A mixed-method analysis, in *Archives of Hellenic Medicine*, Vol. 38, No. 3, pp. 367-375.**

Smyrnakis and colleagues (2021) present the insights and opinions of medical students on the use of web-based seminars (webinars). In this study, 118 final-year Greek medical students were asked to voluntarily attend webinars on the topics of

“multimorbidity” and “motivational interviewing”. They were subsequently invited to participate in an online survey on their experience of the webinars.

Findings from the study show that the overall response to the webinars and estimation of their effectiveness were positive. Specifically, 59 % of the medical students stated that they would participate in webinars organized at least once weekly. Students also highlighted the accessibility of webinars, which helped them to keep in contact with the university environment. The major disadvantages reported were the lack of face-to-face communication, and technical issues. The authors conclude that the use of webinars is a novel teaching approach in the general practice setting. It can successfully confront the barrier of distance which derives from the need for the simultaneous teaching of medical students in scattered geographical areas. This study exhibits the positive attitude of medical students towards the use of webinars in this field, in conjunction with the traditional models of teaching.

**Sprenger, D. A. & Schwaninger, A. (2021), Technology acceptance of four digital learning technologies (classroom response system, classroom chat, e-lectures, and mobile virtual reality) after three months' usage, in International Journal of Educational Technology in Higher Education, Vol. 18, No. 8.**

Sprenger and Schwaninger (2021) notes that the most established model for measuring acceptance is the technology acceptance model, which can predict the behavioural intention to use the technology. In this study, the authors compared four digital learning technologies (e-lectures, classroom response system, classroom chat, and mobile virtual reality) in terms of their technology acceptance. The results show that the classroom response system had the highest level of acceptance. It was closely followed by e-lectures, then the classroom chat and then mobile virtual reality. The authors note that the classroom response system and e-lectures are well aligned, and students can use them to better prepare for end-of-semester exams. The popularity of both confirms previous findings (Gormley et al., 2009; Hunsu et al., 2016). Classroom chat and mobile virtual reality do not have such a clear link to the exam, which could explain the comparatively lower acceptance of them. The findings further show that the students evaluated all tools favorably before and after usage, except for mobile virtual reality, which saw a substantial drop in perceived usefulness and behavioral intention after 3 months' usage. Feedback from students indicated that the setup of the mobile VR sequences took too much time—technical issues for some few students detained the entire class—which could have negatively impacted their technology acceptance.

## **Student-activation tools (10 studies)**

**Burvill, S., Owens, S. & Organ, K. (2022). The digital explosion: It's impact on international student achievement, in *International Journal of Management Education*, 20 (2022) 100585.**

Burvill and colleagues (2020) conduct an empirical study into the use of an interactive e-book in a predominantly international MSc Business Management cohort, evaluating its impact in engagement, and academic achievement. In the study, quantitative data was obtained and analysed using t-test and correlational analysis.

The key findings from the study were that the use of interactive e-book significantly impacts students' achievement. The data concludes that those students that engaged with the e-book, and actively undertook the reading and activities, scored significantly higher coursework and examination marks than those who did not. The harder the students worked on the platform activities, the better they performed across their assessment. The results also provide important findings regarding how best to engage students with digital interactive learning. The key contribution here is, as noted by the authors, that including it as summative assessment was far more effective than when it was incorporated as formative assessment. The author also note that the study adds to the pedagogical theoretical literature through its confirmation that a combination of social constructivist and connectivism approach can be successful and is critical to student success.

**Campillo-Ferrer, J. M., Miralles-Martinez, P. & Sanchez-Ibanez, R. (2019), Gamification in Higher Education: Impact on Student Motivation and the Acquisition of Social and Civic Key Competencies, in *Sustainability*, Vol. 12, 4822.**

Campillo-Ferrer and colleagues (2019) investigates to what extent the popular online gaming platform called Kahoot can be used as a creative and effective tool to promote motivation, engagement, and meaningful learning. For this purpose, a quasi-experimental study was conducted with a sample of 101 undergraduate students of education who participated in online Kahoot quizzes by designing their own questions as part of the formative assessment. According to the results of the pre- and post-tests, the integration of this game-based student response system into the teaching process improved students' perception of certain concepts in social science teaching, increased their active participation in the lesson, and motivated them towards learning in a more interactive and stimulating environment. The authors therefore recommend taking gamification to a whole new level with attractive digital participation platforms to increase motivation and enhance students' learning experience in higher education contexts.

**Hernandez-Lara, A. B., Serradell-Lopez, E. & Fito-Bertran, A. (2019), Students' perception of the impact of competences on learning: An analysis with business simulations, in *Computers in Human Behavior*, 101 (2019) pp. 311-319.**

Hernandez-Lara and colleagues (2019) study aims to analyse the contribution of a e-learning method – namely business simulation games – to enhancing students' learning outcomes. The authors also attempt to determine which competences are perceived by students to contribute most to improving learning. The study was conducted through the use of questionnaires, which were given to 115 students who were participating in business simulation games within official management courses as part of bachelor's and master's degrees.

The findings reveal that, from the students' perspective, the most relevant competences affecting their learning outcomes were generic ones, such as information processing, decision-making, teamwork, dealing with uncertainty and reaching agreements. In the case of specific managerial competences, however, the effect was found to be insignificant. The findings also reveal better learning outcomes of younger students participating in business simulation games compared to older students. This result is in line with the findings of previous research that found a negative correlation between age and technology acceptance, with the younger generations more immersed in and better adapted to new technologies. The authors argue that the study has pedagogical implications for deciding the best way to enhance students' learning outcomes when using business simulation tools.

**Herting, D. C., Pros, R. C. & Tarrida, A. C. (2020). Patterns of PowerPoint Use in Higher Education: a Comparison between the Natural, Medical, and Social Sciences, in *Innovative higher education*, 45, pp. 65-80.**

Herting and colleagues (2020) note how PowerPoint is one of the most widely used technological tools in educational contexts, but little is known about the differences in usage patterns by faculty members from various disciplines. In this study, the authors used a survey specially designed to explore this question, and it was completed by 106 faculty members from different disciplines. The authors note that, in accordance to widely used theories regarding the use of PowerPoint, the best way to improve effectiveness of PowerPoint presentations is to use a combination of images and voice or images and texts. However, the results from the study suggest the existence of different patterns in the use of PowerPoint. There was a high predominance of visual or combined presentations in the natural and medical sciences, while the social sciences were still dominated by textual slides, which could limit their effectiveness in learning. The use of textual slides was further associated with a purpose based on rote learning. In addition, the importance of habit in its use is highlighted. Those professors who reported greater

dependence on the use of PowerPoint in the classroom, tended to use PowerPoint primarily as study material for their students. Low scores on the habit scale were related to the use of PowerPoint for critical reflection. The authors conclude by noting how this latter type of use should be a priority in all higher education institutions in order to exploit the pedagogical potential of PowerPoint.

**Hutain, J. & Michinov, N. (2021). Improving student engagement during in-person classes by using functionalities of a digital learning environment, in *Computers & Education*, 183 (2022) 104496.**

Hutain and Michinov (2021) argue that higher education teachers need to be able to optimize the use of digital learning technologies in order to improve student engagement in the learning process during in-person classes. In the following quasi-experiment (N = 303), an increasing number of functionalities of a digital learning environment was used to examine the impact on changes in cognitive, affective, and behavioural student engagement between the beginning and the end of a series of lectures. The three conditions were: i) 'low number of functionalities' in which students had only to answer quizzes during the lectures; ii) 'moderate number of functionalities' in which students additionally could ask the teacher written questions at different moments during the lectures; iii) 'high number of functionalities' where students also were able to visualize the teacher's slideshow for the course on their own device in real time during the lectures.

