Ref. Ares(2023)3049320 - 02/05/2023

Electronic, didactic and innovative platform for learning based on multimedia assets

e-DIPLOMA

Funded by the European Union

D.2.2 e-learning ecosystem for practice based learning with disruptive technologies
Version No.V1.3
27.04.2023

Disclaimer:
"Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency (REA). Neither the European Union nor the European Research Executive Agency (REA)can be held responsible for them."

HISTORY OF CHANGES			
Version*	**Publication date**	**Beneficiaries**	**Changes**
V1.0	20.04.2023	TU	▪ Initial version of Deliverable Owner
V1.2	25.04.2023	UJI, TU Delft	▪ Pre-final version reviewed by Internal Reviewers
V1.3	27.04.2023	TU	▪ Final version sent to the Project Coordinator

(*) According to the section "Review and Submission of Deliverables" of the Project Handbook

1. Technical References

Project Number	101061424
Project Acronym	e-DIPLOMA
Project Title	Electronic, Didactic and Innovative Platform for Learning based On Multimedia Assets
Granting Authority	European Research Executive Agency (REA)
Call	HORIZON-CL2-2021-TRANSFORMATIONS-01
Topic	HORIZON-CL2-2021-TRANSFORMATIONS-01-05
Type of the Action	HORIZON Research and Innovation Actions
Duration	1 September 2022 – 31 August 2025 (36 months)
Entry into force of the Grant	1 September 2022
Project Coordinator	Inmaculada Remolar Quintana

Deliverable No.	D2.2: Review of e-learning ecosystems
Work Package	WP2: Focused view on European current situation of e-learning and co-creation of educational practices with emerging technologies
Task	T2.2: Analysis of remote e-learning in teacher training.
Dissemination level*	PU- Public
Type of license:	CC-BY
Lead beneficiary	Tallinn University (TU)

PIC of the Lead beneficiary	▪ 999421653
Contributing beneficiary/ies	▪ Universitat Jaume I (UJI) ▪ Technische Universiteit Delft (TU Delft) ▪ Budapesti Muszaki es Gazdasagtudomanyi Egyetem (BME) ▪ Universitat Politécnica de Valencia (UPV) ▪ Innogrowth European Association for Innovation and Growth (INN) ▪ Center for Social Innovation LTD (CSI) ▪ Aris Formazione e Ricerca Societa Cooperativa (ARIS FR) ▪ Brainstorm Multimedia SL (BRAINSTORM)
PIC of the Contributing beneficiary/ies	▪ UJI: 999882985 ▪ TU Delft: 999977366 ▪ BME: 999904228 ▪ UPV: 999864846 ▪ INN: 900529668 ▪ CSI: 913552403 ▪ ARIS FR: 911643734 ▪ BRAINSTORM: 999441732
Due date of deliverable	30. 04. 2023
Actual submission date	28. 04. 2023

2. Table of Contents

3. Introduction

3.1. Executive Summary

This report D.2.2 of e-DIPLOMA project explores the remote e-learning practices with disruptive technologies on experiential and practical topics aiming to discover existing opportunities, barriers and risks. The goal of the current review is to amplify the current knowledge at European level about the suitability of institutional capacities for using disruptive technologies for experiential practice based education. The main research question of this report is:

What are potential, opportunities, barriers, accessibility issues and sustainability and ethical risks of using emerging technologies for teaching and learning?

The report is based on

- the empirical desktop analysis of recent research papers about using disruptive technologies for practice based learning;
- the values' workshops to elicit the values related to potential learning scenarios with disruptive technologies;
- the survey analysis of the current situation of distance learning in higher and vocational education institutions in participant countries that take part in this project paying special attention to experiential teaching.

The deliverable is aimed to empower the next phases of the e-DIPLOMA project codesign of e-learning modules with disruptive technologies. Thus we also attempt to highlight the critical instructional design criteria that should be considered when setting different learning goals with disruptive technologies.

The Covid pandemic time outburst of e-learning in European universities raised the e-learning practices. In Chapter 4.1. “State of Art of Practice Based Learning: Brief overview of the learning gap for practice based e-learning” we investigated what way the practice based e-learning was conducted at the pandemic time and which gaps there were for conducting hands-on learning in e-learning mode. The literature analysis (between 2020-2022) revealed that the main issues of e-learning are creating social, emotional, and cognitive engagement, catering to diverse student needs and providing holistic learning experiences in e-learning. Challenges in practice based e-learning were delivering the situated practice and problem-solving. e-learning was found to limit bodily practices, abstract thinking, decrease the intensity of the experience, and slow down the pace of learning. There was a preference for synchronous delivery of practice based class sessions as well as video demonstrations that keep the learners more passive viewers. These findings show that there is the need for developing different approaches to how practice based learning may be mediated in distant learning format in case of emergency situations, but also as an opportunity for the universities to move towards course delivery in an e-learning mode.

e-DIPLOMA project aims testing out disruptive technologies in experiential learning scenarios as an opportunity to find best solutions for practice based distance learning. In this report for Chapter 4.2. “Overview of the literature about disruptive technologies for e-learning” we collected a sample of recent (from the period of 2019-2022) studies of disruptive technologies - virtual learning environments, extended and augmented reality, artificial intelligence and chatbots in learning, gamified virtual learning environments. We explored these empirical and meta-studies regarding what types of learning practices, and scaffolding practices, and interaction types were used with disruptive technologies. Secondly we viewed which learning outcomes were measured and documented in these studies, to discover the opportunities and gaps in cognitive, metacognitive, affective and psychomotor and embodied learning domains. We also reviewed the main theoretical constructs that guide learning designs with disruptive technologies. We found that although there are plenty of experiments with disruptive technologies, there is not sufficient clarity on what way the technologies provide useful changes to practise based digitised learning. The learning experiments with disruptive technologies lack the collaborative coworking dimensions, the interactivity in activities involving learning artefacts falls short of reaching adequate levels, and the learning process results are conceptualised at individual learner level. Research in empirical studies is focusing only on limited types of learning outcomes. Few studies relate psychomotor and embodied learning effects with cognitive, metacognitive and affective effects. The lack of this knowledge constrains the learning designers to understand how the new type of immersive, gamified and with personalised adaptive feedback loops learning medium may impact on learning, and which premises the disruptive environments offer to practise based technology mediated activities.

In Chapter 4.3 “The values and sustainability issues of using disruptive technologies” we provide empirical data of how the practice based example learning scenarios with disruptive technologies are perceived. The data were collected in partner countries from workshops where the users could only read about the scenarios and discuss the values they perceived regarding these. The value space around the practice based learning scenarios was described associating the perceived values and concerns with the learning scenarios, with learners, with the technologies and with the learning effects. This approach demonstrated that understandings of the learning potentials of the disruptive technologies are not clear. The needs coming from future workplaces to use disruptive technologies, and the opportunities to keep learners more engaged and motivated were seen as drivers of designing new practices in education. The designing complexity, the skill-demanding nature and the costs were perceived as threats of disruptive technologies accompanied with the belief that the built environments may be rigid as learning places and may decrease the teachers’ and students' flexibility in planning the learning. Both the literature report and the values workshop revealed a number of physical and societal concerns that using disruptive learning environments creates.

The report is also investigating the capacities for using disruptive technologies in partner countries' higher educational and vocational institutions. Chapter 4.4. “The training ecosystem capacity for using disruptive technologies in e-learning” provides results of the quantitative survey that we conducted in partner countries. The survey viewed the capacity for practice based e-learning from the perspectives of technology specialists that provide support at institutions, lectures who conduct practice based lessons, and students who participate at practice based lessons. The survey was composed of four blocks of capacity elements: infrastructural capacities, normative and regulatory capacities (institutional level), teaching cultures (community level), and competences, attitudes and values (personal level). The analysis revealed specific gaps in the capacity. We found differences in how the specialists, lecturers and students perceived the capacity elements. Also there were some differences between the countries. The specific findings are also provided in tables of Annex 4. The main message is that there are not yet sufficient infrastructures and tools and competencies for using disruptive technologies in higher and vocational education. The potential is highest in Spain, as other partner countries have significant gaps that hinder the usage of VR, AR, AI in courses.

Chapter 5. “Learning design recommendations for practice based e-learning with disruptive technology support” provides an overview of the general suggestions that e-DIPLOMA project could follow when designing learning modules with disruptive technologies for experiential practice based e-learning.

3.2. Relation to Other Project Documents

This document is related to the Deliverable 2.1: Best practices report.

3.3. Abbreviation List

Among the acronyms more used in the present document are the following:

VR: Virtual Reality

AR: Augmented Reality

AI: Artificial Inteligence

NLP: Natural Language Processing

3.4. Reference Documents

See References Section included in this document (page 70).

4. e-learning ecosystem for practice based learning with disruptive technologies

This report explores the remote e-learning practices with disruptive technologies on experiential and practical topics aiming to discover existing opportunities, barriers and risks. The report is based on the empirical desktop analysis of recent research papers about using disruptive technologies for practice based learning, the survey analysis of the current situation of distance learning in higher and vocational education institutions in participant countries that take part in this project paying special attention to experiential teaching, and the values' workshops we have conducted to elicit the values related to potential learning scenarios with disruptive technologies.

The goal of the current review is to amplify the current knowledge at European level about the suitability of institutional capacities for using disruptive technologies for experiential practice based education. The report set the goals to understand the barriers that exist, such as social, cultural, technological, and pedagogical in using disruptive technologies for practice based learning. It also aims to discover the currently known potentials of disruptive technologies for learning. The specific focus is set on discovering the sustainability issues and the negative unforeseen consequences.

The main research question of this report is:

RQ. What are potential, opportunities, barriers, accessibility issues and sustainability and ethical risks of using emerging technologies for teaching and learning?

The particular sub-questions were formulated for the i) literature review analysis, for the ii) values workshop and for the iii) survey analysis.

Literature review:

RQ 1: What was the state of art of practice based e-learning at pandemic time?

RQ 2: What does research already know about using e-learning and disruptive technologies for achieving specific learning goals in practice based learning?

RQ 3: Which obstacles do e-learning modes, multimedia learning and using disruptive technologies create for practice?

Values workshop:

RQ 4: What ethical and sustainability dimensions do people associate with the learning scenarios with disruptive technologies?

The survey

RQ 5: What is the capacity of educational institutions in countries to perform practice based e-learning with disruptive technologies?

RQ 6: What are the main gaps in the capacity to perform practice based e-learning with disruptive technologies?

The deliverable is aimed to empower the next phases of the e-DIPLOMA project codesign of e-learning modules with disruptive technologies. Thus, we also attempt to highlight the critical instructional design criteria that should be considered when setting different learning goals with disruptive technologies.

4.1. State of Art of Practice Based Learning: Brief overview of the learning gap for practice based e-learning

e-DIPLOMA project aims to enhance the gap in practice based e-learning. To discover the state of art of practice based e-learning at pandemic time we formulated the research question:

RQ 1: What was the state of art of practice based e-learning at pandemic time (2020-2022)?

We have analysed the period 2020-2022 in Scopus database regarding the keyword practice-based e-learning. From 106 papers, only about 10 papers actually investigated how the pandemic period rapid transition to e-learning affected conducting practical learning activities. None of the studies that explored particularly this aspect were found. We identified that the gap in doing online practical e-learning was particularly perceived in the medical domain (Pierce, 2020; Müller et al., 2020; Wolf et al. 2022), engineering and mathematics domain (Lopez et al, 2021; Calder et al. 2021), STEM-learning (Selco & Habak, 2021) and physical education (Infantes et al. 2022; McNamara et al. 2022). The main issues in practice-based e-learning were: performing algebraic thinking, collaborative problem solving, meeting difficulties in communicating when making sense of problems and then mediating their thinking while problem-solving through the contestation and clarification of ideas (Calder et al. 2021), replicating clinical environments (Müller et al., 2020), patient case studies, mentoring (Pierce 2020), practical-surgical contents and skills couldn't be adequately represented by purely online offers (Wolf et al. 2022); little hands-on work in the virtual classes/labs limited the students to better understand the content (Selco & Habak, 2021). So the main issues in practice based e-learning were with situated practice and problem-solving, but also with abstract thinking. Some examples of hands-on work STEM in e-learning included performing experiments with household items, creating mathematical models on computers, building circuits with purchased equipment, examining rock samples from loaned kits, creating instruments to collect data, designing experiments, testing physics theories with common objects, dissecting plants and nuts, and creating compost (Selco & Habak, 2021). e-learning in physical education was found to limit bodily practices, decrease the intensity of the experience, and slow down the pace of learning (Infantes et al., 2022). Concerted efforts are needed to investigate trends in these settings to determine best practices and how students with disabilities experience body related e-learning adapted physical education within an online setting (McNamara et al. 2022). For example, Alawayee (2021) points to the difficulties of students using sign language in e-learning environments. In the case of virtual laboratory STEM courses, there was a slight preference for synchronous delivery of practice based class sessions as well as video demonstrations (Selco & Habak, 2021). Similar preference that practical tutorials should be performed synchronously with active participation of the students facilitated via web meeting, in order to better assess the student's progress and difficulties was reported by Dubois et al. (2022). Generalising the challenges Müller et al. (2020) highlighted the main issues of creating social, emotional, and cognitive engagement, catering to diverse student needs and providing holistic learning experiences in e-learning.

Only few studies reported of specific e-learning fitted tools for doing practical e-learning such as cyber security laboratories added to Moodle (Fabini et al., 2021). The development of hybrid practice-oriented teaching concepts is necessary in domains such as medicine (Wolf et al., 2022). Some authors did not recommend fully and abruptly replacing face-to-face teaching in engineering subjects with other methodologies in an off-campus nature (Lopez et al, 2021).

4.2. Overview of the literature about disruptive technologies for e-learning

To discover what opportunities there are to complement practice based e-learning the literature analysis was conducted. We explored the SCOPUS research database regarding empirical and meta-analyses papers about using disruptive technologies for practice based learning using the keywords of VR, AR, XR, MR, AI educational Chatbots and gamified learning from the period of 2020-2022.

The data analysis focused on the following research questions:

- RQ 2: What does research already know about using e-learning and disruptive technologies for achieving specific learning goals in practice based learning?
- RQ 3: Which obstacles do e-learning modes, multimedia learning and using disruptive technologies create for practice?

We viewed three types of disruptive technologies:

- Interactive media technologies: the virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR)
- Adaptive support technologies: Learning AI and chatbots
- Motivation management technologies: virtual gamification

Virtual reality (VR) is the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a headset with a screen inside or gloves fitted with sensors. VR creates a completely synthetic virtual world which can be used through devices like a headset. VR may be presented within different devices as a smartphone, computer, web based platform, or with headset in the physical spaces.. Virtual reality (VR) is conceptually a technological system that can precisely substitute a person's sensory input and transform the meaning of their motor outputs with reference to an exactly knowable alternate reality ("knowable" to distinguish from dreams or hallucinogenic experiences). In this view motor actions and sensory input are not separable. VR produces an illusion of reality and profits from exploitation of the brain to produce illusions of perception and action (Slater, 2014).

Augmented reality (AR) is the real-time use of information in the form of text, graphics, audio and other virtual enhancements integrated with real-world objects. It is this "real world" element that differentiates AR from virtual reality. AR allows its users to supply digital overlays of data, creative content, or holographic images, animations, text, and documents. Augmented reality can be viewed through AR goggles that combine a view of the immediate surroundings with computer graphics, or on a smartphone display that does the same thing using the phone's camera to see and manipulate the world in front of the viewer.

Mixed Reality (MR) lies somewhere at the intersection of VR and AR. This technology blends real and virtual worlds to create complex environments where physical and digital elements interact in real time.

Extended reality or cross reality (XR) is a cover concept that summarises a group of technologies (VR, AR) or Mixed Reality (MR) environments in a way that lets you interact with different technologies simultaneously to create an entirely virtual experience for users. All XR tech takes the human-to-PC screen interface and modifies it, either by 1) immersing you in the virtual environment (VR), 2) adds to, or augments, the user's surroundings (AR), or 3) both of those (MR). XR may be multisensory integrating the five traditional senses, including sight, hearing, smell, taste and touch or even more senses.

Conversational AI bots are artificial intelligence based conversational robots that are able to process Natural Language Processing (NLP) and provide answers to user questions. The traditional Rule-based models answer questions based on rules used in the training stage. These bots are created through a rule-based approach. The Retrieval-based models use predefined question/answer pairs. Then, they match user's queries against the predefined questions through simple algorithms like keyword matching or using more complex processing like information retrieval models. Next, they return the most suitable answers to the matched question as a response to the user's query. Since these models use a predefined pair of question/answer, they return responses with no grammatical errors. However, they have some shortcomings in that bot's responses are limited to the predefined set and are not sensitive to changes of queries. Generative models use Natural Language Processing (NLP) techniques and Deep learning techniques to model and train the Chatbot system. Most of these proposed models use the sequence-to-sequence approach that emerged in the Machine Translation, Speech Recognition, and Text Summarisation fields (Cheddak et al., 2021). Conversational chatbots mimic humans, and may assist in university processes, such as application forms, enrollment, tuition costs, deadlines, and more, help students to be self-regulated, provide one-to-one tutoring, prompt them with bite-sized lessons, help to do queries in inquiry providing data insights or support information search processes.

Gamified digital learning refers to environments, in which the integration of gamification provides a way for students to encounter new experiences, approach learning activities in a playful manner, and interact with other students in unconventional or distinctive ways (Bourke, 2020). Gamified digital learning consists of two components: game-based learning and virtual platform (Chan et al., 2020), i.e. gamified platforms with technological design such as virtual reality (VR) and augmented reality (AR). Game platforms can replicate real-life scenarios and facilitate in-class teaching and learning processes, which are often restricted by factors such as geographical, temporal, and resource limitations that hinder field studies (Davis & Singh, 2015).

4.2.1. Practice based learning models' applicability in e-learning

4.2.1.1. Practice-based learning models

Disruptive technologies have the potential to interrupt traditional learning and teaching practices.

There are several types of practice-based learning models such as inquiry learning, action learning, experiential learning, simulations, gamified learning etc., which can be supported by disruptive technologies. In this report we understand practice-based learning as an umbrella term for teaching strategies, which invites learners to be active participants in the learning process. Practice-based education involves learning from experience in the real world (Willems, 2018) and the goal of instruction with different content forms (multimedia) supplied by disruptive technologies is to provide practice in exercising skills and receive feedback (Mayer, 2021). Thus, according to Kolb (1984) learning is seen as "the process whereby knowledge is created through the transformation of experience".

The list of potential practice-based learning approaches is as follows:

- Inquiry-based learning refers to an instruction in which learners, rather than having a procedure demonstrated, are required to discover it themselves by following certain inquiry steps (Mayer, 2001). Inquiry paradigm relates to different reasoning approaches. Most common is the deductive inquiry that starts from a hypothesis and its testing with different methodologies. Critical thinking and data-evidence based deductive reasoning processes are practised to find the solutions. Second approach is inductive inquiry in which hypothetico-predictive reasoning (Lavoie, 1999) processes and observations would lead to formulating an empirical based hypothesis. Third type of abductive inquiry associates with abductive reasoning processes (Thagard & Shelley, 2005) that are very common in model-based learning. The abductive reasoning process uses models as metaphors in making inferences about the phenomena. In e-learning the computer-supported collaborative learning model has also described a collaborative progressive inquiry approach (Hakkarainen, 2003) in the community of practice where that emphasises that every theory can be debated and should be collectively constructed and validated.
- Experiential learning refers to an engaged learning process whereby students "learn by doing" i.e. "the process whereby people make sense of their experiences, especially those experiences in which they actively engage in making things and exploring the world" (Kolb, 1984). In a way this

type of learning is present in all educational stages and enables a more responsive approach to tackle future challenges.

- Action learning can be seen as an approach to problem solving immersing students in real life, where one solves problems that involve taking action and reflecting upon the results (Reynolds, 2011; Revans, 1998). The purpose of action learning is to help learners to think more deeply, explore new options and perspectives and reflect in order to make better choices and decisions.
- Simulations are virtual worlds that let students engage with representations of real-world events and phenomena (Plass, Homer, & Hayward, 2009) providing opportunities for active learning (Mayer, Mautone, & Prothero, 2002) and affording exploration (Rieber, 2005). The user can alter several parameters inside a specific simulation, and an underlying computer model reacts by presenting the outcomes of the user's input (Plass & Schwartz, 2014).
- Gamified learning intends to provide playful learning experiences (Buijs-Spanjers, 2020), turning something into a game that was not originally conceived as a game. Gamified learning provides students with an opportunity to encounter new experiences, tackle educational activities through playful methods, and interact with their peers in distinctive and innovative ways (Bourke, 2020).

According to the literature analysis on various disruptive technologies and practice-based e-learning, it is not very apparent which practice-based learning model has been used.

Virtual games and VR have been mainly used to provide simulations as a learning context. In fact, one of the most beneficial aspects of using these technologies for educational purposes is to turn real-life situations and phenomena into a tangible practice based learning, which otherwise would not be possible to experience. Simulations with VR are rather common in the field of healthcare and medicine. For instance, VR simulations have been used to provide health workers with a realistic environment for exercising and performing Covid-19 infection prevention and control within a safe environment (Barrett et al., 2021) or to educate nursing staff about the self-protection procedures for chemotherapy drug leakage accidents (Chang & Hwang, 2021). VR simulations have been also implemented in training pre-service teachers to exercise managing challenging behaviour of students in the classroom, such as sleeping, disturbing others and using mobile phones (Chen, 2021) or to simulate disruptive behaviours of 1st and 6th graders in a classroom (Delamarre et al., 2021). Furthermore, simulations have been also used for experiencing safety scenarios, work at heights, etc. (Ummihusna & Zairul, 2021). Virtual games together with simulated situations have been also implemented in healthcare settings, such as providing a narrative about four working days of a healthcare professional to provide care for an older patient who has undergone a hip surgery (Buijs-Spanjers et al., 2020). All actions the players take will manipulate the narrative and after each play day of the game, players receive tailored feedback on how their care can be improved (Buijs-Spanjers et al., 2020). Scenario-based simulation has been added to enhance the teaching-learning process in urban tourist virtual games (Chan et al., 2020). The use of scenario-based approach, game-based learning, and e-Learning platform together is anticipated to bring forth their individual advantages and enhance the teaching and learning experience. This is particularly beneficial in institutions with limited resources and in subjects like tourism training, where real-world examples are crucial (Benckendorff et al., 2015).

4.2.1.2. Student interactivity with disruptive technologies

It has become the norm that constantly developing disruptive technologies allow us variable modes of interaction with content and technology. We can all instantly access, analyze and process informational artifacts, change them into different representational states, or produce brand-new ones. We have the ability to continuously and interactively disconnect from and recouple with a variety of external resources and artifacts (Sutton, 2008). In principle this development has the potential for shifting patterns of power, roles, and responsibilities in educational settings. For understanding students' interaction with disruptive technologies and content, the following category was taken as a basis (Väljataga et al., 2015):

- Consume - The simplest and most static method to engage with the technology and content. This relates to watching a video, listening to a podcast, or just reading a text. The content item will remain untouched by its users, no changes will be done with the actual content of that artefact.
- Annotate - Content can be annotated with several forms of information, including highlights, likes, ratings, tags, and comments. As the user interacts with the content, mostly at the metadata level, annotation gives it significance and a personal touch. In online communities, some annotations (such as tags and bookmarks) can be shared.
- Manipulate – Students are engaged in interacting with some components of the content by, for instance, clicking on hot spots, dragging and dropping some elements to correct location, or filling in some fields in a digital form. The content itself can't be modified or new content added. The technology might give immediate personal feedback to student's interactions with content. The student's interaction level remains restricted and temporary, as digital content is not changed permanently.
- Submit – On this level, the students are prompted to solve some problems, manipulate interactive content or enter responses to questions. In contrast to the previous level, the outcomes of such interaction will be presented to the teacher or other students for evaluation and feedback. The input requested from students and the feedback given by the teacher will not be included in the content itself.
- Expand - Students can edit or complement an artefact, add some micro content to the original artefact, however, the core content of that artefact remains mainly intact. For instance, merging together some video clips, filling in blanks in a self-test, adding a story to a photo etc. With this level the original content itself will be complemented with some additions, however, the core parts of the content are still visible and recognisable.
- Remix - Students can alter the original state of the content by adding, removing, and/or changing pieces of the item. It is difficult to extract its initial version and parts. The main characteristic of remixing is that it appropriates and changes other materials to create something new. The original meaning of the content and the intention of the author might change entirely and the student makes the material her own.
- Create - Students can create a totally new artefact from scratch. In this case the students don't make use of any other content, but develop their own.

Although interaction has been promoted as the key added value of digitalisation (Väljataga et al., 2015) and disruptive technologies inherently refer to an innovation that can challenge established models and processes of education and educational content production, its organisation, and provision, our literature analysis of various cases shows rather modest modes of interaction with the content (see Figure 1). Pedagogical design with disruptive technologies very often follows knowledge transmission or information acquisition view (Mayer, 2021) and treats students as passive consumers of ready-made content. Thus, from the pedagogical perspective, disruptive technologies like AI, AR, VR, chatbots, and virtual games do not yet appear to have the capacity to change how education is currently conducted, in particular, to support more advanced forms of interaction. Prevalent interactivity types in learning scenarios with disruptive technologies are the lowest (consume, annotate, manipulate), meaning, students can simply consume static content without an option to modify it or add new content. The technology may provide the student with instant, personalised feedback on their interactions with content; but, the teacher or other students are unable to observe, hear, or analyse the learner's responses. A rather typical interaction mode with disruptive technologies is also submit, i.e. the results of such interaction or problem-solving will be submitted for review and feedback to the teacher or other participants in the process of learning. Only in a few cases, learning scenarios with VR have been designed in a way that students were actively engaged in interaction with the content in the role of a creator.

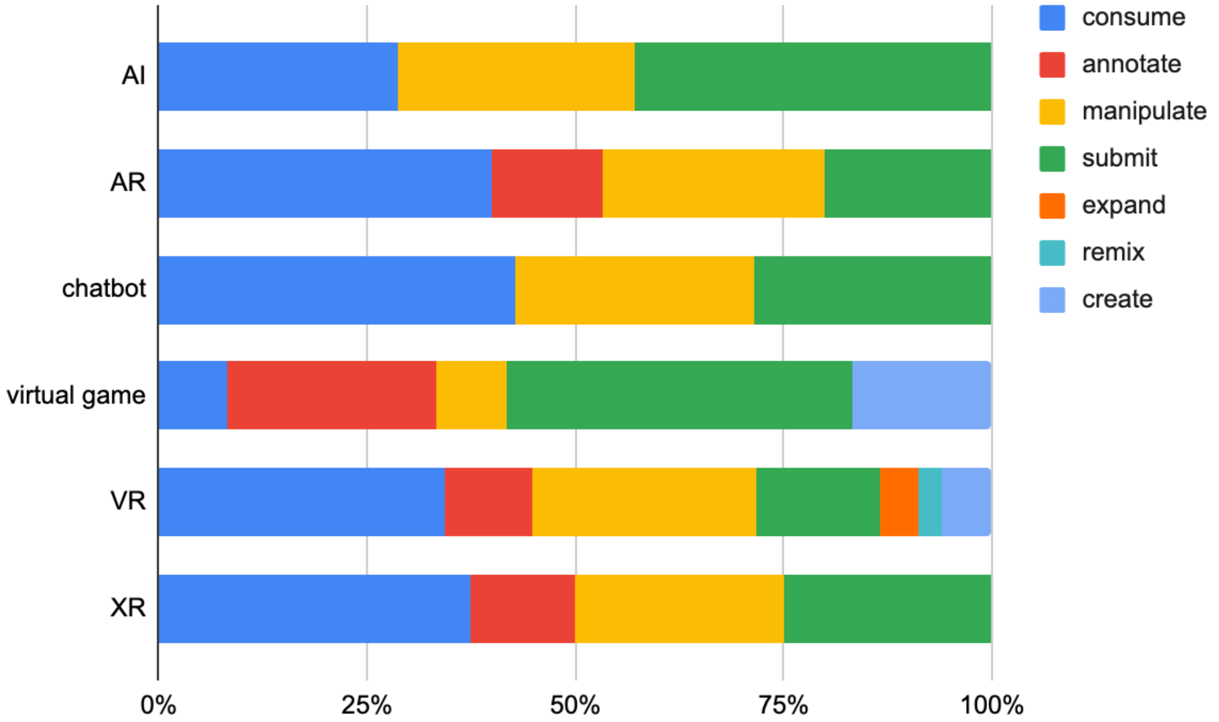


Figure 1. Students interactivity in learning scenarios with disruptive technologies based on our empirical literature review.

However, many modern pedagogical approaches emphasise learner-centred education and knowledge creation or construction metaphor (for instance Paavola, Engeström, Hakkarainen (2012) trialogical learning), in which the focus of instruction is shifted from the teacher to the student. In this view learning is a sense-making activity and it is essential that students collaboratively create and develop shared, novel (digital) artefacts with the support of technologies of various kinds. This view is also somewhat aligned with Kolb's experiential learning (Kolb, 1984), i.e. learning occurs through discovery and active participation, thus, experience is critical in the development of knowledge construction. While the concept of students as creators and producers is certainly not an entirely new one, in theory, digitisation and disruptive technology has a power to transform existing practices and stimulate the emergence of various forms of interaction. It is quite obvious that there is a need to support more advanced forms of interaction, in which teachers and students are becoming (co-)authors of digital content (Väljataga et al., 2015), especially in the context of practice based learning (Figure 2).

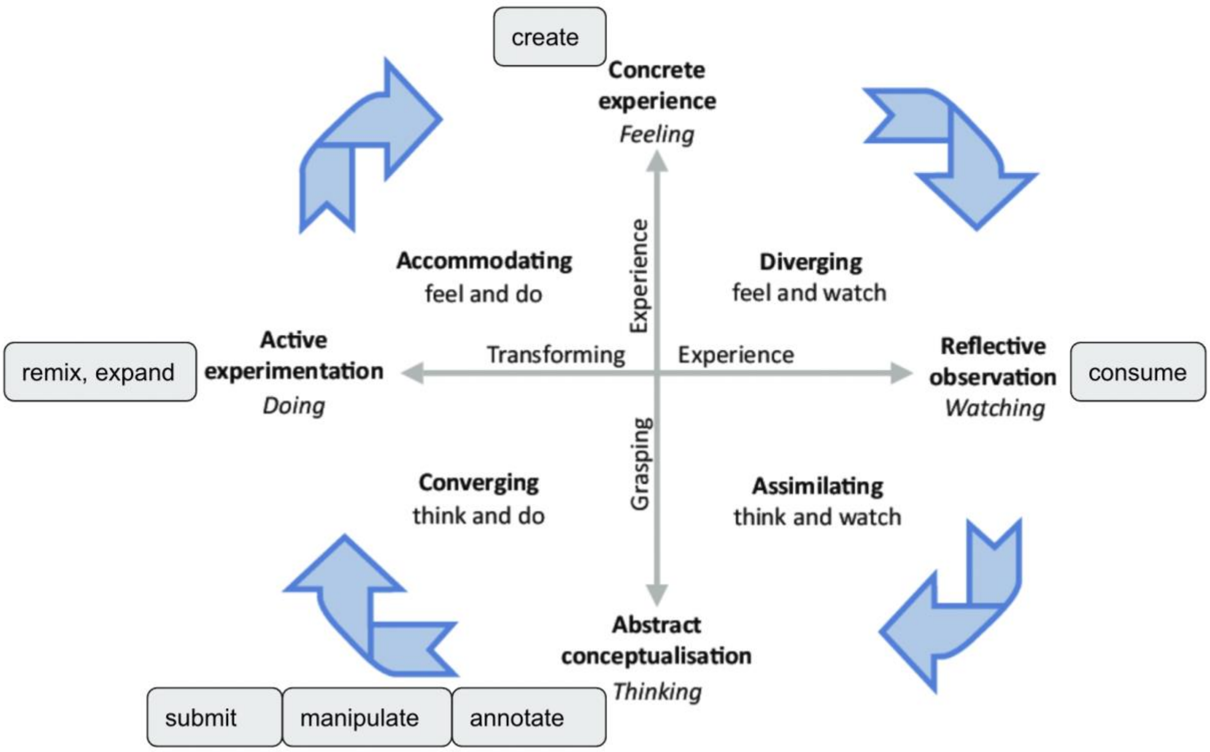


Figure 2. Experiential learning in relation to student interaction levels with the content and disruptive technologies.