Results revealed that visualizing the teacher's slideshow on their own device, in addition to quizzing and questioning, increased affective engagement of students between the beginning and end of the lectures. Furthermore, when only quizzing activities were provided, a greater proportion of students engaged behaviourally to perform additional quizzes administered one week after the end of the last lecture to prepare exams. The authors also argue that, based on the findings, it is not the integration of technologies in lectures per se that improves student engagement, but rather the way teachers use them in implementing a set of functionalities which leads to students being more or less engaged in learning.

**Hyll, M., Schvarcz, R. & Manninen, K. (2021). Exploring how medical students learn with the help of a digital presentation: a qualitative study, in *BMC Medical Education*, 19:210.**

Hyll and colleagues (2021) present a study where the web-based presentation software Prezi was used to create a digital presentation in order to facilitate antibiotic knowledge in an undergraduate course on infectious diseases in the Karolinska Institutet Medical Programme. The authors used a qualitative study design for an in-depth exploration of the students' experiences of using the presentation in their studies.



Results from the study show that the students experienced that they own their learning: the presentation provided flexibility in studying and increased engagement in the learning process. Findings also indicate that the presentation was part of a superficial learning process: students saw it as a complement to other educational activities but expressed that there was an absence of pedagogical encounters which prevented the information in the presentation to be placed in a larger context. The authors conclude by noting that the Prezi presentation, when used as an e-learning tool, was a useful part of and a complement to blended learning in medical education. However, it cannot replace face-to-face learning situations, especially not when the content of the course is complex, such as in the case of antibiotics. The authors further note that learning objectives should be connected to a learning theory and made explicit for the students. Students should also receive instructions and support during the course on how to use new e-learning tools. Hyll and colleagues (2021) also note that continuous pedagogical interaction with feedback and reflection between students, teachers, and patients should be provided to enhance deep learning.

**Lohr, A., Stadler, M., Schultz-Pernice, F., Chernikova, O., Sailer, M., Fischer, F. & Sailer, M. (2021). On powerpointers, clickerers, and digital pros: Investigating the initiation of digital learning activities by teachers in higher education, in *Computers in Human Behavior*, 119 (2021) 106715.**

Lohr and colleagues (2021) investigate the initiation of digital supported learning activities and personal and institutional factors associated with them in different higher education courses. With a sample of 1625 higher education teachers, they found that higher education teachers, on average, initiated a mixture of digital learning activities rather than just one type of digital learning activity. More specifically, the findings show that higher education teachers use digital technology predominantly for passive and active digital learning activities and less often for constructive and interactive digital learning activities, in which digital technology could better fulfil the potential it has for teaching and learning.

The authors also identified three levels at which higher education teachers initiated digital learning activities: a low level (power points), a moderate level (clickers), and a high level (digital pros). The findings also support the relevance of the contextual factors for initiating a high level of digital learning activities, namely digitalization policy and commitment of university administration, institutional equipment, technical and educational support, self-assessed basic digital skills, and self-assessed technology-related teaching skills. All of these factors explain a substantial amount of variance in the level of initiated digital learning activities.

The authors conclude that a comprehensive approach using a broader scope of different digital learning activities, rather than isolated measures, might

contribute to successful teaching and learning in higher education. This might help to address a variety of learning goals and to facilitate learning activities that are theoretically associated with cognitive processes facilitating the transfer of knowledge.

**Mader, S. & Bry, F. (2019). Fun and Engagement in Lecture Halls Through Social Gamification, in International Journal of Engineering Pedagogy, Vol. 9, No. 2.**

Mader & Bry (2019) argue that traditional lecture is a teaching format which offers students few opportunities for engagement, which turn them into passive listeners of the lecturers' presentations. However, with audience response systems, such as technology-supporting classroom quizzes, breaks which reactivate the students can be introduced into the lecturers' presentations. This study thus report on an audience response system coupled with a social gamification of quizzes based on teams: Each student is assigned to a team and the students' answers to quizzes contribute to their team's success.

The results indicate that the impact of a team-based social gamification is dependent on the configuration and context of its deployment. In a small course with small teams, the team-based social gamification had a positive impact on participation in and on engagement during lectures. On the other hand, in a large class with randomly assigned large teams, the team-based social gamification failed to foster any kind of engagement. Moreover, the results show that while students in the small course perceived the gamification of quizzes as fun, students in the large course did not feel that way. A possible explanation for that is the lack of identification with one's own team as well as the distribution of team members over the whole lecture hall.

The findings further revealed that students in the small course favoured the competition introduced by teams over answering quizzes on their own and without being rewarded points. In the large course, students would have preferred to solve quizzes on their own and being rewarded points. These results suggest that students of both groups would like their lecture hall to be gamified, and that gamification injected directly in traditional lectures has the potential to make lectures more fun and more engaging for students. However, in the large course, the chosen gamification failed to do so appropriately. Furthermore, there seems to exist not one configuration or gamification fitting all contexts, and that for the team-based social gamification, the chosen team configuration seems to be the crux of the matter.

**Mio, C., Ventura-Medina, E. & Joao, E. (2019), Scenario-based eLearning to promote active learning in large cohorts: Students' perspective, in Computer Applications in Engineering Education.**

Mio and colleagues (2019) present results from an investigation on the students' perspective of the use of scenario-based (SBL) e-learning and their performance in a first-year core chemical engineering module in a Scottish university. SBL is a pedagogy that promotes active learning by bringing to the classroom practical and industrial experience. The authors argue that, when combined with online delivery, SBL can be used to increase students' engagement in large cohorts. A survey was used to capture students' insights on the activity and the use of the Scenario-Based Learning Interactive tool. These data were then analysed in combination with students' exam performance.

Findings from the study indicate that students fully engaged with this form of learning as it links module content with real industrial applications. There is, however, a significant difference between female and male students in terms of the enjoyment they derived from the computer-based activity. Male students reported a preference for the scenario over the tutorial problems in contrast with their female counterparts. There is no relationship between the perceived level of difficulty of the scenario and the exam performance in either cohort. The majority of students identified that they developed their problem-solving and analytical skills through doing the scenario activity. They were actively engaged while doing the scenario and had to use reflection, draw on previous knowledge and connect concepts in order to progress the solution of the problem presented in the scenario. In general, the students found the software difficult to use which suggests the need to explore other tools for the delivery of scenario-based activities.

**Raes, A. & Depaepe, F. (2020). A longitudinal study to understand students' acceptance of technological reform. When experiences exceed expectations, in Education and Information technologies, 25, pp. 533-552.**

Raes and Depaepe (2020) investigates technology acceptance over time of interactive quizzes and screen sharing in a university setting. Quizzes or polls were used to support interactive lectures, and screen sharing was used for collaborative learning. The authors use the Technology Acceptance Model (TAM) and investigates students' expectations towards educational technology at the start of the project and throughout the academic year. Results from the study show that students started out with a positive predisposition to the usefulness, ease of use, and behavioral intention of using educational technology in university settings. Their perceptions after experiencing the technology were significantly higher than before using the technology. This was the case for both interactive quizzes and screen sharing technology. Yet, students' expectations regarding the interactive quizzes

were significantly higher compared to the screen sharing technology. As interactive software (e.g. Socrative, Mentimeter, Kahoot) have been on the market for several years, and probably more acknowledged and experienced by students in the past, this can have created a higher technology acceptance at the start of the project regarding the use of quizzes at university level. The authors conclude by noting that, although educational reform is also related to organizational processes, students' acceptance is critical to make sure that technologies might contribute to improve learning and teaching.