4.2.1.3. Disruptive technology and practice based learning support

The technique of scaffolding, which has its roots in Vygotsky's "zone of proximal development" (Vygotsky, 1978) refers to a set of practices that enable a student to accomplish tasks that would otherwise be beyond their individual abilities. Scaffolding as an instructional method by providing students with guidance, feedback, and support, can be provided by means of appropriately designed technologies.

Four scaffolding types have been determined by Hill and Hannafin (2001):

- Conceptual scaffolding - the student receives guidance on what aspects to take into account, how to establish connections between concepts, and how these connections shape a framework that provides support (Hannafin et al., 1999). Conceptual scaffolding "helps students reason through complex problems as well as concepts where misconceptions are prevalent' (1999, p. 17). Conceptual scaffolding can be accomplished by several mechanisms: providing a hint to help students to reach a solution; coaching comments; providing feedback and advice on performance; provoking reflection or providing a model for design (Cagiltay, 2006).
- Metacognitive scaffolding - supports underlying learning management processes and thinking about a task (Hannafin et al., 1999). In the case of metacognitive scaffolding students are encouraged to engage in introspection by being asked questions and having their weaknesses highlighted. Students may be also prompted to recall a familiar experience or concept from their own lives (Hannafin et al., 1999).
- Procedural scaffolding - emphasises various ways to utilise the available resources and tools within a given environment (Hannafin et al., 1999). In this form of scaffolding, teachers can provide continuous assistance and guidance on the functions and capabilities of the system, as well as how to utilise them (Cagiltay, 2006).
- Strategic scaffolding - guides students in examining and tackling learning tasks or problems, while emphasising the usefulness of alternative methods (Hannafin et al., 1999). Strategic scaffolding entails informing the student about tools and resources that are accessible and could be beneficial in certain situations, while also offering instruction on how to utilise them (Hannafin et al., 1999).

In addition, affective scaffolding plays an important role in supporting students and keeping their motivation.

- Affective scaffolding - refers to how emotions and motivation are scaffolded (Steinert, Marin & Roeser, 2022) and environmental resources that set up, drive, and regularly contribute to affective regulation (Sterelny, 2010). Emotion-regulation is a fundamental process that humans undertake to shape and manage their mental lives (Steinert, Marin & Roeser, 2022). Environments, where people function, directly impact their emotional experiences, this applies also to virtual and multimedia enhanced environments. Our cognitive abilities frequently rely on and are facilitated and controlled by the resources in our surroundings and the equipment we utilize (Steinert, Marin & Roeser, 2022). These resources available in the environment can also provide structure, improvement, and regulation for affective experiences (Roeser 2018). They set up, drive, and regularly contribute to affective regulation (Sterelny, 2010). According to Candiotto & Dreon (2021), specific resources can balance human affective life if they are integrated into structured and repeated practices of interaction.

We can draw from the literature analysis that scaffolding is not always explicitly designed into the practice based learning with disruptive technologies. According to literature analysis conceptual and procedural scaffolding are the most common types that have been implemented with disruptive technologies (Figure 3).

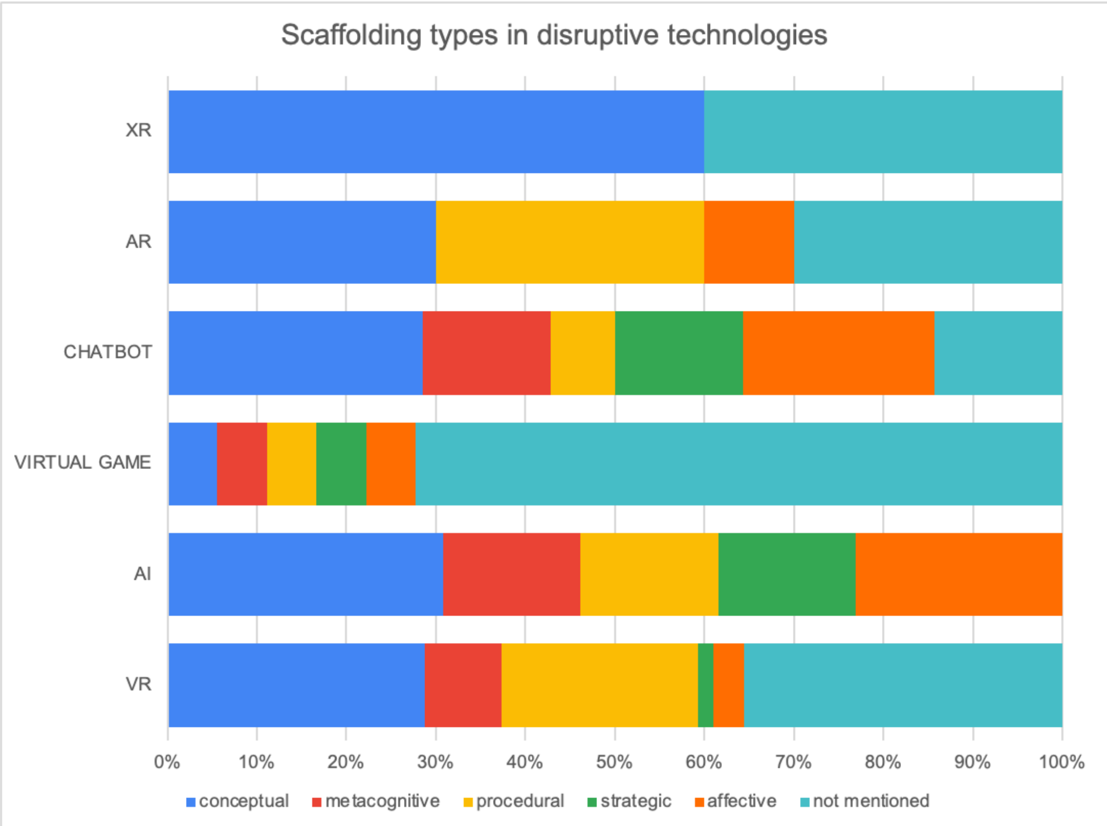


Figure 3. Scaffolding types in practice based learning scenarios with disruptive technologies based on our empirical literature review.

Examples of a typical conceptual scaffolding are designed in learning activities with Chatbots. Chatbots are often used as mimicking tutors to provide learning support, motivate learners, prompt for reflection of past learning, conduct a formative assessment, interact with students or provide adaptive feedback. Chatbots have also been used for personalization of the learning process: adapting learning situations to students' learning styles and personality features. Situations in which chatbot provides one-to-one support or one to group discussion support have been developed (Kuhail et al., 2022).

Yet another example of conceptual scaffolding is presented in the research by Bourke (2020), in which the VR environment provided the healthcare students with examples of how to provide good quality care to delirious patients. In this VR Delirium Experience, students receive written feedback as well as feedback that is incorporated in the narrative. The feedback in the VR game gave the students more knowledge about actions that should be taken when providing delirium care.

Without previous experience, virtual environments can be unaccustomed and challenging. In the case of a virtual game for pre-service teachers to exercise managing challenging behaviour of students in the classroom (Chen et al., 2021), required teachers to support students to develop a sense of the virtual space. They provided continuous assistance and guidance on the functions and capabilities of the game. If the students noticed and stopped a challenging behaviour, they immediately heard a bell sound, which served as the feedback, thus providing procedural scaffolding. Being an emerging technology and not yet widely implemented in education, learning and teaching with disruptive technologies require first some procedural understanding of ways of operating with these technologies. Therefore, in the beginning a lot of effort may be put into explaining the functions and the overall operation of the technology, which in later phases fades away as the participants get acquainted and accustomed to new technologies.

Practice-based learning scenarios with disruptive technologies enable to design scaffolding into the technology or leave it to the teachers and facilitators. Both of these ways have some advantages and disadvantages. Very often teacher scaffolds consist of dynamic, one-to-one support that is contingent on students' current performance characteristics (Belland, Kim, Hannafin, 2013). A teacher could pose an exploratory question to a student and subsequently create helpful resources tailored to the specific difficulties faced by that student (Belland, 2014; van de Pol, Volman, & Beishuizen, 2010). The research done by Buyego et al. (2022), represents a good example of the combination of teacher and system delivered support. Teachers provided both instructional and troubleshooting support to the participants in cases of device or procedural glitches during the course, but at the same time the immersive, dynamic and interactive VR environment notifies participants every time they get a step wrong through an audio cue and doesn't let them proceed until they have perfected the procedure (Buyego et al 2022). However, technology-based scaffolds are meant to complement, not replace, teacher scaffolds (Saye & Brush, 2002).

An example of metacognitive scaffolding can be seen in works of Clack et al. (2021). In their VR simulation environment the aim of the learning activity was to foster experiential learning and sustainably changing health care providers' hand hygiene behaviours. A part of the learning activity was also debriefing, which took the form of a live, post-training session in which the HCP learner had an opportunity to reflect on the virtual training experience, the learner had an option to review video-excerpts from their training exercise and view descriptive data about the extent of contamination that was established as a result of missed hand hygiene opportunities in the virtual environment (Clack et al., 2021).

Every new technology brings in some novelty aspects, making users excited, curious and motivated to explore its potential. Our literature analysis shows that currently affective scaffolding is hardly considered and used with practice based learning supported by disruptive technologies. However, a promising example of affective scaffolding can be seen in the case of situated language learning in the cognitive immersive language learning environment (CILLE) (Divekar et al., 2021), in which XR brought visual context to the students while the AI provided opportunities to roleplay conversations inside the visual context (Divekar et al., 2021). The CILLE's AI has the ability to perceive and comprehend its users through hearing and seeing, and is capable of engaging in multi-modal conversations that involve more than two participants. The XR technology utilized by the system allows students to experience the sensation of being in a different location without the need for invasive equipment, and enables interactions between multiple parties in different modes. By combining AI and XR, the system creates an immersive and natural conversation experience that promotes the acquisition of foreign language skills. Furthermore, the system operates without the need for any wearable devices, enabling multiple users to interact simultaneously and in a collaborative manner with the environment and each other (Divekar et al., 2021).

Candiotto and Dreon (2021) claim that besides the impact of the environment on the actions of the agents (environment produce, shape and manage emotions), the ongoing and repeated emotional interaction between the agent and the environment (including both natural and cultural aspects) plays a crucial role. Emotions are strategic moves within the environment, implying a deliberate involvement with the social world (Griffiths and Scarantino, 2008). Immersing students into augmented and virtual worlds, affective "environmental" scaffolding (Clark and Chalmers, 1998) becomes particularly important in supporting emotions, especially the social embeddedness of emotions, being social signals that constantly reframe relationships (Griffith and Scarantino, 2008).

4.2.1.4. Social dimension of practice based learning

Social constructivism views learning as a social and cultural process that occurs in the context of human relationships and activity (Dudley-Marling, 2012). In the approach to learning that is centred on social factors, the sociocultural context isn't just where learning occurs, but it also plays a role in how individuals learn by participating in cultural activities and what they learn by engaging in social practices. Social aspects and socially cued content are especially important in multimedia learning in which information is presented through different modes. Mayer (2005) proposes a set of principles for multimedia learning that rely on social cues. These social cues include visual cues that make the person explaining something visible, auditory cues that convey relevant social characteristics of the speaker, and linguistic cues that relate to the style of language used in the explanations (Töpper, Glaser, Schwan, 2014). When social cues are present, the learner becomes motivated to understand the speaker's message. This motivation leads to active and thorough processing of the learning material, resulting in improved selection, organization, and integration of the presented information (Mayer, 2005). Thus, technologies can interrupt social relations, ways of interactions and relationships.

In our literature analysis we took a closer look at different learning modes in practice based learning scenarios with disruptive technologies:

- individual - practice based learning activity is carried out individually
- pair with facilitator - practice based learning activity requires or enables one-to-one interaction with the facilitator, takes place in multiple forms through various communication channels
- group with facilitator - practice based learning activity requires or enables group interaction with the facilitator
- peer-peer - practice based learning activity require or enables peer-to-peer interaction, learners to interact with other learners
- peer-group - practice based learning activity requires or enables interaction with the group.

Figure 4 below demonstrates the current situation regarding the learning modes in practice based learning with disruptive technologies. It is evident that individual tasks make up the majority in all three types of disruptive technologies: Interactive media technologies (VR, AR, MR, XR), adaptive support technologies (AI and chatbots) and motivation management technologies (virtual gamification). A few examples can be provided regarding the learning modes of pair with facilitator (see for example Kuhail et al., 2022; Li et al., 2022; Curley et al., 2020) and group with facilitator (for instance Arayaphan et al., 2022; Argyriou et al., 2020; Baceviciute et al., 2021; Buijs-Spanjers et al. 2020). Peer-to-peer and peer-to-group learning modes are demonstrated in studies provided by, for example, Elzie & Shaia (2021), Drigas et al. (2022), Kulkarni et al. (2022) and others.

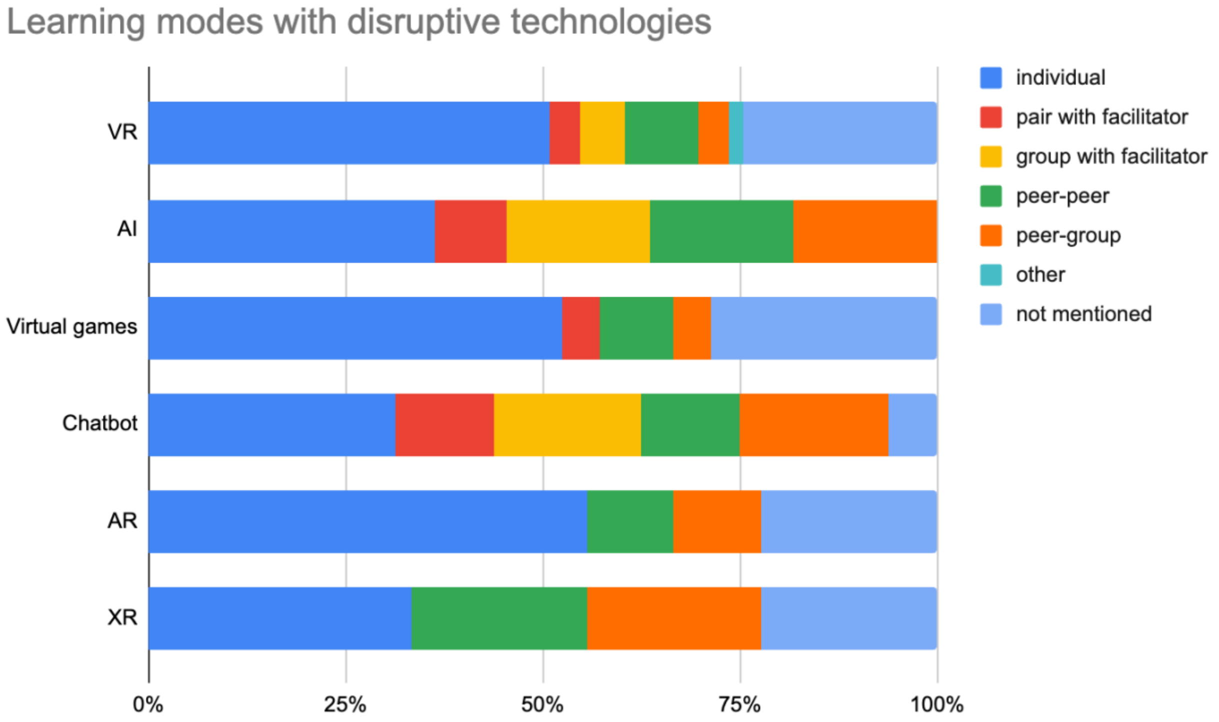


Figure 4. Learning modes with disruptive technologies based on our empirical literature review.

A typical individual learning activity in an immersive 3D VR environment is demonstrated by Johnston-Glenberg et al. (2021), where the learner is placed in a rainforest (with rainforest sounds, such as birds chirping and water flowing) and must catch at least 20 non-poisonous butterflies before the timer runs out. The player is in the role of a zookeeper in charge of feeding the birds, thus, acting alone to complete the task. There are six levels that last for 60 s each (Johnston-Glenberg et al., 2021). Another example of individual practice based learning with disruptive technology is presented in Dobricki et al. (2021). Their experiment is situated in the VR and AR environment, in which the user has to create a basic tree garden by placing and organising some trees for 5 minutes. Secondly, they were asked to modulate the trees regarding the properties described in the stimuli and apparatus section (Dobricki et al., 2021).

Learning with various digital technologies characterised as seamless learning across different contexts (Wong and Loo,i 2011) tends to shift the learning process towards a much more personal and individualised experience (Schneider et al., 2021). However, according to recent research, the process of learning with digital technologies and materials is still perceived as a social interaction process (Apps et al. 2019; Liew et al., 2020), which are elicited by social cues (Mayer et al. 2003). For instance, the CASTLE theory (Cognitive-Affective-Social Theory of Learning in digital Environments) proposes that social cues activate social schemes leading to (para-)social processes, which can influence the selection of information, how the information is processed in working memory, and the integration and retrieval of mental models in long-term memory (Schneider et al., 2021). Furthermore, in addition to cognitive processes, peer and group learning influences one's individual and group identity, sets out social norms, stresses the importance of group awareness and collective knowledge in learning processes, etc.

Drawn from our literature analysis, an example of peer-to-peer interaction, in which a student interacts with the robot acting as a learning companion in language learning can be seen in the study conducted by Chen et al. (2022). The aim of the robot is to facilitate dialogues and promote speaking proficiency (Chen et al., 2022). In this case the human peer is replaced by the chatbot. Another example with an option to share with peers is presented in Alamäki et al. (2021) experiment with 3D-based AR application. The context of the study is a campaign of a dairy firm that was shared on their milk cans. The content of the

AR application presented "an interactive 3D morning cat", and the users were able to play with the cat on the screen of their smartphones (Alamäki et al., 2021). There was an option to experiment individually or share with two or three other users when conducting the VR headset and AR experiments (Alamäki wt al., 2021). Chatbots can take various roles while interacting with students (Chhibber & Law, 2019; Baylor, 2011): teaching agents (take the role of human teachers, present instructions, illustrate examples, ask questions (Wambsganss et al., 2020), provide immediate feedback (Kulik & Fletcher, 2016)), peer agents (serve as learning mates for students to encourage peer-to-peer interactions (Kuhail et al., 2022)), teachable agents (the agent acts as a novice, in which students guide them along a learning route (Kuhail et al., 2022), and motivational agents (serve as companions to students and encourage positive behaviour and learning (Baylor, 2011). However, the potential of chatbots in terms of their various ways for supporting learning, is not used.

The examples of learning modes presented above represent a typical learning scenario with the support of some disruptive technologies, in which learners individually have to complete a certain task within the set time limits and the system provides feedback about the achievement. Although there are some studies, in which learning activities are carried out as peer or group work, however, there are currently hardly any studies, which would take a closer look at, for instance, group polarisation, group dynamics, social norms in collaborative learning, group trust, group awareness, individual and group identity, the role of self-conception and related cognitive processes and social beliefs in an in-group settings, etc. and explore these concepts in the context of practice based learning processes with disruptive technologies. For example, group polarisation, the concept, which relates to the group's inclination to make decisions that are more radical than the original inclinations of its individual members (Sunstein, 1999), have an effect on the learning experience and outcome with disruptive technologies. It may also change group's attitudes towards a situation, in the sense that the individuals' initial attitudes have strengthened and intensified after group discussion, a phenomenon known as attitude polarisation (Myers & Lamm, 1975).

It is obvious that in situations where learners are immersed in various augmented, extended, virtual realities and their learning activities are enhanced with different combinations of disruptive technologies; different processes, challenges and opportunities emerge while operating in groups.

4.2.2. Learning effects in practice based e-learning with disruptive technologies

For exploring the possible effects on users we selected four domains: cognitive effects, metacognitive effects, affective effects, and psychomotor, behavioural and embodied effects. We viewed these effects on the level of individual learners, as well as in the situations with facilitators or in peer groups.

- Cognitive domain refers to information processing and understanding and acting based on knowledge. Several approaches explain cognition, thus one cannot give only one definition. Information processing (Atkinson & Shriffin, 1968) theory explains cognition within the individuals through representational processing of sensory inputs to result in knowledge acquisition and knowledgeable actions. Social constructivists (Vygotski, Wenger, 1998; Lave & Wenger, 1991) explain individual cognition situated within the culturally mediated interaction and lived practice between individuals, groups and cultures for shaping symbolic meanings and developing forms of knowledge that reach beyond individual to the collective levels and would be internalised by individuals. The distributed cognition approach (Hutchins, 1995) assumes that cognition is partially off-loaded into the environment through social and technological means and shared representations that are distributed in sociocultural systems (external artefacts, work teams, cultural systems for interpreting reality) constitute the tools to think and perceive the world. Embodied cognition approach (Varela, Thompson and Rosch, 1991: 172; Shapiro, 2011) looks at the adaptive and ecological perceptional interplay of organism's bodies in interaction with its' environments through affordance niche creation that may act as conceptual states of affairs (Clancey, 1997) without considering the symbolic information representational processes as necessary drivers of action. In the sections below we will explore some concepts that have been used in disruptive technologies related with these different cognition paradigms in learning.

- Metacognitive domain refers to one's awareness of thinking and the self-regulatory behaviour that accomplishes this awareness (Driscoll, 2005, p. 107). Learning processes can be adapted through adaptive instruction or self-directed learning (Kester & Merrinboer, 2022: 101-102). In our cognitive architecture self-directed learning skills are closely related to self-regulation of comprehension and task performance, which has important sub-processes of monitoring and control. Monitoring refers to the thoughts the learners have about their cognition, and based on these metacognitive thoughts learners respond to the environment or adapt their behaviour, which is termed control (Zimmerman & Schunck, 2001).
- Affective domain refers to motivation, emotions and affect in learning. Although these have been considered as non-cognitive variables, they are recently recognised as mediators, moderators and even outcomes of learning (Plass & Kaplan, 2016). Cognitive-affective theory of learning with media (Moreno & Mayer, 2007) explains the role of effective learning.
- Behavioural, Psychomotor and Embodied domain. Behavioural learning paradigma considers learner behaviour conditioning with stimulus and response shaping (e.g. Thorndike, 1932; Bandura, 1962) and does not define information processing paths in the brain. The behavioural learning relates to the social and behavioural aspects of the learner in their learning environment: ability to regulate their behaviour and respond to the environment, and ability to regulate social interactions while learning. Aligned to the information-processing theory, the psychomotor learning model (Armstrong, 1970) relates with the psychomotor constructs in the long-term memory and bodily responses. Psychomotor learning focuses on physical movement, coordination, and anything related to motor skills. Hierarchically the psychomotor skills are believed to develop towards mastery within five levels: 1) imitation; 2) manipulation; 3) precision; 4) articulation; 5) naturalisation. Embodied cognition domain (see Varela et al., 2017, Gibson, 1988; Lackoff & Johnson, 1999; Damasio, 1989) differs from previous cognitive learning theories to explain bodily behaviours without the information-processing loop in the working memory and long-term memory. Embodied cognition suggests that there are more immediate physical reactions that depend on our sensorimotor capacities and the affordances the body is able to read and enact from the environment and other people's emotions and movement. Embodied cognition has been used in instructional design to explain bodily reasoning.

Different learning theory frameworks could be considered when building learning scenarios with disruptive technologies: behaviourist approach (Skinner, 1938), cognitive information processing approach, constructive cognitivist approaches, social learning approaches, situated and embodied cognition approaches. In this section of the report in sections 4.2.2.1-4.2.2.4. we present the specific learning approaches related with cognitive, metacognitive, affective and psychomotor, behavioural and embodied effects. Each learning theory provides a set of concepts and processes that explain learning phenomena. Thus we highlight these concepts under the relevant sections. We also provide in section 4.2.2.5. an empirical overview of which of these learning-related constructs have been studied regarding disruptive learning technologies. Annex 1 explains the literature review approach and Annex 2 provides concrete tables.

4.2.2.1. Cognitive learning aspects

Information processing-driven cognitivist learning theories are most often used to design learning with multimedia (see for more in Mayer & Fiorella, 2022, Multimedia Handbook of Learning). Mayer and Fiorella (2022, p. 5) define multimedia as presenting words (such as printed or spoken text) and pictures (such as illustrations, photos, animation or video).

The mulsemedia definition as a broader concept was proposed by (Saleme et al., 2018). This also captures other sensory channels besides visual and auditory and will be described below in the section of sensorimotor, behavioural and embodied cognition effects.

The multimedia learning and instruction approach is driven by Cognitive theory of multimedia learning (Mayer, 2010), Cognitive load theory (Sweller, Ayres, & Kalyuga, 2011) and integrative model of text and picture comprehension (Schnotz & Bannert, 2003). In this approach the central idea is the concept of processing of mental representations in working memory and storing and retrieval of the knowledge in the long-term memory. The design of multimedia based messages is supposed to follow the supposed information processing (Atkinson and Schriffin, 1968) in multi-store and multi-layered memory that is described by the cognitive learning framework.

Briefly the memory model assumes a sensory input with very short term (few milliseconds) sensory memory that requires attention and pattern recognition. The selective attention constrains the input of information from the senses to the working memory (Driscoll and Burner, 2005, p 79). Selective attention is the learners ability to select and process certain information while simultaneously ignoring the other information. Attention is influenced by how well the learner understands the meaning of the tasks, if the learner has prior knowledge, the surroundings of the learner, the learners ability to control its attention, the presence of competing tasks, the task complexity (the need to notice simultaneously different information with the same or different senses). In trained behavioural situations automatized processing is started, and attention is selective and focused only on required elements (Shiffrin and Schneider, 1977). The Flow theory (Csíkszentmihály & Csikszentmihalyi, 1992) often used in explaining the effects of gamification also explains the situations where attention is only on the limited dimensions of the reality, that enables to experience the state of flow […] a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it."

Part of the attention is guided by the pattern recognition phenomenon, that is the process whereby environmental stimuli are recognised as exemplars of concepts and principles already in the memory (Driscoll, 2005, p. 85). Pattern recognition involves eased noticing by comparing the information from the senses with the pattern prototypes, and this is believed to lessen the cognitive processing. Such pattern prototypes are not only defined by personal experiences but may be culture defined (see Alexander et al., 1977).

From sensory memory the information inputs to the working memory. Working memory in the model of Baddeley (1986) is retrieving and encoding information from perception and long term memory and encoding and sending it to the long term memory. There the processing of information would happen in real time. The working memory holds a limited capacity in time and amount for rehearsal and chunking of information. Within the short term memory the visio-spatial sketchpad and phonological loop are distinguished. The visuospatial sketchpad refers to our ability temporarily to hold visual and spatial information. It is responsible for storing and processing information in visual or spatial form, as well as the location or speed of objects in space. The phonological loop in the models of working memory is a dedicated memory store that holds and processes auditory information. The multimedia learning describes the information processing and chunking processing between visuo-spatial and verbal and auditory types of information as an integrative text comprehension process that is executed by Central executive in working memory (Schnotz & Bannert, 2003). Important learning concepts related with the working memory are rehearsal as a repeated information processing activation in working memory, and encoding that refers to relating information from working memory, sensory memory and long term memory. Many learning techniques are built on supporting encoding into narrative sequences, visual schemas, spatial journeys etc.

The concept of cognitive load (Sweller, Ayres, & Kalyuga, 2011) explains information processing difficulties in the working memory and proposes three types of cognitive loads in learning situations. Intrinsic cognitive load is the inherent level of difficulty associated with a specific instructional topic. Extraneous cognitive load is generated by the manner in which information is presented to learners and may be of specific focus in the learning situations with VR, AR, XR. Germane cognitive load is the processing, construction and automation of schemas and this also can be maintained by sequencing the cognitive operations in the learning processes.

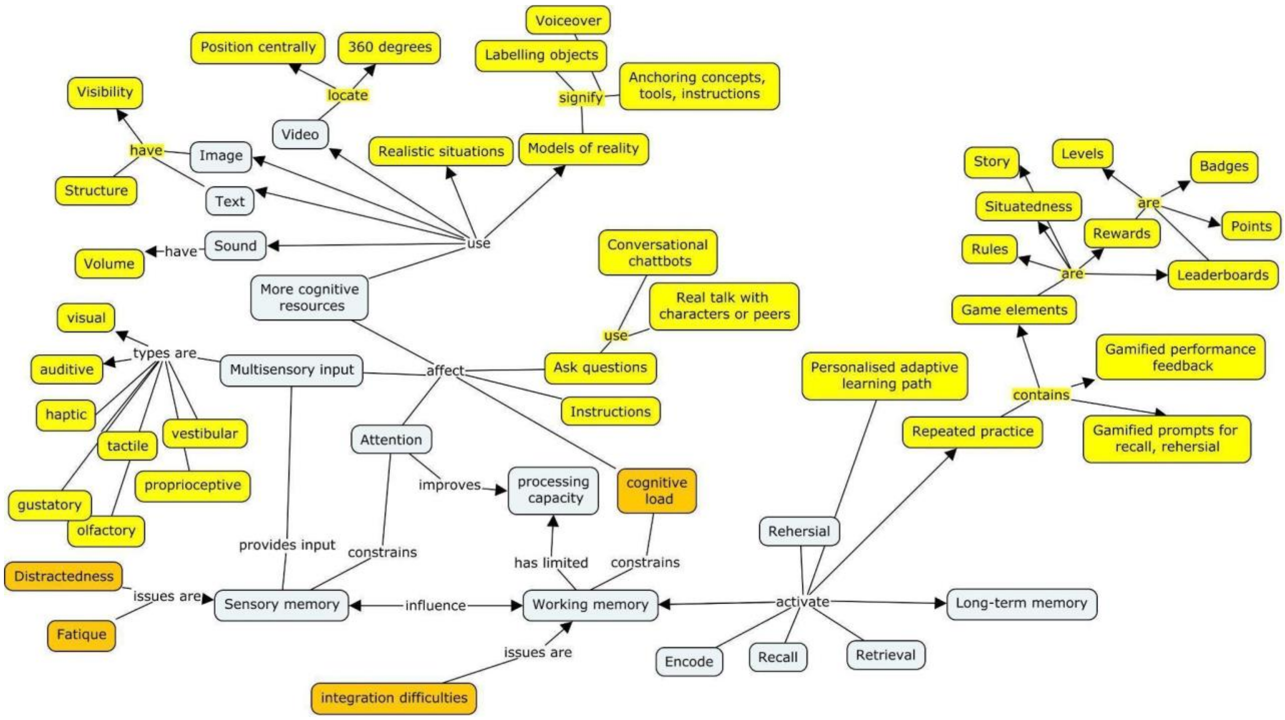


Figure 5. Cognitive learning processes and used design elements

Long term memory is capable of retaining an unlimited amount and variety of information. Long term memory is divided into Semantic memory, Episodic memory and Procedural memory (Tulving, 1972). Semantic memory is supposed to store the conceptual facts of the world as schema-like structures. Episodic memory would store the personal experiences as episodes and enable to retrieve and mentally re-experience the information about the events, and contexts and keep the time sequences between the events etc. Procedural memory stories the processes and actions, and provides informational responses to actions. Semantic and Episodic memory are important in explaining cognitive learning, they together are considered propositional and compose our declarative memory. The network model of memory (Anderson, 1971) explains adaptive control of thought. McClelland, Rumelhart and the PDP Research Group (1986) has proposed that connections are the building blocks of memory, and act as a vast network of distributed processing, strengthening some connections as patterns of activation. The Procedural memory concept may be used in explaining psychomotor learning and training effects. Although the information processing model has gained a lot of explanatory power in time in explaining learning with multimedia, there is not sufficient evidence that this model mirrors the actual neural processes in the brain.

Information processing theory in education addresses information processing towards developing objective knowledge, that is aligned to how science is able to explain phenomena. Following the cognitivist and radical constructivist approaches, the individuals construct knowledge from their own experience. Learning for knowledge acquisition approach has been prevailing in past educational designs. Knowledge is presented in learning designs at different complexity levels, either authentic situational ways or more abstract ways through concepts, algorithms and visual expressions. Bloom's taxonomy (Bloom et al.,1956) of cognitive outcomes have often been used in instructional design to differentiate declarative knowledge in cognitive domain. This incorporates hierarchical constructs of knowledge at the level of remembering, comprehension at the level of grasping the meanings, application as the process of using abstract knowledge (rules, principles, ideas) in concrete situations, analysis, synthesis and evaluation as higher level knowledge manipulations. Knowledge construction is supposed to develop conceptual coherence in information that is processed so that understanding is created. The presentation of information, processing of information and storing of information can cause misinterpretations and faults in knowledge processing.