### **Simulation tools (8 studies)**

**De Vires, L. E. & May, M. (2020), Virtual laboratory simulation in the education of laboratory technicians-motivation and study intensity, in *Biochemistry and Molecular Biology Education*, Vol. 47, No. 3, pp. 257-262.**

De Vires and May (2020) note how virtual laboratory simulations are used in three different ways: (i) as a replacement for firsthand exercises, (ii) in preparation for firsthand exercises, or (iii) in addition to purely theoretical courses. To investigate this further, the authors present an evaluation of virtual laboratory simulation for educational use in a chemical and biotechnical science course at University College Copenhagen in Denmark. The purpose was to assess if, and how, virtual laboratory simulation could be applied to a practically oriented education. The study investigated how specific virtual lab simulation cases stimulated motivation, study intensity, and learning among 78 laboratory technician students.

Overall, the results indicate that students were positive regarding the use of laboratory simulation as well as the specific cases assessed. The study show that virtual lab simulation seems to help the students connect theory with practice. Virtual lab simulations also help them visualize molecular processes, as well as practical laboratory procedures and instrument techniques. Besides, the evaluations showed that lab simulation can contribute to increased study activity and motivation among laboratory technician students. However, a clear link between the use of virtual exercises and student's perception of their own study intensity was not shown. Evaluation of the individual virtual simulation cases indicated that content, length, and specific practical application may have influenced the students' estimations of whether a simulation had impact on their work effort or not. The study also show that virtual laboratory simulations pose technical challenges. The overall conclusion of this study is that virtual lab simulation is an effective supplement to traditional teaching activities for the education of lab technicians.

**Gorucu-Coskuner, H., Atik, E. & Taner, T. (2019), Comparison of Live-Video and Video Demonstration Methods in Clinical Orthodontics Education, in Journal of Dental Education, January 2020.**

The aim of Gorucu-Coskuner and colleagues' study (2020) was to compare the effectiveness of live-video and video demonstration methods in training dental students in orthodontic emergency applications. Two clinical applications were demonstrated with either live-video or video demonstration. During the live-video demonstration, the lecturer gave information about the steps of the procedure while performing the clinical application on the patient using a camera attached to the loupes. The students were able to see the process on the screens. During the video demonstration, previously recorded videos of those clinical applications were shown, and information was given to students in a classroom. A total of 105 dental students in Turkey participated in the study, with pre- and post-test regarding the demonstrations.

The results showed that the mean posttest scores on the video demonstration were significantly higher than on the live-video demonstration. However, no significant difference between the demonstration methods was found regarding increase of scores from pre- to posttest. The results also show that most students preferred use of the two demonstrations together for education in the clinical orthodontics lecture. The study further found that the two demonstration methods had comparable effects on increasing students' level of knowledge. From the students' perspective, however, the two should be used together to achieve the highest effect. In this way, students can not only observe applications in detail, but also can see the clinical environment and patient-dentist relationship.

**Herodotou, C., Muirhead, D. K., Aristeidou, M., Hole, M. J., Kelley, S., Scanlon, E. & Duffy, M. (2019), Blended and online learning: a comparative study of virtual microscopy in Higher Education, in Interactive Learning Environments, 28:6, pp. 713-728.**

Herodotou and colleagues (2019) notes that the latest VLE developments is the design and use of Virtual Microscopes that allow for viewing and manipulation of online images by multiple students. Although students are found to be generally satisfied with the use of Virtual Microscopes, it is yet not known what teaching and learning conditions better support their use and lead to enhanced learning outcomes. The aim of this paper is to compare the usage patterns and perceptions of two different cohorts of undergraduate students that made use of the Virtual Microscope in blended and online only learning conditions, respectively. Data collected from a survey with 139 students and 11 semi-structured interviews revealed that blended learning better caters for students' engagement and satisfaction due to the systematic use of the Virtual Microscope in course design, its

complementary use with a physical microscope, and the ongoing provision of tutors' support and guidance. Yet, blended learning conditions did not cater for better learning outcomes as perceived by students, but equally good with online only settings. The authors also note that their findings suggest that the use of Virtual Microscope in online only conditions currently may not support student engagement and satisfaction with learning as well as it could, as it is mostly used as an add-on to current materials.

**Jacquesson, T., Simon, E., Dauleac C., Margueron, L., Robinson, P. & Mertens, P. (2020), Stereoscopic three-dimensional visualization: interest for neuroanatomy teaching in medical school, in *Surgical and Radiologic anatomy*, 42, pp. 719-727.**

Jacquesson and colleagues (2020) notes that the complex anatomy of the brain and the skull is difficult to learn and to teach, since classic schematical two dimensional drawings or photography has difficulties in providing a clear, simple, and accurate message. In this study, the authors report their experience of stereoscopic 3D lecture for neuroanatomy teaching to early medical school students. Another aim of using 3D technology was to plunge the students into the brain like surgeons, and to induce a stronger interest in anatomy. In their study, feedback from 195 students was analyzed. The results show that all the students (100 %) were satisfied with the 3D lecture, and 97,5 % reported a better knowledge transfer of brain anatomy and its 3D architecture.

The results also show that the stereoscopic 3D teaching of neuroanatomy made medical students enthusiastic involving digital technologies. It could improve their anatomical knowledge and test scores, as well as their clinical competences. The authors further argue that, depending on university means and the commitment of teachers, this new tool should be extended to other anatomical fields. However, its setting up requires resources from faculties and its impact on clinical competencies needs to be objectively assessed.

**Kazoka, D., Pilmane, M., Edelmers, E. (2020). Facilitating Student Understanding through Incorporating Digital Images and 3D-Printed Models in a Human Anatomy Course, in *Education Sciences*, Vol. 11, No. 380.**

Kazoka and colleagues (2020) note how combining classical educational methods with interactive three-dimensional (3D) visualization technology can support students in Human Anatomy courses in their study process, training, and simulation of different medical procedures. In their study, students were offered the 3D Virtual Dissection Table "Anatamage", with possibilities of virtual dissection and digital images at the Department of Morphology. The authors focused on students' interaction with digital images, 3D models, and their combinations.

Results indicate that the incorporation and use of digital technologies offered students great tools for their creativity, increased the level of knowledge and skills, and gave them a possibility to study human body structures and to develop relationships between basic and clinical studies. The transition from traditional anatomy to virtual anatomy presents certain challenges for both educators and students, and the methods of preparing and delivering the topics of lectures or practical labs change. Contents of lectures and practical labs can be prepared by educators, and students can learn all study materials at home on a personal computer. The accessibility of digital images makes it easier to present them in seminars, conferences, scientific works, and other activities, including the use of these tools in the distant education process.

The authors underline the fundamental necessity of cadaveric dissection and continuation of it for the future in combination with new and modern directions. They thus consider that students and tutors should use both traditional and progressive technological tools for anatomy education, theoretical knowledge, and practical skills.

**Mayne, R. & Green, H. (2020). Virtual reality for teaching and learning in crime scene investigation, in *Science & Justice*, 60 (2020), pp. 466-472.**

Mayne and Green (2020) argue that simulated crime scene investigation is an essential component of forensic science education. However, its implementation is costly and poses challenges to accessibility, since offering personal investigations in higher education scenarios is often impossible. Virtual reality (VR) offers prospects for teaching and learning, especially for imparting practical skills. In their study, the authors document a multidisciplinary experimental study in which a VR crime scene app was designed and implemented, after which it was assessed by both undergraduate student and staff/postgraduate student cohorts.

Results from qualitative and quantitative analyses show that VR applications support learning of practical crime scene processing skills. The authors further show how VR-based practical sessions have the potential to add value to forensic science courses, through offering cost-effective practical experience, the ability to work in isolation and in a variety of different scenarios. Both user groups reported high levels of satisfaction with using the app and reports of adverse effects (motion sickness) were minimal. With reference to user feedback, the authors proceed to evaluate the scalability and development challenges associated with large-scale implementation of VR as an adjunct to forensic science education.

**Reeves, L., Bulpitt, M., Scott, A., Bolton, E., Tomey, I., Gates, M. & Baldck, R. A. (2021), Use of augmented reality (AR) to aid bioscience education and enrich student experience, in Research in Learning Technology, Vol. 29**

Reeves and colleagues (2021) sought to integrate an augmented reality (AR) based experience into a biochemistry module in order to support the delivery of university lecturers on protein structure and function. Traditionally, this topic would comprise two-dimensional still images of complex three-dimensional (3D) structures. By combining a breadth of subject-specific and technological expertise from across the university, the authors developed an AR-enhanced learning experience. AR was used to flexibly create and introduce several 3D protein crystal structures at scale that students could dynamically explore in the classroom.

Findings from the study show how AR enabled full illustration of the complexity of these 3D structures, while promoting collaboration through a shared user experience. Assessing the impact of the AR experience via a formative test and survey, further revealed that despite only a modest increase in test performance, students overwhelmingly reported positively on the engaging nature and interactivity of AR. The authors conclude that AR has the potential to enrich bioscience education and may serve as an effective teaching aid where visualisation of 3D models is central to the learning outcomes. Expanding the repertoire of content delivery formats will support the forward-thinking blended learning environments adopted across the higher education sector.

**Schnieder, M., Williams, S. & Ghosh, S. (2021), Comparison of In-Person and Virtual Labs/Tutorials for Engineering Students Using Blended Learning Principles, in Education Sciences, Vol. 12, No. 153.**

Schnieder and colleagues (2021) compare the effectiveness of in-person and virtual engineering laboratory sessions. The in-person and virtual laboratory sessions comprised six experiments combined with short tutorials. The virtual lab combined enquiry-based learning and gamification principles. The integration of the virtual labs with in-person teaching created a blended learning environment. The effectiveness of this approach was assessed based on students' feedback, their engagement with the virtual lab, and the impact on the academic performance.

Findings from the study show that while the students rejected the suggestion to use the virtual lab as a replacement for the in-person lab, most students preferred to complete both the in-person and the virtual lab. This result is interesting given that this option apparently doubles the workload of the students. The students further reported greater confidence in the understanding of theory in the virtual lab than the in-person lab. The authors note that this is interesting, seeing that the instruction for the virtual lab and the in-person lab of one experiment is identical. The main advantages of the virtual lab mentioned by the students was



the ability to complete the virtual lab anytime, anywhere, for as long as they needed, and highlighted the benefits of the interactivity. Results further show that the median class test scores of the students who completed some or all the virtual lab experiments was higher than those who did not (83–89% vs. 67%). Overall, and based on the results, the author argue that it is best to offer both virtual and in-person learning environments to maximise student satisfaction, learning outcomes, and class test performance.

### **Learning management systems (7 studies)**

**Bond, M., Marin, V.I., Dolch, C., Bedenlier, S. & Zawacki-Richter, O. (2018). Digital transformation in German higher education: student and teacher perceptions and usage of digital media, in *International Journal of Educational Technology in Higher Education*, Vol. 15; no. 48.**

Bond and colleagues (2018) notes that different policies, initiatives, and strategies are being proposed in Germany, addressing educational technology innovations in higher education. In this study, the University of Oldenburg is presented as an example, in an endeavor to gain an understanding of what is being proposed and what is actually happening in teaching and learning in German university classrooms. In this study, two datasets are examined regarding the use and perceptions of students (n = 200) and teachers (n = 381) on the use of digital tools.

Findings reveal that both teachers and students use a limited number of digital technologies for predominantly assimilative tasks, with the Learning Management System being perceived as the most useful tool. The teacher results show that they are using the institutional platform (Stud.IP) mostly as an organisational tool for their classes, for example to check class enrolments, plan seminar topics and upload materials, and not for promoting student-centered, technology-enhanced learning within the course (in a blended or online format) or as a 'learning management system', considered more sophisticated and necessary. In terms of usefulness, students find search engines, word processing, Stud.IP and computers outside of the university 'very useful', and lecture recordings, cloud storage, forums within Stud.IP and instant messaging 'quite useful'. The results provide an initial insight into how teachers and students use digital tools for teaching and learning, which points to the need for increased teacher professional development, in order to address academic digital literacy. This study also highlighted that students have access to a range of tools and are open to using digital media for academic learning. However, this depends upon teachers implementing digital media, and the university fostering policies to this effect.

**Bralić, A. & Divjak, B. (2018). Integrating MOOCs in traditionally taught courses: achieving learning outcomes with blended learning, in *International Journal of Educational Technology in Higher Education*, 15(2).**

Bralić and Divjak (2018) note that teachers in higher education have been incorporating Massive Open Online Courses (MOOCs) with varying degree of success in traditional classroom setting. The argument for MOOC is often to support various learning preferences, introduce this new way of learning to students, and to make learning available to those who might not be able to follow traditional instructions. The aim of their study is thus to investigate a blended learning model where a MOOC has been integrated in a traditional classroom at master level of a study program at University of Zagreb. They implement a learning outcome-based approach and use a qualitative approach to analyse students' learning diaries.

Findings from their research show that MOOCs have supported the experience of students' learning in virtual environments, providing a new experience to most of the students. To them, the possibility to learn at their own pace was very important. The feedback from the students also showed that the part-time students appreciated the opportunity to manage their learning. The results further show that, in order to introduce MOOCs into a traditional classroom, fine tuning of learning outcomes, assessment methods, and students' workload is required. Language was highlighted as a barrier and a challenge for many students, seeing that the learning was in English. The authors thus argue that good command of English language can significantly contribute to easier completion of a MOOC.

The authors also asked if the use of a MOOC motivate students for deep approach to learning and further use of MOOCs. The findings indicate that students were connecting ideas and topics to prior knowledge and many thought critically about the learning material – aspects which are characteristics of a deep approach to learning. However, some students completed the MOOC without connecting anything what had been learned to prior knowledge or any known concepts. Bralić and Divjak (2018) also stress that the extrinsic motivation related to obtaining good grades in this blended learning model needs to be taken into consideration – particularly since this is a factor commonly related to the surface approach to learning. They thus suggest further analysis, in order to investigate students' motivation and approach to learning in MOOCs.

**Broos, T., Pinxten, M., Deleporte, M., Verbert, K. & De Laet, T. (2020). Learning dashboards at scale: early warning and overall first year experiences, in *Assessment & Evaluation in Higher Education*, Vol. 45, No. 6, pp. 855-874.**

Broos and colleagues (2020) note that feedback and support in the first year has a critical role in education. Learning analytics provides opportunities for a new feedback model, and student-facing dashboards have recently gained attention. To

address this, Broos and colleagues present a case study involving two self-service dashboards (the LASSI and REX dashboards) offered to first-year university students in several study programs in Belgium. The self-service dashboards provided feedback on learning and study skills, as well as on academic achievement. Data was collected by tracking students' dashboard usage in detail.

The authors found that early dashboards usage is related to academic achievement later in the academic year. On average, dashboard usage resulted in a non-negligible 6.4 percentage points increase in end scores. The study also found that students' review of the feedback received in the first year improved. Significantly improved perceptions were found for items related to information about academic achievement, study efforts and enabling social comparison. The availability of the self-service dashboards improved the satisfaction of students with the information received in the first year. However, changed beliefs of what constitutes successful study, deeper reflection or behavioural change could not be demonstrated as a result of introducing the self-service dashboards.