From the standing point of social constructivism and situated learning (see Vygotski; Wenger, 1998; Lave & Wenger, 1999) adds the social context and group learning dimensions to the cognitive knowledge construction. According to sociocultural and the situated views of learning, individual's development actualizes in interaction with the environment; thus learning happens first on social level rather than based on individual mental constructions (Säljö, 2001). The social interaction with the facilitator and with the peers in collaborative groups adds the interpersonal dimension to the conceptual knowledge - there is the need to develop mutual conceptual understandings about what is learnt, as the group cognition or shared cognition, and how learning is co-driven by the group (this refers to shared metacognition), as well as the shared motivational zone should be developed in social actions (Brophy, 1999). The reasoning and argumentation processes to develop common ground is the basis of shared cognition. Shared cognition is extended to situated cognition that focuses on peer learning in contexts where they are applicable (Brown, Collins, & Duguid, 1988 and Lave & Wenger, 1991). These contexts refer to objects, practices as well as situations where learning takes place and about what the learning is. Particularly, problem solving in authentic contexts and with authentic, complex ill-structured problems is supposed to create the opportunity for the learners to associate abstract conceptual knowledge with actual situations through the problem solving. The situation awareness concept of team or shared mental models has been used in situated social-constructive learning contexts (Hopp et al., 2002).

The individual and group knowledge in socio-technical systems may be offloaded to the digital reality as chat logs, artefacts, documents, videos, images creating distributed cognition opportunities (Hutchins, 1995). The artificial intelligence-aided socio-technical systems add another social co-construction layer in which accumulated knowledge objects may be semantically annotated, and recommended to the learners as a kind of collective knowledge (Ley, Seitlinger & Pata, 2016). In situated learning the learning is seen as participation in situated community practice cultures (Lave & Wenger, 1991) in which the learning trajectory as the learner's participation over time may be viewed (Wenger, 1998). With AI supported cognitive learning these learning trajectories may be accumulated and used by recommendation engines to provide adaptively cognitive advice to the learners what content they should read, or what tasks they might do to learn in personalised learning paths.

Situated learning design uses the idea of anchored instruction, where digital design incorporates in the multimedia interface the noticing aspects for the learners to find relevant cues about knowledge, practices with culture specific tools, or to get metacognitive support in processing the problem solving tasks.

All these perspectives to learning for conceptual knowledge presume different learning outcomes from the learners in the scope of individual to group to collective level knowledge constructs.

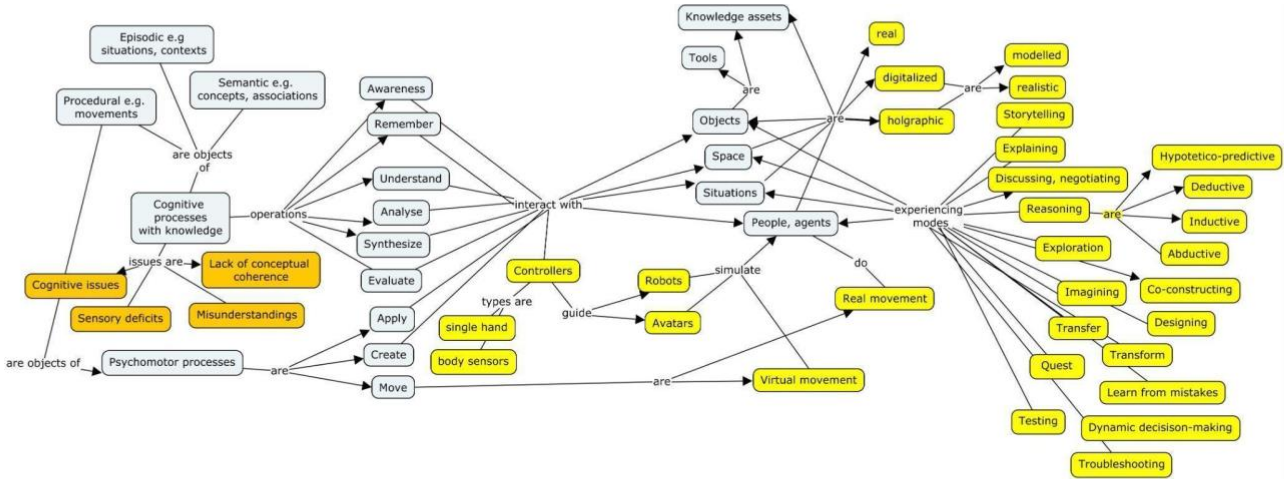


Figure 6. Cognitive learning processes and design elements

Below we present these cognitive learning related constructs that we discovered in the literature survey about learning with disruptive technologies. We have looked separately for positive learning outcomes and obstacles that have been found in the cognitive domain. These provide us with some useful design principles that can support or hinder specific learning outcomes that we will highlight in the summary sections of the deliverable.

4.2.2.2. Metacognitive aspects

Metacognition is thinking about the contents and processes of one's cognition (Winne and Azevedo, 2022:93), and it is central in learning and self-regulation. Self-regulation in turn is associated with motivation. Schunk and Zimmerman (1994: p.309) considered self-regulation to be the reciprocal of motivation, and defined it as the process whereby students activate and sustain cognitions, behaviours, and affects, which are systematically oriented toward the attainment of their goals.

Declarative metacognitive knowledge includes beliefs about self-efficacy, knowledge, and tasks, beliefs about the strategies and the strategies to be successful (Winne and Azevedo, 2022:93-94). Declarative metacognitive knowledge is describing self, tasks and contexts that affect decisions about whether and how to engage tasks. Procedural metacognitive knowledge is knowledge of the processes and actions to carry out tasks and learning strategies. Conditional metacognitive knowledge is knowing when and why declarative and procedural knowledge are relevant and matter in learning, why strategies are effective and when they are appropriate, and it is a key to adapting and transferring learning strategies to unfamiliar contexts (Winne and Azevedo, 2022:95).

Metacognition can be modelled with forms of thinking - metacognitive monitoring that processes information to generate awareness about what type of metacognitive knowledge is required in specific situations, metacognitive control when intention is generated to direct cognition or behaviour toward the goal, and self-regulated learning that adapts cognition and the behaviour within tasks and reachers forward to plan future tasks (Winne and Azevedo, 2022:95-96).

Task comprehension, goal orientations, interest and task value, the learner beliefs, learners' feelings and affective states play a role in how metacognition works. Self-regulated learners show motivational commitment, they are goal oriented, persistent, attentive to their knowledge, beliefs and they have volition that keep them on the track (Renniger & Järvelä, 2022). Although self-awareness, self-judgements, self-concept, and self-efficacy are often segregated from metacognition, these factors are intrinsically entwined with metacognition (Bandura, 2001).

Metacognition is usually measured post-action through self-reporting because conscious focus on metacognitive processes can slow down cognitive operations. As part of metacognition the constructs of goals, managing motivation, applying strategies and self-regulated learning (Schraw and Dennison, 1994), the ease of learning, feeling of knowing, retrospective confidence of judgements (Dunlosky and Tauber, 2016), as well as the time allocated to learning could be measured from self-reports. Some aspects of metacognition relate with: Diagnosing learning needs in the light of given performance standard, Formulating meaningful goals for learning, Developing and using a wide range of learning strategies appropriate to different learning tasks, identifying resources for accomplishing various kinds of learning objectives, Carrying out a learning plan systematically and sequentially, Diagnosing and monitoring performance.

Another method to measure metacognition is by think-alouds during the task performance. It is not clear whether thinking aloud impedes task performance or enhances it (Winne and Azevedo, 2022:104). Traces of metacognition may be collected with educational data-mining and come from movements, utterances, eye movements towards the areas of interest, accessing the help seeking, or physiological features such as heart rate, sweating, facial expressions. There is not sufficient knowledge about the metacognitive domain yet. It is believed that developing domain-general metacognition would be useful, as well as embedding metacognitive triggers to specific task context, making metacognition more conscious, and also more automated in the long run (Winne and Azevedo, 2022: 106).

According to Knowles (1975: 18) self-directed learning is a process in which individuals take initiative with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating outcomes. Self-directed learning is considered a personal disposition or human quality, but it also refers to the method or organising instruction so that learners would take primary responsibility for control over decisions on planning, implementing, and evaluating their learning experiences (Väljataga, 2010: 17). Learner-control and teacher-control may be distinguished in instructional settings to instructional components: learning objectives, learning strategies, learning resources, evaluation criteria and process reflection (Väljataga, 2010:25). A shift in control and responsibility in the learning situation towards increased learner control is the significant change towards a more learner centred approach.

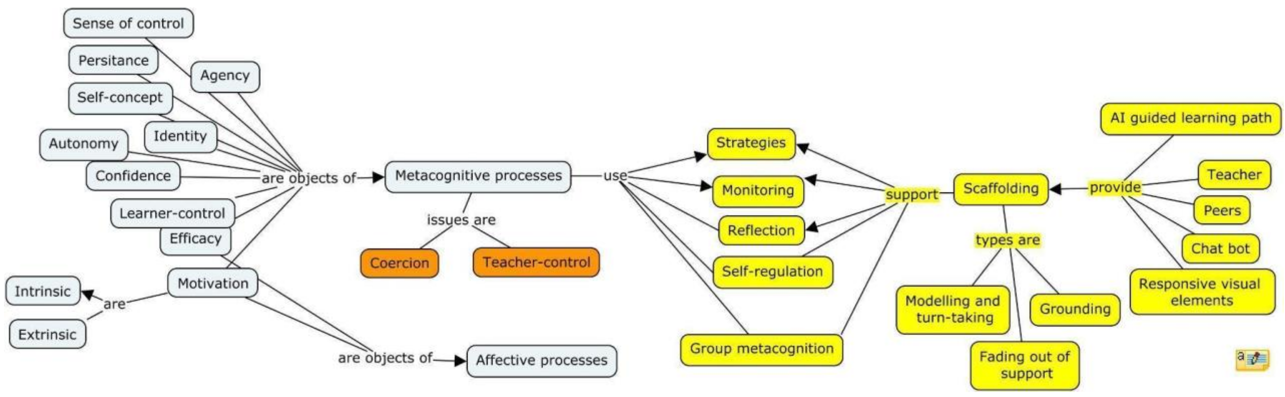


Figure 7. Metacognition learning related concepts and design elements

4.2.2.3. Affective aspects

Motivation and affect are combined often under the umbrella of either motivation or affect or affective-motivational factors and they both have positive and negative valence (Schrader, Kaljyuga and Plass, 2022: 122).

Affective states consider motivation as a component of emotions.

Emotions can be described as experienced states that arise and develop in the context of learning and achievement. Emotions are multifaceted concepts that are composed of psychological, affective, cognitive, motivational and expressive components (Scherer, 2009). Emotions have motivation-behavioural components (Roseman, 1984) but emotions and motivation are considered separate constructs. Emotions are - enjoyment, boredom, anxiety, anger, hope, shame, confusion etc. Emotions are proposed to impact motivational constructs. Positive emotions trigger learning and result in enhanced motivation to learn (Isen & Reeve, 2005), while negative emotions undermine motivational engagement to invest in a task (Linnenbrink & Pintrich, 2002) but could also foster efforts to achieve learning success (Bless et al., 2006). Positive emotions have been found to increase intrinsic motivation (Müller & Reichelt, 2015).

Enjoyment is a positive affective state that occurs when a person engages in an experience or activity that satisfies a desire, goal, or need, including but not limited to the need for pleasure, meaning, security, safety, sustenance, esteem, belongingness, or love. (Smith et al., 2014). Anxiety is an emotion that describes one's worriedness, nervousness, or uneasiness. It is also characterised by an unpleasant state of inner turmoil, often accompanied by the nervous behaviour (Seligman et al., 1984).

Attitudes are learned evaluations of persons, places or issues that affect thoughts and behaviour. They are composed of affective (feelings and emotions), behavioural and cognitive components (knowledge and beliefs).

Motivation refers to the process whereby goal-directed behaviour is instigated and sustained (Schunck, 1990:p 3). Motivation is the internal process that is involved in goal-direction, intensity and persistence of behaviour (Eccles, Wigfield & Schiefele, 1998).

Motivational constructs are interest, intrinsic and extrinsic motivation, goal orientation and task motivation, and self-efficacy (Murphy and Alexander, 2000). Interest is characterised as a person-object relationship that leads to engagement or reengagement and is differentiated into individual interest and situational interest triggered by context (Hidi and Renninger, 2006). Magner et al. (2014) have shown that decorative illustrations in multimedia learning had effect on situational interest, but did not increase learning outcomes.

Intrinsic motivation is the internal desire to engage in certain activity due to interest, enjoyment or challenge and extrinsic motivation is guided by external incentives (Schrader, Kalyuga and Plass, 2022). According to the Self-determination theory (Decy and Ryan, 1985) intrinsic motivation requires learner competence, relatedness and autonomy and this leads to action-related behaviours. Self-efficacy is one's self-perception to be able to perform a specific task (Bandura, 2004). Self efficacy has been found to positively predict learner engagement (Azila-Gbettor et al., 2021).

Motivation towards the achievements may be low or high. Other variables influencing motivation are high and low anxiety (Lazarus et al., 1966), high or low internal control (Rotter, 1966), curiosity and interest. Curiosity has been related to complex problem solving situations.

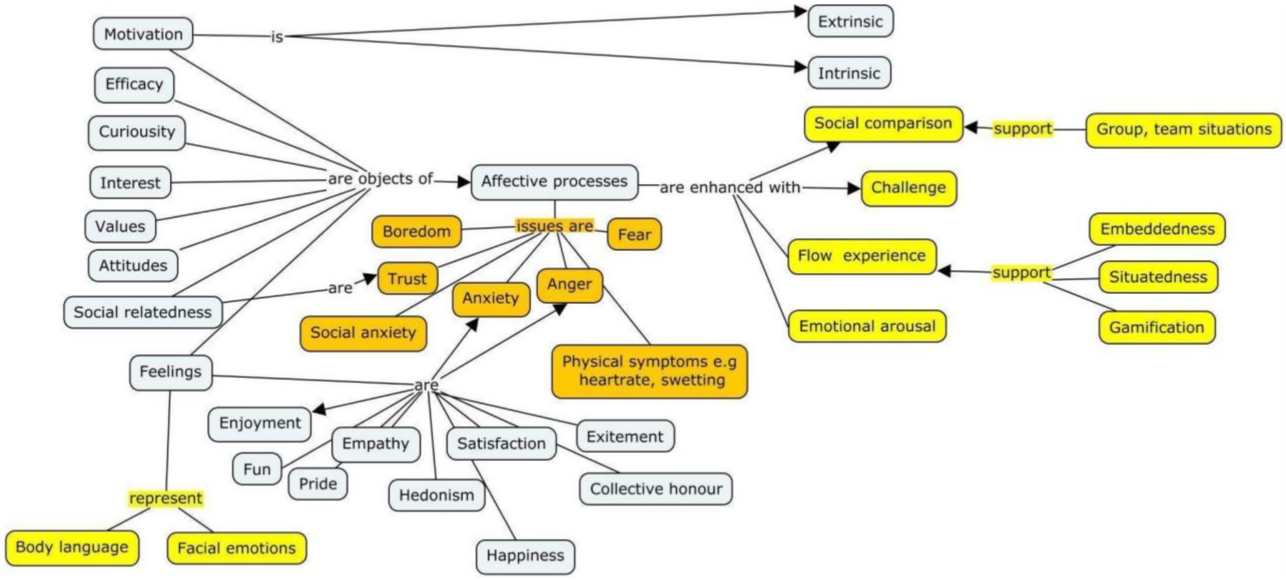


Figure 8. The affective constructs and design elements that support affective learning

4.2.2.4. Behavioural, psycho-motor, and embodied aspects

Human interaction with the surroundings is constrained by our senses. Exteroceptive senses of humans, corresponding to a sense organ, are that of sight, (visual), hearing, taste (gustatory), smell (olfactory), and touch (tactile/haptic). Sensation is carried out by these sense organs that convert energy from the environment to an electrical pulse. This electrical signal is transmitted to the brain, where it is processed and interpreted, creating a perception.

Humans also have interoceptive capabilities that make them aware of the internal state of the body. These can be broken down into the following categories:

Equilibrioception contributes in helping us maintain our balance. Although vision plays a main role in this sense, the vestibular system of the internal ear provides the leading contribution to the sense of balance and spatial orientation.