Although these results are modest in comparison to how high the bar is sometimes set for learning analytics applications, Broos and colleagues (2020) argue that low-cost deployments of self-service dashboards are an interesting approach to start building experience with similar tools and to start paving the way for future developments.

**Dombrowski, T., Wrobel, C., Dazert, S. & Volkenstein, S. (2021), Flipped classroom frameworks improve efficacy in undergraduate practical courses – a quasi-randomized pilot study in otorhinolaryngology, in *BMC Medical Education*, 18:294.**

Dombrowski and colleagues (2021) argue that curriculum design and specific topic selection for on-site practical courses in clinical disciplines is challenging. The authors thus demonstrate the introduction of a flipped classroom curriculum with e-learning for practical courses in Otorhinolaryngology (ORL) in real world practice to improve the on-site time management and students' experience. Core knowledge was taught preliminary based on the open-source Moodle learning platform in predominantly interactive formats. Two quasi-randomized groups were formed with 212 participants, either receiving or not receiving access to the e-learning program. The aim was to investigate if students using the flipped classroom more often felt better prepared for the practical course.

Findings from the study show that the online learning platform was highly accepted and frequently used by 66 % of the participating students in the e-learning group. Students with frequent use of the e-learning platform significantly felt better prepared for the practical course ( $p = 0.001$ ). The majority of all students supported the idea of further development of e-learning. The study also show that

handouts were the overall most important learning resource and more than 50 % of the students relied solely on them.

Drombrowski and colleagues (2021) conclude by noting that flipped classroom curricula can save time and help improving the on-site experience in practical courses, especially in smaller surgical disciplines. The acceptance of digital learning is high among the students, and most relied on handouts for learning ORL. The students also emphasized the need for guidance by the teacher through electronic learning.

**Meum, T. T. et al. (2021). Perceptions of digital technology in nursing education: A qualitative study, in Nurse Education in Practice, 54 (2021) 103136.**

Meum and colleagues (2021) note how digital platform are in widespread use in nursing education, and how rapid technological advancement provides new opportunities to support learning and teaching. As such, the authors explore how digital technologies can facilitate interactive learning in a 15-credit theory module on basic nursing at the Department of Nursing Science at a university in Norway. The study investigates the digital platform Canvas, and three focus group interviews were conducted with a total of 10 students and teachers.

The authors found three themes related to experiences with existing learning activities and general perceptions of digital technologies: i) pedagogical methodology affects learning and social fellowship, ii) need for varied, high-quality forms of learning, and iii) need for structure and predictability. The main finding is that digital technology can be integrated as a part of the study program in nursing if it is based on educational principles and structural factors.

The findings also illustrate how students and educators perceive the use of digital technologies as an integrated part of a study program in nursing education. The introduction of new technology in education not only involves technical skills in using new digital tools, but it must also be adapted to professional needs in accordance with the educational program. In particular, the authors highlight the need for a shared learning space that includes various learning resources to enable alignment between educational goals and learning activities. They further emphasise the situated nature of learning and argue that students and educators must be involved in the design process to raise awareness of learning needs, as well as to facilitate teacher–student interaction. This study has also raised awareness of the educational resources available in the digital platform that has led to expanded use of Canvas Learning Management System (LMS). First, opportunities for online group discussions have been enhanced to foster improved teacher–student interaction. In addition, new functionalities have been designed and made available on the digital platform (quizzes and audio podcasts) to provide support and coherence in the learning process. These are ongoing activities that illustrate the

iterative process of designing and implementing educational technologies. Meum and colleagues conclude by noting how their study revealed several educational needs and emphasised the importance of digital competence involving professional knowledge and skills to facilitate the educational use of digital technologies.

**Pikhart, M. & Klimova, B. (2020). eLearning 4.0 as a Sustainability Strategy for Generation Z Language Learners: Applied Linguistics of Second Language Acquisition in Younger Adults, in Societies, Vol. 10, No. 38.**

The aim of Pikhart and Klimova (2020) pilot research study is to explore the gap in second language acquisition research for technologically savvy Generation Z, whose members use modern technologies, especially mobile applications, in their learning process in a massive way. More specifically, the authors focus on students' perceptions of the use of traditional and blended learning supported by an eLearning course in order to reveal students' attitudes to and expectations from these learning modalities. Altogether, 40 university students participated in an experiment.

The findings show that the present eLearning platform is no longer an attractive option for students of Generation Z since these students want to participate in the creation of its content and collaborate and interact with each other in ways they are used to with other social media platforms such as Facebook. The implications of the research are important for educators and designers of various eLearning courses who need to take this into account. Further implications suggest a new approach to the exploitation of eLearning platform connected to Web 4.0. The basic principle of the new approach is to use these platforms and should harness all the possibilities of artificial intelligence, deep learning, machine learning, and computational linguistics. In conclusion, the study reflects the basic and pragmatic principles upon which eLearning 4.0 should be based in order to become a more efficient tool for modern education and sustainability.

**Vorbach, S., Poandl, E. M. & Korajman, I. (2019), Digital entrepreneurship education: The role of MOOCs, in International Journal of Engineering Pedagogy, Vol. 9, No. 3, 2019.**

Vorbach and colleagues (2019) note how MOOCs are one of the strongest trends and influences the content and flow of teaching and learning in higher education. The authors aim to contribute to a better understanding of the necessary skills, opportunities and risks arising from the use of MOOCs.

Based on the results from the study, the authors argue that MOOCs can be seen as an appropriate tool to teach courses on entrepreneurship as they can increase personal entrepreneurial attitudes and inclinations, improve problem solving skills and facilitate the execution of multiple tasks. With its ease of scalability,

operational flexibility and cost advantage, MOOCs can provide a large heterogeneous audience with economics and convenience in achieving education, especially entrepreneurship education.

However, results from the study also show that lack of self-discipline to complete the MOOC is mentioned as a hurdle compared to lecturers with compulsory university attendance. The results also show that lack of interaction with others are one of the main obstacles of MOOCs compared to lecturers. Taking a course only online, the students missed the chance to ask the lecturer for rephrasing, discuss the content in real time and learning in interaction with others. Challenges for lecturers were also identified, such as cost to create and develop videos, need of special equipment and infrastructure for the video recording and production, and focus on a small area of content. The authors conclude by noting that further research is required to evolve methods for improving cognitive skills, maintaining regularity, and reducing dropouts in MOOCs.

### **Collaboration tools between students (1 study)**

**Ritella, G. & Sansone, N. (2020), Transforming the space-time of learning through interactive whiteboards: the case of a knowledge creation collaborative task, in Qwerty – Open and Interdisciplinary Journal of Technology, Culture and Education, Vol. 15, No. 1**

Ritella & Sansone (2020) qualitatively explore the emergent space-time configurations of Interactive Whiteboard usage within a collaborative task in a university course. During the course, the students had an opportunity to use Interactive Whiteboard technology to support the collaborative learning process within small groups of 4-5 students.

The findings reveal that the interactive whiteboard was only partially integrated within the students' activity and most of the usage took place during the first phase of the course. The authors conclude that the usage of interactive whiteboards and the effectiveness of the emergent space-time configurations are both strictly dependent on the nature of the learning task and the pedagogical approach adopted. The interactive features of interactive whiteboard were appreciated by students but were not essential for the accomplishment of the knowledge creation task during the second and third phase of the course, when individual work was prioritized. The implication is, as noted by the authors, that instructional designers and teachers should consider the features of the chronotype of knowledge creation and design learning environments able to flexibly support the students' engagement in each phase of the accomplishment of the task.

## **Several forms of digital technology/other (19 studies)**

**Bedenlier, S., Bond, M., Buntins, K., Zawacki-Richter, O. & Kerres, M. (2020), Facilitating student engagement through educational technology in higher education: A systematic review in the field of arts and humanities, in Australian Journal of Educational Technology, Vol. 36, No. 4.**

Bedenlier and colleagues (2020) note that understanding how educational technology can enhance student engagement is becoming increasingly necessary in higher education, and particularly so in arts and humanities, given the communicative nature of courses. This narrative systematic review synthesizes 42 peer-reviewed arts and humanities articles published between 2007-2016, indexed in four international databases.

The results show that educational technology supports student engagement, with behavioral engagement by far the most prevalent dimension. Affective engagement was the lowest observed dimension, with affective disengagement the most prevalent negative dimension. Blogs, mobile learning, and assessment tools were the most effective at promoting engagement. However, caution and education in how to use technology are needed, as any use not underpinned by effective and informed pedagogy can also lead to students feeling overwhelmed and disengaging from learning. Further research is needed on online collaboration, as well as international courses that offer cross-cultural opportunities for language use, and the increased use of qualitative methods is also advised.

**Costa, C., Murphy, M., Pereira, A.L. & Taylor, Y. (2018), Higher education students' experiences of digital learning and (dis) empowerment, in Australasian Journal of Educational Technology, Vol. 34, No. 3.**

Costa and colleagues (2018) focus on learning practices in higher education in relation to a digital participatory culture. Using key principles of critical education, the research set out to explore higher education students' sense of agency online – or lack of it – as part of their formal learning practices.

The research found that although students were proficient Web users, they did not exercise their learner agency beyond what they assumed to be expected of them, thus evidencing the stability of their learning habitus in relation to the learning conventions associated with the academic field. Perhaps more surprisingly, however, is students' perception of the Web not only as a space of student participation, but also as a space of student surveillance. The authors further note that such perceptions constitute real obstacles to meaningful participation as a form learning.

**Dhillon, S. & Murray, N. (2021). An Investigation of EAP Teachers' Views and Experiences of E-Learning Technology, in Education Sciences, Vol. 11, No. 54.**

Dhillon & Murray (2021) report on a small-scale pilot study, exploring the views and experiences of EAP (English for Academic Purposes) teachers regarding their development of digital literacy skills, their application of e-learning technology in their teaching, and their perceptions of its value as a learning tool—areas on which there has been little research to date.

The findings reveal that the EAP practitioners utilised a range of online tools such as video, plagiarism software, and corpus linguistics tools. The most frequently cited benefits associated with the use of these tools concerned their ability to promote student engagement and motivation, the development of learner autonomy, and the cultural capital it represented in respect of students' future careers. The findings further indicate that of the fifteen online tools specified in the survey, only six were being used by more than 50% of the teachers surveyed, with lack of training and lack of confidence in using e-learning technology being cited as the principal reasons for a reluctance to engage with the tools available. The limitations also included a lack of time for teachers to develop digital literacy and insufficient pre- and in-service training opportunities focused on the effective use of digital technologies and managing technical issues. The authors thus conclude by noting that it is incumbent upon universities to provide teachers and students with access to and training in those technologies, just as it is incumbent on teachers to take responsibility for taking up opportunities to develop their expertise and skill in employing them for the benefit of their learners.

**Dunn, T. J. & Kennedy, M. (2022). Technology Enhanced Learning in higher education; motivations, engagement and academic achievement, in Computers & Education, Vol. 137, pp. 104-113.**

Dunn and Kennedy (2022) note that Technology Enhanced Learning (TEL) has become a common feature of Higher Education. However, research has been hindered by a lack of differentiation between usage and engagement and not recognising the heterogeneity of TEL applications. The current study aimed to assess the impact of emotional, cognitive and behavioural engagement with TEL on students' grades and to also look at how motivation levels differentially predict engagement across different types of TEL. In a sample of 524 undergraduate students, the authors measured engagement and usage of TEL, student learning motivations and self-report student grades. The results indicate that intrinsic motivations predict engagement, whilst extrinsic motivations predict usage. Importantly, engagement was predictive of grades whereas usage was not. Furthermore, when TEL was broken down by type, the use of social media groups was a significant predictor of grade, whereas reviewing lecture slides/recordings, reading



additional content and using course blogs/discussion boards were not. The authors conclude that a sole focus on usage of TEL is misleading. Implications for researchers and educators are discussed.

**Fernandez-Batanero, J.M., Roman-Gravan, P., Reyes-Rebollo, M.M. & Montenegro-Rueda, M. (2021). Impact of Educational Technology on Teacher Stress and Anxiety: A Literature Review, in International Journal of Environmental Research and Public Health, Vol. 18, 548.**

The aim of Fernandez-Batanero and colleagues (2021) review was to find out how research on teacher stress and anxiety associated with the use of educational technology was proceeding. A systematic review was conducted through the following bibliographic databases: PubMed, Web of Science, and Scopus. Sixteen articles were found from the review. The main findings show that teachers present high levels of anxiety or stress due to their use of educational technology in the classroom. During the search for studies conducted, it was observed that the problem of teacher stress and anxiety related to educational technology has grown exponentially over time. Among the conclusions, the need for research on different strategies to prevent the emergence of these anxiety and stress symptoms in teachers stands out.

**Forde, C. & OBrien, A. (2022), A Literature Review of Barriers and Opportunities Presented by Digitally Enhanced Practical Skill Teaching and Learning in Health Science Education, in Medical Education Online, Vol. 27, 2068210.**

Forde and O'Brien (2022) note that an evidence gap exists identifying the challenges and opportunities presented by digitally enhanced practical skill teaching and learning in health science education. The authors conducted a literature review to address this gap and to provide recommendations for overcoming identified challenges.

Identified potential challenges posed by technologically supported practical skill teaching were i) Inaccessibility and Inequity of Online Learning (ii) Digital illiteracy Among Staff (iii) Technological Challenges (iv) Lack of Engagement with Preparatory Material Hinders Practical Learning (v) Lack of Staff-Student Interaction (vi) Negative Attitudes Towards Online Learning and (vii) Skill Suitability. The opportunities presented by digital technologies identified were (i) Facilitates Higher Order Learning (ii) Ability to Practice in a Safe Environment (iii) Efficacious Use of Class Time (iv) Access to Education (v) Learning Brought to Life (vi) Diverse Range of Learning Materials (vii) Promotes Autonomous Learning.

The authors notes that the literature review demonstrates the acceptability and usability of digitally enhanced practical teaching in health science education among students and educators. They further conclude that potential barriers to

online delivery and student engagement must be acknowledged and addressed by relevant stakeholders.

**Lomer, S. & Palmer, E. (2021). 'I didn't know this was actually stuff that could help us, with actually learning': student perceptions of Active Blended Learning, in Teaching in Higher Education**

Lomer and Palmer (2021) analyse student perceptions of Active Blended Learning during the transition to an institutional pedagogy at the University of Northampton. In focus groups with 227 student participants across all four faculties, they explored factors mediating student engagement with Active Blended Learning. Students expressed a preference for face-to-face teaching and perceived an increase in expectations of independent learning. Students challenged the relationship between online components and assessment. Consumerist narratives were a consistent thread, with online learning perceived as offering less value for money. Although the lecturers self-reported as having fully implemented Active Blended Learning, the students' descriptions suggested that learning was not always active, with blended learning often a bolt-on to traditional classroom practice.