Nociception is the sense of pain. Seen initially as an experience related to touch, recent research showed that this phenomenon corresponds to a specific area of the brain.

Proprioception is the awareness of the position of our body. This kinesthetic sense is responsible for conveying information of where our body parts are, even if we cannot see them. People do not notice the proprioceptive sense because of habituation, desensitisation, or adaptation to sensory stimuli that are continuously present. This unnoticed sensation continues in the background while an individual's attention can move to another concern.

Thermoception is the sense of heat and cold that relies on the temperature sensors in our skin. Temporal perception is related to the perception of time. Although this can be subjective, research shows that our basal ganglia and other parts of the brain are responsible for it.

Interoception conveys information about our visceral sensory receptors found in our internal organs.

In disruptive technologies (VR, AR, XR) the scope of media formats that have effect on human senses have increased. The Multiple Sensorial Media or mulsemedia definition (Saleme et al., 2018) transcend the traditional senses of sight and hearing, adding smell, touch, and taste into multimedia applications to create more immersive experiences for the users. Mulsemedia—multiple sensorial media—makes possible the inclusion of layered sensory stimulation and interaction through multiple sensory channels (Ghinea et al., 2014). Mulsemedia addresses different types of instructional messages that relate with behavioural and psychomotor domains as well as with embodied cognition. Mulsemedia concept captures other sensory channels besides visual and auditory - tactile (processing touch information from the body), vestibular (sense of head movement, orientation and balance in the space), proprioceptive (sensations from muscles and joints of body, senses of the position, location, orientation, and movement of the body muscles and joints, sense of the relative position of neighbouring parts of the body and effort used to move body parts), gustatory (sensations from tastes), olfactory (sensations from smells). NEWTON project (NEWTON Networked Labs for Training in Sciences and Technologies for Information and Communication 2016-2019) has provided an overview of multisensorial learning preferences of learners. Saleme et al., 2019 note that there is little research that has investigated how multisensory information is represented in working memory.

Our perception is influenced by senses, and how we can substitute a sense with a combination of other senses or what happens when a sensory stimulus is stronger than the others was studied by Sulema (2016). He states that cross-modal correspondences should be considered alongside semantic, temporal, and spatial congruency in the design of VR products. The process of multisensory integration describes the synergy among the senses and the fusion of their information content. Multisensory integration is more likely to occur under time and space coincidence constraints and it is enhanced by semantic and synesthetic congruency on multisensory information processing (Spence and Ho, 2015).

In the VR, XR systems the following sense related concepts are considered:

Embodied action (Varela, Thompson & Rosch, 1991: 172) highlights the notion that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and that these individual sensorimotor capacities are themselves embedded in more encompassing biological, psychological and cultural context. Sensory, motor processes, perception and action are fundamentally inseparable in lived action.

The sense of embodiment SoE term refers to the ensemble of sensations that arise in conjunction with being inside, having, and controlling a body especially in relation to virtual reality applications (Kilteni, Groten and Slater (2012). Kilteni et al. (2012) noted that Sense of Embodiment (SoE) in immersive virtual reality has allowed experiencing the same sensations towards a virtual body inside an immersive virtual environment as toward the biological body. They state that SoE consists of three subcomponents: the sense of self-location, the sense of agency (SoA), and the sense of body ownership (SoO). VR creates virtual embodiment (or just embodiment) through an illusory effect of transfer of the sense of body ownership (SoO), sense of agency (SoA), and sense of bodily self-location.

Kilteni et al. (2012) define the sense of self-location as one’s spatial experience of being inside a body and it does not refer to the spatial experience of being inside a world (with or without a body); for example, the experience of presence— specifically, Place illusion (Slater, 2009). Self-location is concerned with the relationship between one’s self and one’s body, an example of self-location could be the feeling that one’s self is located inside the biological body or an avatar’s body. Self-location is highly determined by the visuospatial perspective given that this is normally egocentric (Blanke et al., 2015). Vestibular signals are also considered to play a significant role in one’s self-localization (Lopez et al., 2008). These signals contain information with respect to the ‘‘translation and rotation of the body in addition to orientation with respect to gravity’’ (Blanke & Metzinger, 2009, p. 10). The tactile input also influences self-location since the border between our body and the environment is our skin. Multisensory integration is one of the main mechanisms behind the process of bodily self attribution, mediated by continuous monitoring of inputs from available sensory modalities (visual, proprioceptive, tactile, etc.),and their simultaneous processing to plausible image of the bodily self (Ehrsson, 2012).

Of special interest for the self-recognition is the process comparing a person’s intentions to expected sensory outcomes (Tsakiris et al., 2005), known in the literature as “central monitoring theory” of action recognition or the “comparator model” (David et al., 2008). According to this model, an initiated voluntary action is accompanied by its efference copy. For motor actions, this means that when bodily movement occurs, it is compared to the efference copy of the intent, if such intent existed. In case of match, the observed action is self-attributed, while in the case of afferent sensory signalling not preceded by a corresponding motor command, the observed action is attributed to an external cause (von Holst and Mittelstaedt, 1950; Jeannerod, 2007).

Personal space is the space our body occupies, peripersonal space is the space adjacent to the body that is within arms' reach, and extrapersonal space is the far nonreachable space (Halligan, Fink, Marshall, & Vallar, 2003; Vaishnavi, Calhoun, & Chatterjee, 2001, Kilteni et al. 2012). The extension of peripersonal space by tool use results in tool embodiment (Giummarra, Gibson, GeorgiouKaristianis, & Bradshaw, 2008).

Presence refers to the relationship between one's self and the environment, the feeling of one's self being located in a physical or virtual room, even if this does not require a body representation in the room (Kilteni et al., 2012). Heart rate correlates with the sense of presence (Yu et al., 2022). The work on body representation shows that VR can be used not simply for Place Illusion and Plausibility but also to change the self (Yee and Bailenson, 2007; Banakou et al., 2013; Kilteni et al., 2013; Peck et al., 2013).

The sense of agency (SoA) refers to the sense of having ''global motor control, including the subjective experience of action, control, intention, motor selection and the conscious experience of will" (Blanke & Metzinger, 2009, p. 7). Sense of agency (Blanke and Metzinger, 2009)

is often described in the context of control of motor actions; however, the SoA can be treated as a more general concept that represents a feeling of authorship of intent in the brain, covering also covert actions such as the capability to create a thought in the stream of thoughts (Gallagher, 2000, 2007). For the action recognition process, one must feel the SoA toward one's own actions.

When the predicted consequences of the action and the actual consequences of actions match by, for example, the presence of synchronous visuomotor correlations under active movement, one feels oneself to be the agent of those actions. This also applies for the embodiment of tools when these are under the control of the user. Agency depends on the synchronicity of visuomotor correlations. Several studies have shown that discrepancies between the visual feedback of the action and the actual movement negatively affect the feeling of agency (Blakemore, Wolpert, & Frith, 2002; Franck et al., 2001; Sato & Yasuda, 2005). In the study of Franck et al. (2001), a discrepancy of more than 150 ms was found to reduce agency.

Agency can be developed by tracking the full-body movements of the participant with a real-time motion capture system and applying the resulting motion to the avatar (Slater, Spanlang, & Corominas, 2010). SoA for bodily actions of virtual avatar is the essential principle behind virtual embodiment.

Body ownership refers to one's self-attribution of a body (Gallagher, 2000; Tsakiris, Prabhu, & Haggard, 2006). Body ownership is not exclusive to artificial body parts but can also be felt for artificial whole bodies; for example, avatars or mannequins (Normand et al., 2011; Petkova & Ehrsson, 2008; Slater et al., 2009; Slater, Spanlang, SanchezVives, et al., 2010). The sense of body ownership has been proposed to emerge from a combination of bottom-up and top-down influences (Tsakiris, 2010; Tsakiris & Haggard, 2005). Here, bottom-up information refers to the afferent sensory information that arrives to our brain from our sensory organs; for example, visual, tactile, and proprioceptive input, whereas top-down information consists of the cognitive processes that may modulate the processing of sensory stimuli; for example, the existence of sufficient human likeness to presume that an artificial body can be one's body, or the seen and the felt stimulation follow the same spatiotemporal pattern (Botvinick & Cohen, 1998; Shimada, Fukuda, & Hiraki, 2009; Tsakiris & Haggard, 2005). Individualised avatars could strengthen body ownership since this would also promote body and self-recognition (Kilteni et al., 2012). Body ownership illusions using targeted sensory manipulation can temporarily override perceived bodily image and cause partial or full body ownership transfer (first described in the rubber hand illusion, created by Botvinick and Cohen, 1998).

Sense of immersion with wearables and VR was studied in project WEARTUAL (WEARTUAL Designing and Developing Wearables for Virtual Reality Environments with a Research Through Design Process 2019-

2021). The relationships with sense of immersion and self-identity, hybridity, skin conductance, and social interaction features were explored in this project.

Sense of immersion indicates engagement together with feelings of Absorption, Flow, and Presence (Cioubotaru et al., 2017).

Virtual, augmented and mixed reality (VR, AR, and MR) can add to our surroundings a component which cannot be seen in reality and revive the ”genius loci” (the spirit of the place).

Sensorimotor contingencies refer to acts of perception by the participant that change his or her sensory stream while they integrate perception and action (O’Regan and Noë, 2001; Noë & Nöe, 2004).

Sensory motor contingencies include reaching out and touching, and receiving haptic tactile and force feedback stimuli (Slater, 2014). Sulema (2016) notes that sensorimotor contingencies may increase the speed and accuracy of visual search,and might reduce the mental workload increasing the attention attributed to a singular sensory modality. He argues that in mulsemedia systems, sensory inputs are integrated according to the temporal interval between the stimuli, and when the real-time data streams are transmitted over a network, the delay jitter may disturb the temporal relationship between the media streams. Sensorimotor correspondences may affect metaphorical understanding, feelings of “knowing,” behaviour, learning, and perceptual experiences.

Behavioural changes is one of the expected results from learning activities. Following the behaviouralist approach (Skinner, 1938), the learners may be prompted to move towards new expected behaviours by shaping that is the reinforcement of successive approximations to a goal behaviour with positive reinforcement, negative reinforcement or punishment, whereas chaining serves to establish complex behaviours made up of discrete, simpler behaviours already known to the learner (Driscoll, 2005, p. 44-48). Behavioural training also requires the fading stages in which the stimuli (sensory cues) used to initially establish the desired behaviour are withdrawn.

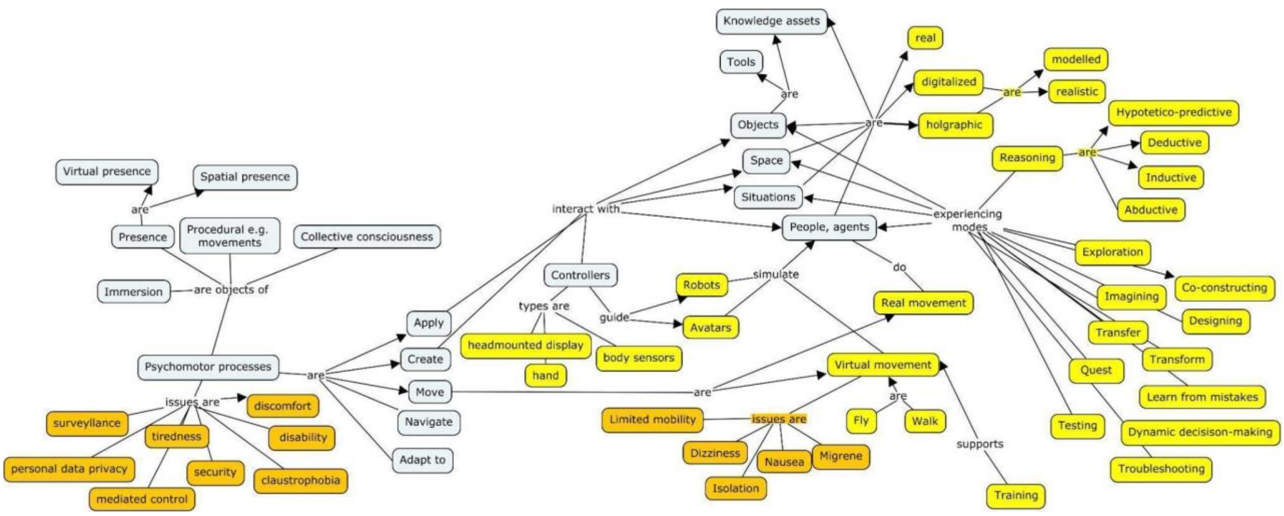


Figure 9. the overview of the psychomotor related learning effects and design elements

4.2.2.5. The overview of the learning opportunities and gaps with disruptive technologies

Our literature analysis indicates that practice based learning models, student interactivity, learning support and social dimension in learning environments with disruptive technologies so far have followed a rather traditional approach not yet systematically disrupting education towards active learning practices. Similarly Feldon et al. (2022) noted in the recent Multimedia handbook of learning that interactivity is not more effective on multimedia than others in contexts of learning.

In the handbook of Multimedia learning (Mayer and Fiorella, 2022) the experimental studies have validated some of the principles why processing different types of media (text, audio, images, diagrams, animations, videos) may be difficult for the learners. Our literature analysis indicates that theoretically explaining the processing of multisensory mulsemedia in disruptive learning environments and collecting evidence of its combined effects on cognitive, metacognitive, affective and psychomotor and embodied learning are not well studied. There is still a lot of technology optimism without strong evidence based knowledge of how technology learning affects learning. Below we combine the findings of our literature research with the findings of the recent generalisations about the multimedia learning studies (Feldon et al., 2022). The recent handbook of Multimedia Learning (Mayer & Fiorella, 2022) presents a chapter of mistaken principles that multimedia learning design has used, that empirical evidence has validated negatively (Feldon, Clark and Jeong, 2022).

There continues to be no credible evidence of learning benefits from any medium or combination of media including classroom teaching or multimedia teaching that cannot be explained by other, non media factors - both multimedia and physical learning situations are equally effective to learning (Feldon, Clark and Jeong, 2022). The studies in our sample papers compared rather the situations in which comparisons were made of the learning effects between different multimedia situations, such as web-based simulations and interaction with the multimedia in the space. Feldon et al. (2022) noted that the empirical data to validate that virtual laboratories with multimedia are better in learning gains compared with physical experimenting has not been validated. The empirical evidence in our sample of papers did not always indicate which forms of learning with disruptive technologies are more effective (see Johnston-Glenberg et al., 2020; Di Natale et al., 2020; Makransky et al. 2019; Zhang et al., 2020; Arayaphan et al., 2022; Yang & Goh, 2022).

Feldon et al. (2022) note that learning effects of discovery learning with multimedia come from prior knowledge of expert learners, while the novice students benefit more from provided guided instruction. We found very few papers in which the previous expertise level of learners was considered comparatively in the studies with disruptive technologies.

Feldon et al. (2022) noted that multimedia instruction should be presented in learner paced segments to improve performance and reduce cognitive load. In our sample of the literature of interactive media environments (VR, AR, XR, MR) we found frequent claims but only some empirical evidence about the cognitive load issues that disruptive technologies might cause in the working memory information processing (Di Natale et al., 2020; Bahari, 2021). The chatbots as cognitive agents were effectively used (Kuhail et al., 2022; Bahari, 2021) to improve students' attention, and the students did not show problems in focusing at more in-depth details in interactive media environments of disruptive technologies. We found evidences of several cognitive learning issues such as distractions when learning with AI based chatbots (Qin et al., 2020), not paying attention to learning objectives in virtual reality (Arayaphan et al 2022), being too much adsorbed in the simulations (Ebadi & Ebadijalal, 2022; Bhagat & Huang, 2018), feeling bored in the virtual reality that is frequently used, or having fatigue (Chen, 2021; Johnston-Glenberg et al. 2020), the usage of popups distracting students (Kuhail et al., 2022) and having integration difficulties (Bahari, 2021). Visual and sound level challenges, and reading speed issues were faced by some students who had specific impairments.