**Magano, J., Alves, M., Durao, R. & de Carvalho, C.V. (2020). Adoption and Use of Educational Technology Tools by Marketing Students, in Electronic Journal of E-Learning, Vol. 18, No. 4, pp. 347-356.**

Magano and colleagues (2020) note that we still do not have enough data to confirm or deny students willingness and aptitude to educational technologies, or even assess if students benefit from a technologically supported approach to learning. More studies are therefore necessary, in particular in subject areas that are not so connected to the technology, like humanities, economics, and social sciences, where students cannot be expected to be so proficient in the use of those tools and therefore their technology adoption process might be dependent of other variables. This article intends to contribute to this effort by presenting a study that uses the UTAUT model to assess which variables influence the use and adoption of educational technologies' tools by Higher Education Marketing students, using a sample of 101 students. Although the sample size was a limitation of the work, the authors note that an interesting finding was that Social Influence had a significant moderating effect on Behavioural Intention and Effort Expectancy was also a significant predictor. The model showed that, for these students, the use of technology was very much dependent on social factors and influence and effort expectancy. So, although that does not necessarily translate directly in actual use, it seems that the teacher, as a social influencer, still has a substantial role in the student's decision to use educational technologies.

**Marcelo, C. & Yot-Dominguez, C. (2019). From chalk to keyboard in higher education classrooms: changes and coherence when integrating technological knowledge into pedagogical content knowledge, in Journal of Further and Higher Education, Vol. 43, No. 7.**

The study by Marcelo and Yot-Dominguez (2019) examines to what extent university teaching has changed with the implementation of digital technologies in university classrooms. They also examine how faculty describe the integration of technological knowledge into pedagogical content knowledge when designing and developing technology-based learning activities. The authors collected data from two different samples of university teachers using semi-structured interviews.

The results from the study reveal that teachers use technologies to conduct learning activities focusing on the content and the teacher. Student-centered learning activities are only timidly being incorporated. The findings also reveal that the extent to which such activities are implemented is linked to the teachers' techno-pedagogical content knowledge. Furthermore, the factors that facilitate or inhibit teachers from using technologies in the teaching-learning process respond to intrinsic aspects, such as teachers' knowledge and beliefs, but also to extrinsic and contextual issues, such as the discipline taught or institutional policy at the university regarding the use of educational technologies.

**Mei, X.Y., Aas, E. & Medgard, M. (2019), Teachers' use of digital learning tool for teaching in higher education Exploring teaching practice and sharing culture, in Journal of Applied Research in Higher Education, Vol. 11, No. 3, pp. 522-537.**

Mei and colleagues (2019) explore teachers' use of digital tools for teaching in higher education. It also investigates how the use of digital tools affects educational practices and how teachers experience the culture of sharing among colleagues and within the organization. Semi-structured interviews were conducted with teachers at a higher education institution in Norway.

The findings show that teachers are concerned with the convergence of how technology and digital learning tools can support educational processes by engaging and involving students. The findings further indicate that they are committed to using digital tools to motivate, engage and facilitate student-based education, which in turn leads to more reflection on teachers' own teaching practices. The respondents agree that sharing is a basic prerequisite for a learning organization. They experience, however, that sharing between colleagues is easier in formal forums than at informal settings.

**Mercader, C. & Gairin, J. (2020). University teachers' perception of barriers to the use of digital technologies: the importance of the academic discipline, in *International Journal of Educational Technology in Higher Education*, Vol. 17, No. 4.**

Mercader and Gairin (2020) notes that digital technologies are currently one of the most used resources among students for developing their personalized learning environment. However, recent studies continue to demonstrate a lack of usage on the part of teaching staff for developing their teaching practices, especially at the university level. Through the identification of personal, professional, institutional, and contextual barriers, this study seeks to reveal the reasons why teachers in institutions of higher education do not use digital technologies for teaching purposes and whether the academic discipline influences this perception.

The results suggest that professional barriers are the most prevalent. The findings also suggest that teachers in the arts and humanities are, significantly, the ones who perceive the most barriers to integrating digital technologies in practically every case. The authors conclude by noting that one of the keys to breaking down existing barriers involves strengthening teachers' professional development in terms of digital competencies (time management, training, pedagogical approaches, experience and teaching approaches using digital technologies, etc.). They also note that there is a need for more institutional involvement through strategic plans.

**Nortvig, A.M., Petersen, A.K., Balle, S.H. (2019). A Literature Review of the Factors Influencing E-Learning and Blended Learning in Relation to Learning Outcome, Student Satisfaction and Engagement, in *Electronic Journal of E-Learning*, Vol. 16, No. 1, pp. 46-55.**

Nortvig and colleagues (2019) note that in higher education, e-learning is gaining increased impact, especially in the format of blended learning, and this new kind of traditional teaching and learning can be practiced in many ways. Several studies have compared face-to-face teaching to online learning and/or blended learning in order to try to define which of the formats provides, e.g., the highest learning outcome, creates the most satisfied students or has the highest rate of course completion. However, these studies often show that teaching and learning are influenced by more than teaching format alone. Many factors play significant roles, and this literature review look further into some of them. The review has a special interest in professional bachelor education and teacher training, and it focusses on factors that influence learning experiences in e-learning, online learning and blended learning.

The findings from the review show that among the many factors some seem to dominate more: educator presence in online settings, interactions between

students, teachers and content, and designed connections between online and off-line activities as well as between campus-related and practice-related activities. It is also found that e-learning/blended courses should be designed to foster coherence between online and offline activities, between campus-related and practice-related activities and between students, teachers and content. In relation to educator roles and relations, the dimensions that are reported to have significant influence on student learning in professional programs offered through blended or online formats include the educator's role in establishing strong educator presence in online settings and in building online learning communities that foster positive relations.

As for the students, findings indicate that a number of factors influence their learning experience in e-learning/blended/online courses. The factors include the presence of appropriate teaching and learning spaces online as well as off-line and the presence of engaging and meaningful learning communities that support the students' social relations. The article thus points in the direction of some significant factors, but it also discusses and questions the relevance of research focusing on comparisons between individual formats of e-learning, online learning, blended learning or "traditional" face-to-face teaching and learning. Teaching and learning are complex and are influenced by more than just the teaching format.

**Pickering, J.D. & Swinnerton, B.J. (2020). Exploring the Dimensions of Medical Student Engagement with Technology-Enhanced Learning Resources and Assessing the Impact on Assessment Outcomes, in Anatomical Sciences Education, Vol. 12, pp. 177-128.**

Pickering and Swinnerton (2020) note that the educational literature postulates that the use of technology can support students in achieving greater learning outcomes by increasing engagement. This study attempts to investigate the dimensions of student engagement with technology-enhanced learning (TEL) resources as part of a medical program's anatomy curriculum using exploratory factor analysis. A survey was administered to 192 first-year medical students, with three emergent factors discerned: satisfaction, goal setting and planning, and physical interaction. The three factors closely aligned with the existing literature and therefore additional nonparametric analysis was conducted that explored the levels of engagement across three custom-made anatomy TEL resources, including: (1) anatomy drawing screencasts; (2) an eBook; and (3) a massive open online course (MOOC).

Usage data indicated that the most popular resource to be accessed across the cohort was the anatomy drawing screencasts via YouTube, with the MOOC being used least. Moreover, some evidence suggests that those students who utilized the MOOC were more engaged. Generally, however, no correlations were observed

between the levels of engagement and TEL resource usage or assessment outcomes. The results from this study provide an insight into how students engage with TEL resources, but do not reveal any relationship between levels of engagement, usage, and assessment outcomes. Although no links between student engagement and learning outcomes were discerned, the patterns of engagement with TEL resources were determined. Although engagement with TEL resources that form part of an anatomy curriculum is an important factor in student learning, given the lack of substantial evidence to support the conflation of engagement with an enhancement of learning outcomes, the introduction of TEL resources into curricula as a proxy to support learning should be conducted with caution. Given the methodologies available to assess the efficiency and effectiveness of a TEL resource on learning gain, these metrics should perhaps be a more determining factor in introducing TEL into anatomy curricula.

**Pinto, M. & Leite, C. (2020). Digital technologies in support of students learning in Higher Education: literature review, in Digital Education Review, No. 37**

Pinto and Leite (2020) present a literature review mapping the digital technologies set for higher education students to use in formal education contexts, over the last five years between 2012 and 2017. Results show a pattern of technologies reflecting teacher's choice for methods combining face-to-face and at distance learning, frequently in relation to the adoption of flipped classroom methods. Mapping the digital technologies used by students, showed a pattern of three most used in a total of nine types identified. Institutional Learning Management Systems mainly support a wider access to information and learning materials, followed by technologies that promote publishing and sharing content related to class activities, and a broad range of technologies categorized under ICTs. The overall impact of use of technologies in students learning process and outcomes revealed to be positive, used with the intention to promote students' active engagement and participation in the learning process inside and outside the classroom walls. The data also revealed digital technologies to support more transmissive ways of teaching, facilitating students individually to Access, share and publish information, and significantly lesser used to promote collaborative and cooperative learning.

**Regmi, K. & Jones, L. (2020). A systematic review of the factors - enablers and barriers - affecting e-learning in health sciences education, in BMC Medical Education, 20:91.**

Regmi and Jones (2020) notes that, despite growing evidence claiming that e-learning is as effective as traditional means of learning, there is limited evidence available about what works, and when and how e-learning enhances teaching and

learning. This systematic review aimed to identify and synthesize the factors – enablers and barriers – affecting e-learning in health sciences education that have been reported in the medical literature. The primary evidence base comprises 24 papers, with two broad categories identified, enablers and barriers, under eight separate themes: facilitate learning; learning in practice; systematic approach to learning; integration of e-learning into curricula; poor motivation and expectation; resource-intensive; not suitable for all disciplines or contents, and lack of IT skills. This study has identified the factors which impact on e-learning: interaction and collaboration between learners and facilitators; considering learners' motivation and expectations; utilising user-friendly technology; and putting learners at the center of pedagogy. The authors conclude by noting that there is significant scope for better understanding of the issues related to enablers and facilitators associated with e-learning, and developing appropriate policies and initiatives to establish when, how and where they fit best, creating a broader framework for making e-learning effective.

**Saadeh, K., Henderson, V., Paramasivam, S.J. & Jeevaratnam, K. (2020). To what extent do preclinical veterinary students in the UK utilize online resources to study physiology, in *Advances in Physiology Education*, Vol. 45, pp. 160-171.**

Saadeh and colleagues (2020) note that online resource use by veterinary students for physiology learning remains poorly understood. Their questionnaire-based study thus aims to investigate the extent to which first- and second-year veterinary students use online resources, including online video clips and social media, in their physiology learning and if this is influenced by factors of age, gender, entry status, or year of study. 122 students across seven UK universities completed the survey.

The findings show that traditional resources (the lecturer and recommended textbooks) were the most preferred sources for physiology learning. Nonetheless, 97.5 % of students used Internet search engines to explore physiology topics. Furthermore, students' tendency to contact their instructor regarding a physiology question was low. Rather, 92.6 % said they would first search for an answer online. Particularly popular was the use of online video clips with 91.1% finding them valuable for physiology learning and 34.21% finding them more useful for understanding physiology than university taught material or lecture slides. YouTube was the most common online video clip platform used by students. Most students stated that they would enjoy interacting with course materials on an instructor-led social media page, but only 33.9 % currently use social media to discuss physiology-related issues with classmates. Additionally, most students expressed concerns regarding the reliability of online resources but attempts to fact-check these

resources were relatively low. Therefore, online resources represent an essential part of veterinary students' physiology learning and this suggests that educators can significantly improve student engagement and understanding of physiology by integrating these resources.

**Sormunen, M., Saaranen, T., Heikkilä, A., Sjögren, T., Koskinen, C., Mikkonen, K., Kaariainen, M., Koivula, M. & Salminen, L. (2020). Digital Learning Interventions in Higher Education A Scoping Review, in *Cin: Computers, Informatics, Nursing*, Vol. 38, No. 12, pp. 613-624.**

Sormunen and colleagues (2020) present a scoping review which synthesizes and describes research related to digital learning interventions in higher education, focusing on technological outcomes. Five electronic databases were searched, and 86 articles were included in the review. The data related to positive and negative technological outcomes and authors' suggestions were analyzed using inductive content analysis. For positive technological outcomes, digital formats of learning were considered effective and participatory forms of learning in a majority of the articles. The students appreciated individualized and self-paced learning, and the digital form increased their motivation to learn. Automated technical solutions that enabled learning and teaching had several advantages, and digital learning was believed to save the resources of students, teachers, and organizations. For negative technological outcomes, the technical difficulties in using the digital devices or platforms were described the most, and a need for resources was identified. Feedback from teachers was considered important from positive and negative viewpoints. Authors' suggestions for future digital teaching and learning as well as related interventions consisted of various activities, resources, environments, and methods.

**Theelen, H. & van Breukelen, D.H.J. (2022). The didactic and pedagogical design of e-learning in higher education: A systematic literature review, in *Journal of Computer Assisted Learning*, Vol. 38, pp. 1286-1307.**

Theelen and van Breukelen (2022) note that, although much has been written about e-learning, little is known about crucial didactic and pedagogical design principles for e-learning. Based on a systematic literature review on e-learning design in higher education, this review tried to fill that gap.

The results show that there were two continuums distinguished as important for e-learning: (1) the active learning continuum and (2) the authentic learning continuum. Those continuums appear to be useful to give a visual representation of included studies through an active and authentic learning continuum. This resulted in four clusters with (slightly) different properties. These properties vary from a relatively low to a high level of authenticity, and from teacher to student



centred. Analysis also revealed four crucial aspects for e-learning design: (1) content scaffolding, (2) process scaffolding, (3) peer-to-peer learning, and (4) formative strategies. In general, most of the e-learning approaches demand an educational design that facilitates authentic learning and self-regulation.

The authors conclude that, to help practitioners in realizing e-learning design, this paper provide some concrete suggestions and tips for e-learning design. Furthermore, this research shows that more well-founded research is necessary to gain more insight in didactic and pedagogical design principles for e-learning.

**Wekerle, C., Daumiller, M. & Kollar, I. (2022). Using digital technology to promote higher education learning: The importance of different learning activities and their relations to learning outcomes, in *Journal of Research on Technology in Education*, Vol. 54, No. 1, pp. 1-17.**

Wekerle and colleagues (2022) note that digital technologies can have positive effects on student learning in higher education. Based on the ICAP framework, they should be particularly effective when teachers use them to encourage student engagement in constructive and interactive as opposed to passive and active learning activities. Using a sample of 381 higher education students, the authors investigated if student engagement in these activities depends on whether technologies are implemented in class or not, and how engagement in these activities affects learning outcome.

Results indicated that when technologies were implemented in class, students felt encouraged to engage in more constructive, but also in more passive and active activities as compared to when no technologies were used. Furthermore, student engagement in active, constructive, and interactive activities was positively associated with learning outcomes. The authors conclude that, overall, the study implies that digital technology has a strong potential to support learning processes and outcomes of students in higher education. However, results indicate that this potential is only partly used in higher education courses, thus suggesting a further learner-centered development of higher education teachers' technology use in courses.

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