Feldon et al. (2022) noted that the research of digital pedagogical agents aiding learning has indicated some effects on retention of learning, yet there is not sufficient research to claim the agents' premise beyond traditional teachers. In our literature sample of studies we found examples of the effect of gamified feedback provision in disruptive environments to be helpful for retention (Rey-Becerra et al. 2021; Zhang et al., 2020). The supposed effects of the immersive media environment to embed and anchor more cognitive information (Baceviciute et al., 2021) and therefore to be helpful for activating learners' prior knowledge and prompt the memory recall capacity were proposed but not validated (Asad et al., 2021).

Students' understandings were found to be improved (Baceviciute et al., 2021; Yang & Goh, 2022, Di Natale et al., 2020), that could be influenced by more realistic and authentic and interdisciplinary and with greater complexity situations in disruptive and gamified environments using narratives in serious games (Eiris et al., 2020; Dehghanzadeh et al., 2021; Erdogmus et al., 2021; Bahari 2021; Cooper et al., 2020; Galeote & Hamari, 2021; Buijs-Spanjers et al., 2020), viewing body language (Akgün & Atici, 2022), picking up objects and examining these (Di Natale et al., 2020; Chen, 2021), AI chatbots asking questions (Kuhail et al., 2022), the interaction with people and group work in the virtual environment (Yang & Goh, 2022), experiencing VR time and space (Li et al., 2022) and the opportunities to make choices and correct their own mistakes in gamified mode (Bourke, 2020). The virtual environments have been praised for increased object visualisation opportunities (Zhang et al., 2020) and presenting non-existent things (Barrett et al., 2021).

We found no studies about developing misconceptions in the interactive media environments that would relate with the level of authenticity instead of misleading modelling. One study that indicated that abstract conceptual understanding could be improved (Di Natale et al., 2020). In another study the issues of signifying objects in virtual reality was highlighted that caused difficulties to remember semantic information (Ebadi & Ebadijalal, 2022). The negative design elements may be gamified competitions for points through multiple assignments (Bourke, 2020), being tested.

We did not find any studies exploring empirically beyond the individual level of cognitive learning - no group cognition aspects were explored such as conceptual shared understandings, coherence etc.

There is no scientifically valid evidence of the benefit of matching instruction to preferred learning style (Kirschner, 2017). Yet, in the empirical studies we found attempts to relate learning style with students' AI empowered learning (Kuhail et al. 2022).

Feldon et al. (2022) noted that the belief of personal presence and social presence in virtual multimedia training environments to enhance learning outcomes has not been sufficiently validated. We found an empirical study (Yang & Goh, 2022) that assumed that interaction with people gave a deeper impression of the learning content. Being anxious of losing face in front of their classmates when asked to perform while the whole class was present (Yang et al., 2020), social comparison pressure and interpersonal communication difficulties (Chan et al., 2020) asymmetric team interactions (Divekar et al., 2021) interacting with avatars without facial expressions replacing students (Chen, 2021), possible cybersecurity threats were negative social presence and privacy related aspects in virtual environments (Dwivedi et al., 2022).

The negative effects of learning were perceived often as bodily effects, such as feeling tired or physical discomfort (Leenaraj et al., 2021; Bahari, 2021), dizziness (DeWitt et al., 2022; Chang & Hwang, 2021), motion sickness and nausea (Munafo et al., 2017; Elzie & Shaia 2021) and migraine (Elzie & Shaia, 2021). Sometimes the lessened opportunity to talk or move and operate bodily was indicated in virtual environments (MacWhinney, 2017; Eiris et al., 2020; Clack et al., 2021). This may have an effect on cognitive learning such as auditory information retention (Di Natale et al., 2020). Also there were issues in interpreting micro-gestures in virtual environments (Dwivedi et al., 2022). Other types of negative effects of cognitive learning in disruptive environments were of the affective kind: emotions like fear (Rey-Becerra et al., 2021).

Metacognitive learning was less frequently studied in the sample of research papers that we observed. To support metacognitive learning with disruptive technologies highlighted the learner autonomy in virtual environments (DeWitt et al., 2022; Li et al., 2021). The instructional design elements such as experiencing different role perspectives (DeWitt et al 2022), debriefing for developing insights (Clack et al., 2021), self-reflection and feedback from teachers (Kuhail et al. 2022), peers or virtual characters (Villegas-Ch et al., 2020; Buijs-Spanjers et al., 2020) were considered important to understand one's actions in virtual reality and games. Self-efficacy was one of the measured constructs related with the metacognition and affections (Asad et al., 2021; Bahari, 2021; Chen et al., 2021; Elzie & Shaia, 2021; Erdogmus et al., 2021). Secondly, development of self-regulation skills (Drigas et al., 2022; Chen & Hsu, 2020) with the scaffolding prompts (Chen et al., 2021) was associated with better attention, attentional awareness and cognitive practice in virtual environments (Drigas et al., 2022). The virtual environments were associated with negative emotions and lower perceived self-control (Dozio et al., 2022). Monitoring of students' interactions with AI that prompted students to give feedback was considered an important instructional design element (Villegas-Ch et al., 2020). Practising specific dialogic interactions triggered by specific scaffolding prompts provided by chatbots (Kuhail et al., 2022; Dhimolea et al., 2022) or characters in the virtual world (da Silva, 2021) were found to improve students' communicative abilities and develop students' identity (da Silva, 2021). Embodying a character in virtual reality, interactivity and game elements made participants more involved, because it gave them a feeling of control over the course of the narrative (DeWitt et al., 2022) and increased learners' confidence (Erdogmus et al., 2021) and agency, which may lead to improved learning outcomes (Zheng et al., 2012).

In Cambridge handbook of Multimedia Learning Feldon et al. (2022) noted that: "multimedia is not more motivation to learners than other instructional media. The multimedia simulation based and classroom based instructional situations show no difference in students motivation, learning or transfer - the unique capacity of multimedia to provide learning benefits in the form of authentic applications are mistaken. The claim of increased motivation from multimedia based gamification has not been sufficiently validated." In our sample of research paper we found that realistic elements in virtual reality environments (Akgün & Atici, 2022; Dwivedi et al., 2022), self location within the story environment (Cummings et al., 2021), affective scaffolding with AI chatbots (Kuhail et al., 2022), social interaction in virtual environments (Hayes et al., 2021) co-presence among users (Cummings et al., 2021), gamification (Dehghanzadeh et al., 2021; Gündüz & Akkoyunlu, 2020), and formative assessment in virtual environments (Zhang et al. 2020) were increasing learners' motivation (Asad et al., 2021) and in some cases also cognitive processing and performance (Ummihusna & Zairul, 2021; Cummings et al., 2021). The negative emotions were decreased by virtual world anonymity (Bahari 2021); attentive and curious AI chatbots telling jokes and fun facts (Kuhail et al. 2022); fun feeling from gamification where to explore different options autonomously (Bourke, 2020; Buijs-Spanjers et al., 2020), collectivistic versus individualistic user orientations that moderate the effects of value on attitudes in a gamification context (Hsu & Chen, 2021), the avatars that help to allay worries about being judged negatively (Chen et al., 2022), open communication processes (Elzie & Shaia 2021), small group learning immersive experience (Bahari, 2021; Dhimolea et al., 2022) and interactive switching of scenarios improving learners' autonomy, active engagement, and collaboration with partners (Bahari, 2021). It was reported that the participants feel less nervous in the virtual classroom (Chen, 2021).

In our analysis we looked for what learning effects were found with disruptive technologies for learning, and what were the potential design elements that have supported this learning.

We noticed that there were very few studies that focused on the collective level learning phenomena, such as shared cognition, culturally defined learning, and shared metacognition. The mainstream pedagogical approach was situated knowledge acquisition and skill training in problem solving context.

Psychomotor and embodied learning effects are the least studied in multimedia learning design and in the current VR, MR, AR, XR technologies because the sensorimotor contingencies such as immersion, spatial and virtual presence, spatial location, identity have not been strongly related with the traditional cognitive and metacognitive, affective and psychomotor learning effects that are currently mainly considered as more important learning outcomes. There are not enough studies of the mulsemedia about how multisensory inputs and information processing takes place. These sensorimotor contingencies of the body are not yet well understood, but it is assumed that cognitive and physical involvement is interrelated in virtual environments (Dhimolea et al., 2022). The virtual reality environment, or augmented reality is formulated as a sensory-motor contact with the world, with the organ serving as the mediator in the process. It is the sensation and vision organ and the kinesthetic structure that constructs knowledge and allows for complete body interaction, allowing users to visualise the world by perceptual learning (Kuhail et al., 2022). VR is supposed to activate the brain to support a user's natural inclination to engage sensorimotor contingencies (Dwivedi et al., 2022). There are some design suggestions that narratives, authenticity realism and interaction with the virtual environment and augmented reality might be improving the sensorimotor contingencies (Akgün & Atici, 2022; Govender & Arneda-Moreno, 2021; Argyriou et al., 2020), the self-evaluation of performance (Govender & Arneda-Moreno, 2021), the egocentric view of the user (Barrett et al., 2021) in the centre of the space are also believed to be developing these sensorimotor contingencies and might improve the skill transition. Psychomotor and embodied learning effects with disruptive technologies relate with some negative physical discomforts that some learners perceive - motion-sickness, dizziness, claustrophobia, migrain (Ciubotaru et al., 2017; Radianti, 2020; Akgün & Atici, 2022; Bahari 2021; Coban et al., 2022; Di Natale et al., 2020; Arayaphan et al., 2022; Li et al., 2022; Elzie & Shaia, 2021) or identity or reality confusion (Kilteni et al., 2012). Simulated movement and real walking is suggested as a remedy instead of flying in virtual spaces (Coban et al., 2022; Dreger & Ticknor, 2022), also it is important to have human bodily features like the number of limbs, size (Kilteni et al., 2012), the virtual world should not outsize the available physical space (Clack et al., 2021). Sensorimotor and behavioural learning causes some accessibility problems for people with visual, motor, hearing and cognitive impairments.

4.3. The values and sustainability issues of using disruptive technologies

Disruptive technologies such as artificial intelligence, robots, virtual and augmented reality are extending the limits of how learning is or may be possible. The values how people perceive these technologies relate with their experience with this technology but also the culture related values have impact on how technologies are perceived. New technologies are often developed and require the establishment of new norms. The normalisation process of establishing values of how technologies are conceptualised builds on positive and negative use cases with the technology that are often mediated by media and social media, and on the empirical validations of the technology in practice that very often is out of reach of practical users. The value formation also incorporates personal values and beliefs about the functions of the technology, that in turn may depend on whether disruptive technologies are seen as an extension to existing practices or as the threat to disrupt learning and teaching practices at a deeper level, that people, professions and organisations may not be ready at.

We conducted 8 workshops (see Annex 2) in partner countries to explore the following research question empirically:

RQ 4: What ethical and sustainability dimensions do people associate with the learning scenarios with disruptive technologies?

We used in the workshops the instrument with 45 values to elicit values in discussions about 4 learning scenarios in which disruptive technologies were used. We collected the values of people associated with four different learning scenarios with disruptive technologies. It was also possible to add own values in the process of the workshop. The frequency analysis of the values was conducted associated with each scenario (see Figure 10)

In the end 59 values were described by the participants. The highest frequency to be considered important while working with disruptive technologies were the values of accessibility, adaptability, autonomy, trust, control, coercion, surveillance, but also accuracy, responsibility, and sustainability. The value dimensions that occurred in all four scenarios (flexibility), or in at least three scenarios (accessibility, connectivity, vulnerability, trust, involvement, autonomy, control, surveillance, challenging, effectiveness, productivity, accuracy, sustainability, and satisfaction) indicate the value perspectives that meant most to people when they saw the learning scenarios with disruptive technologies. Proportionally in all workshops in different countries about the same number of values were mentioned. Some trends of mentioning some values more often in specific countries could be observed with the values of coercion, accuracy and accessibility, but due to the small sample size in the dataset we could not confirm country-specific differences in the values.

The analysis of the values mentioned in case of different learning scenarios revealed (see Figure 10) that some types of scenarios such as learning with VR and AR were perceived in relation to larger number of value dimensions, compared with the scenarios of AI and telepresence robots. We also noticed that in the latter two scenarios, there were more concern-related values, such as trust, vulnerability, equity, fairness, and autonomy. However, the negatively connotated values such as confidentiality, privacy, coercion, control and surveillance were also perceived in regards to scenarios with augmented reality (AR) and virtual reality (VR), and not only with AI.

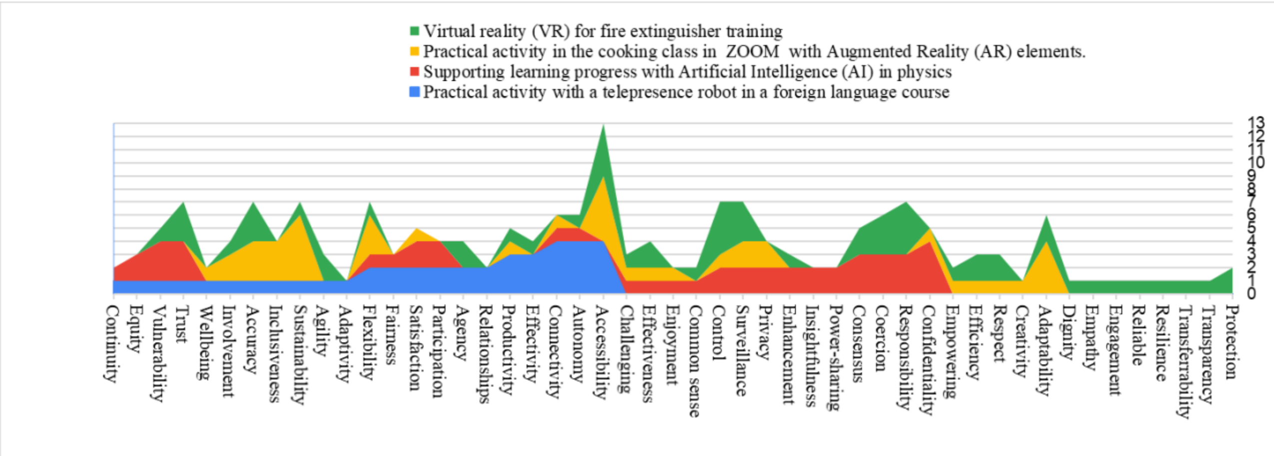


Figure 10. The frequency of value dimensions mentioned in case of different types of learning scenarios

We analysed qualitatively the value-usage contexts in the propositions about the learning scenarios. Table 1 provides an overview of the critical issues related with learning management, technical environments and learning process. This approach demonstrated that understandings of the learning potentials of the disruptive technologies are not clear to users. The needs coming from future workplaces to use disruptive technologies, and the opportunities to keep learners more engaged and motivated were seen as drivers of designing new practices with disruptive technologies in education. The designing complexity, the skill-demanding nature and the costs were perceived as threats of disruptive technologies accompanied with the belief that the built environments may be rigid as learning places, and may decrease the teachers' and students' flexibility in planning the learning. The values workshop revealed a number of physical and societal concerns that using disruptive learning environments creates. These perceived values need to be considered when developing learning designs, as we will propose in section 5.

Table 1. The value-related reactions to the disruptive technology scenarios

Category	Subcategory	Example
LEARNING MANAGEMENT ASPECTS	Learning objectives may be blurry due to games. Learning contracts should be made.	*Possibly hindering achieving learning objectives.* *Participants might take the learning process as a game.* *VR is a game. Use it seriously.* *Potential distraction from learning.* *Students should be informed in advance and agree about learning objectives and results obtained with the experience.*
	Effectiveness is unclear. The	*It is hard to make statements on whether these techniques could be effective.*

	resource- and time-effectiveness.	*There is doubt on whether the real benefits of VR are utilised in this scenario.* *The satisfaction of the teacher is supported by the fact that it does not require additional obligations from the teacher, e.g. the study can take place for all students at the same time (there is no follow-up, etc.). The teacher in this case also wins in time.* *It is effective because a class can be conducted with very few resources.*
	Learning content richness, augmenting.	*An opportunity to better illustrate the topic (illustrating bacteria, pointing out dangers).* *VR could be used for enhanced illustration of the theoretical lecture.* *Augmented reality allows for the creation of more realistic learning situations.*
	Enabling diverse learning activities is expected.	*Ability to do different activities with the same tool, to make presentations, have conversations between different moments, etc.* *The tool can be used in various educational situations and disciplines, assuming it can be easily modified/extended.*
	Usability is out of teacher-student control.	*The responsibility lies with the designers, they have to be sure of the technical serviceability of the devices, with which students work.* *The VR environment is not necessarily usable by everyone.*
	Teacher-designed, teacher controlled process.	*The teacher has control over the entire process including pre-work.* *System must be controlled by the trainer, in terms of scenario, fire placement, etc.* *It is very important for this activity to be controlled by external persons so there won't be issues.* *Make consistent decisions based on the elements and properties of the scenario.*
	Rigidness of scenarios is a threat.	*Pre-prepared scenarios hinder flexibility.* *Students should be in a position to predict the results of an experiment.*
	Adaptability and responsiveness are expected.	*Adaptation to changing environmental conditions.* *Technology allows you to quickly respond to unexpected changes.* *Adaptability to the VR environment, adaptability to the classroom.* *Optimization of available elements and time in the quickest possible way.*
	Personalization is expected.	*It is possible to switch the room or method if the conditions of the participants change.*
	Accessibility and adaptation to learner needs, impairment tool functionality.	*It allows access to educational resources regardless of geographic distance and economic resources.* *The scenario is developed in an accessible language and the possibility of personal adaptation to the individual needs of the learners.* *People with disabilities have the same learning experience.*

		It can aid people with physical impairments, as it might be more accessible to people with limited motor skills. It doesn't come out how special needs (hearing impairment, visual impairment, ATH) are taken into account. The student can be home due to illness, distance, disability etc, and still be able to participate in the lesson.
	Development tools must be available.	*This requires suitable development tools to be provided for the users.*
	Learner-centred experience.	*Provides the participant with increased control to cope with unexpected and dangerous situations through gaining experience. Each of the learners has the opportunity to practise self-reflection on their own achievements, which creates prerequisites for personal satisfaction with the process."*
	Facilitator and student ICT skills are needed.	*There must be prior knowledge for the trainer eg. light intake in glasses (lenses burn out), training for the user is also required in advance. The lecturer must be ready to undergo training in advance The ability to observe 7 learners in the role of a gamer [...] On the other hand, the learner requires technical skills, tools (for example, internet speed; equipment).*
	Consent and feedback from users are required.	*Students should be informed in advance and consulted after the experience. Physiological data falls under the scope of sensitive data, and their collection is regulated by law, and for the collection must be subject to multilateral consent - parent, learner.*
	Resilience	*Online learning during a pandemic, other unexpected circumstances.*
	Inequality	*All users have access to the same assets. Do all schools and/or pupils have the necessary technology available (sufficient connection or technology)? May be undesirable for older learners, so they have limited availability. This is often not possible for reasons concerning the situation of the students: health risks, disabilities, financial possibilities.*
	Technology aided assessment	*The initial assessment comes from an AI that is not influenced by the teacher's emotional background in relation to the student. Draw conclusions and/or make assessments about the learner's learning experience based on physiological data. The teacher uses the technology to check the learner and draw conclusions and/or make*

		assessments about the learner's learning experience based on physiological data.
	Time-consuming	*The group process of strangers or little-collaborated learners (group collaboration) takes more time virtually than being physically together.*
	Costly	*Preparation is costly.*
	Sustainability	*Augmented reality allows the students to practise without the physical waste of food.* *At the environmental level you can be anywhere without having to travel.* *Since learners (and faculty) can be located in different areas, it saves resources related to transportation.* *System reusable for other courses.* *The tool provides opportunities for teachers to use virtual resources that would not be possible to use in physical format.* *VR makes it possible to eliminate sources of danger and expenditure of environmental resources.*
HUMAN RISKS	Legal compliance	*Complying with legal requirements would be complicated.*
	Success	*Teachers should take feedback data with a grain of salt, and use it as a guide to enhance natural cooperation between students and teachers, not as a silver bullet for measuring the success of teaching.*
	Distressing situations	*It improves the response time in unfavourable situations* *it is possible to experience the dangers already in several options and think in a safe environment*
	Failure	*All participants must be open to success as well as failure, and be resourceful in handling unexpected situations.*
	Pressure on learners	*The pressure to be productive all the time.*
	Resistance	*In order to overcome resistance from students/parents they should be prepared in advance.*
	Distrust	*Lack of trust. The use of its technologies (sensors and trackers) in this learning scenario is not justified and there is no link to the learning content.*
	Assurance	*How is confidentiality established? Is a teacher - who is not a psychologist, lawyer, or medical professional - properly trained to establish such a role of confidentiality?* *The confidentiality of the discussion is guaranteed because it is available to the teacher.*
	Cyberbullying	*The teacher is not protected from cyberbullying (e.g. a robot has a magnifying function that can zoom in on a person in a big way).*
	Unwanted exposure, vulnerability	*It can also hurt the way someone performs the task, people may experience a sense of inferiority from it.*

		Watching performance by others is perhaps questionable. *Observing from the outside can be inconvenient for a participant.* *Students can feel more "bold" as robots and indulge in more than is ethical.*
	Security	*The learner's lack of security and the data are not reliable.*
TECHNOLOGY RISKS	Control	*There is no control if something happens to the robot on the spot.*
	Personal data, data management and risk assessment	*What if the student does not wish to share this incredibly sensitive information? Deeply personal biometric data is utilised.* *One cannot be sure who has access to the digital data in the system.* *It is not clear how the teacher, given collected data, applies this data in a manner that remains fair.* *Further, to what end can the data be used that was not originally intended in the scenario?* *Where and for how long will the data be stored and who will have access - who guarantees that it will be deleted at the agreed time?* *What prevents the data from being misused?*
	Connectivity	*By connecting to a device we can easily reconnect*
	Monitoring, surveillance	*He feels that he is being controlled and watched.* *Conducting the process allows the teacher to control the student's activities in the room in real time and immediately give feedback.* *Surveillance could be ensured by chatbots, too, if the number of students is too high compared to the number of teachers.*
GROUP LEARNING AND INTERACTION ASPECTS	Learner-facilitator interaction	*It is important for the participants, students, educators alike to make a connection and be able to communicate effectively.*
	Learner-facilitator relationship	*The initial assessment comes from an AI that is not influenced by the teacher's emotional background in relation to the student.*
	Support	*The teacher can use the results of AI to support the learning process and thereby flexibly respond to the emerging needs of the student or group.*
	Peer interaction and peer learning	*Users can interact with peers.* *Lessons can be learned from the experience of others.*
	Social learning	*A great way to build relationships between learners and have a more social aspect in language learning.*
	Connectedness	*The learner should not feel alone, because he has three parties with whose support to "amplify" (fellow learners, lecturers, robot).*
	Empathy	*Empathy of the trainer lets them provide better guidance to the trainee.*

		Empathy of monitoring agents towards the trainee lets them learn and put themselves in the trainee's place.
	Collaborative learning	*They work in groups for learning tasks.* *The student is alone and with the other in the group, the student should be prepared to cooperate too*
	Participation, involvement	*Be adequately prepared from home, so their participation will be as easy as possible during the lesson.* *A simulation provides more involvement than "just" a theoretical introduction.*
	Role distribution	*During the session, there is a distribution of roles and groups.*
	Needs of the group	*The teacher can use the results of AI to support the learning process and thereby flexibly respond to the emerging needs of the student or group.*
	Mutual respect	*Mutual respect is promoted, since each person shall respect its own right and boundaries but also the people around them.*
	Class dynamics	*The use of technology can make the class more dynamic so the student enjoys the teaching and pays more attention*
	Body language	*Conveying the body language of the user (teacher) to the people (students).*
	Communication	*Telepresence allows continuous communication with people abroad, which allows for longer contact*
	Interaction with environment	*The user has the option to interact with the environment.*
	Feedback	*Students can try their own strategies and receive instant feedback from the simulation and from the instructor.*
	Competition	*Situations where pressure or competition may arise would probably work better.*
	Group dependance	*Overestimation of one's own abilities might occur or an unrealistic dependance of the collective.*
	Mutual responsibility	*Students should be aware about their responsibility and role and agree with each other and support decisions together.*
	Power relations	*Supervisor VRs have too much control, forcing the participant to enter an unpleasant situation.*
	Obeying	*it is fundamental for the person to obey the instructions given, and therefore practise responsibility to their role.*
	Collective decision-making	*Important so all the agents to be in agreement with each other and support their decision collectively.*
COGNITIVE LEARNING EFFECTS	Attention	*When focussing on one modality (e.g. visuals), there is a risk of paying less attention to others, e.g. narrative.*
	Cognitive load	*They have more physical effects as VR changes basic needs, shifts the emphasis away from learning, to exist in this VR space, and simultaneously learning, guidance, coping with*

		crises can create cognitive overload, especially in some age groups presumably.
	Knowledge	*The knowledge that will be given through this value is important.*
	Memorization	*It is possible to use creativity/humour to illustrate the "consequences/dangers" (potentially increases memorization).*
	Knowledge transfer	*Therefore, all involved parties (e.g. students, teachers) are supposed to agree that learning with these AI techniques benefits the depth of knowledge transfer.*
METACOGNITIVE LEARNING EFFECTS	Overestimation	*Overestimation of one's own abilities might occur*
	Autonomy	*Students can try their own strategies and receive instant feedback.*
	Learners needs	*It may not be suitable for everyone to act before the eyes of others, including their own group members.*
	Self-regulation	*The students can follow the lesson at their own pace and place.*
	Agency	*It enables each of the learners to participate equally with ideas and activities.*
	Performance	*Agents have to act accurately in order to get good feedback (by the system and the trainer).*
	Confidence	*It allows you to be more confident in a real situation*
	Reflection	*It includes significant debriefing and practising after the VR experience in real life.*
	Safety	*It is important for everyone's mental safety to be ensured.*
	Enhancing confidence	*Practising in a virtual environment can provide self-confidence to solve the problem*
AFFECTIVE LEARNING EFFECTS	Motivation	*This creates prerequisites for the active participation of students with different levels of knowledge, skills, and motivation.*
	Interest	*all the parties involved, (students) should be interested for the topic and be adequately prepared from home*
	Involvement	*It is possible to look at the participant in VR glasses and be involved even without glasses, giving advice, this creates a situation from several points of engagement.*
	Engagement	*There is an extension to engage students (in the second part of the lecture) by providing channels for communication between students.*
	Satisfaction	*From the learner's point of view, satisfaction arises from the aspect of involvement in studies* *If the student is forced to stay away from study for a longer period of time, then participating in the*

		study through a robot offers him satisfaction (there will be no lag behind).
	Negative emotions	*not feeling at ease. May create a negative experience.*
	Wellbeing	*Emotional well-being is disturbed.*
	Enjoyment	*The use of technology can make the class more dynamic so the student enjoys the teaching and pays more attention*
PSYCHOMOTOR EFFECTS AND HEALTH	Awareness	*Students should be aware about their responsibility and role.*
	Multisensorial environment	*VR also allows you to experience different spaces/environments. All that is missing from the real Realistic experience is the smell, the temperature.*
	Spatial limitations	*Availability may be limited by the size of the space required at the same time.*
	Perception of space	*Having glasses on loses the sense of space, may cause getting scared more easily and losing the sense of space might cause dangerous situations.*
	Personal space	*through showing elements of the place/environment (for example kitchen) there is infringement of privacy.*
	Personal boundaries	*Mutual respect is promoted, since each person shall respect its own right and boundaries but also the people around them.*
	Presence	*The students will be able to control as if they were in the classroom both the movements and the activity that has to be done in the physical place.*
	Shared space	*Further efficiency could be derived from visualizing instructions in the virtual space, and even operating together in a shared virtual space.*
	Safe environment	*It is possible to experience the dangers already in several options and think in a safe environment Improvement and training of skills without physical risk.*
	Movement	*Students are not expected to sit in "Prussian" static front-facing rows, but are allowed free movement. Limitations of technology - e.g. robot movement problem in extreme conditions.*
	Sense of balance	*Already turning around and looking at the picture might lead to losing sense of balance and cause nausea.*
	Nausea	*Already turning around and looking at the picture might lead to losing sense of balance and cause nausea.*
	Misleading	*Can there be mislearning (e.g., illustrating things wrong)? Will the boundaries of the real world/real disappear.*

	Skills	*Training improves skills to cope with demanding experiences.*
	Multi-level skill acquisition	*The acquisition of theoretical knowledge is supported by multi-level cognitive experience, providing an opportunity to experience the described (hazard) situation in a vital/ realistic way*
	Performance improvement	*We don't know if VR glasses can increase performance, that in a real situation, learners are better prepared to respond to a threat thanks to VR tools*
	Behaviour	*VR situations may not be transferable to actual behaviour.*
	Speed of reaction	*VR can train response speed.*
	Health issues	*The availability is limited by vr glasses, e.g. the technology is not available to everyone (including those used for health reasons)*

4.4. The training ecosystem capacity for using disruptive technologies in practice based e-learning

4.4.1. The survey methodology

The evaluation of the training ecosystem capacity for using disruptive technologies in practice based e-learning was done using the international web based survey approach in partner countries.

Research questions:

RQ 5. What is the capacity of educational institutions in countries to perform practice based e-learning with disruptive technologies?

RQ 6. What are the main gaps in the capacity to perform practice based e-learning with disruptive technologies?

Sample. We planned that in each region (Spain, Bulgaria, Estonia, Italy, Hungary, Cyprus, Netherlands) 10 higher and higher vocational, and vocational education providers will be contacted. In each institution we planned to access: 10 lecturers or researchers who have experiences with some forms of group-learning or practice based learning (100 per country); 20 students from the institution who have experiences with some forms of group-learning or practice based learning / to be spread among each institution, so that different areas students respond, these should not be one group from one class only) (200 per country); Technical and didactical support staff 3-5: educational technologist, IT or technical support specialists, lecturers responsible for technology training, Digital policy administrative specialist (30-50 per country). Three samples of datasets were to be formed when data were to be obtained: the specialists, the educators and the students.

Validity and reliability. We faced difficulties in collecting the data following the initial plan. In the Netherlands, the ethical committee refused to give permission to conduct the survey. The reached sample in 6 countries was considerably different from the planned. The answers were collected totally from the following number of the specialists (N=96), about 30 % of the expected sample, the educators (N=351) about 29 % of the expected sample, and the students (N=516) about 29 % of the expected sample. Below we present the final sample in the countries (regions) (see Table 2). Proportionally, in web-based surveys the reached sample size is at the acceptable level (above 25 %). The generalizability of the data is limited due to the sampling structure: we did not attempt to reach regional coverage because countries in our sample differ greatly in size and we had limited resources for large scale analysis.

Table 2. The sample distribution among different types of respondents.

Role	Country	Total (N)	%
Expert	Bulgaria	6	6.25
	Cyprus	0	0
	Estonia	11	11.45833333
	Hungary	3	3.125
	Italy	9	9.375
	Spain	67	69.79166667
	Total	96	100
Lecturer	Bulgaria	34	9.686609687
	Cyprus	11	3.133903134
	Estonia	19	5.413105413
	Hungary	29	8.262108262
	Italy	28	7.977207977
	Spain	230	65.52706553
	Total	351	100
Student	Bulgaria	77	14.92248062
	Cyprus	7	1.356589147
	Estonia	49	9.496124031
	Hungary	47	9.108527132
	Italy	87	16.86046512
	Spain	249	48.25581395
	Total	516	100

In Estonia responses were collected from 9 institutions (3 vocational schools and 6 HEIs). In Estonia there are totally 18 HEIs and 35 vocational education institutions, thus about 16 % of all institutions were reached.

In Bulgaria responses were from 3 institutions (all HEIs).

In Cyprus responses were from 3 institutions (all HEIs).

In Hungary responses were from 6 institutions (1 vocational school and 5 HEIs).

In Spain responses were from 116 institutions (28 high schools, 41 vocational schools, 47 HEIs).

In Italy responses were from 9 institutions (4 HEIs and 5 social enterprises).

Our partner countries are of very different sizes, and the total number of relevant educational institutions differs greatly. We can estimate that the data of Estonia and Spain form a representative sample of the learning institutions in the region, whereas the data of Italy, Bulgaria and Hungary do not.

Since the educational institution systems are different in the countries we also present the distribution of dataset across the institution types (see Table 3).

Table 3. The distribution of sample sizes among the types of educational institutions in the countries

	High school	Vocational school	Higher educational institution (HEI)	Social enterprise	Total
Bulgaria	0	2	115	0	117
Cyprus	0	0	18	0	18
Estonia	0	4	69	0	73
Hungary	0	17	64	0	81
Italy	0	1	113	10	124
Spain	110	135	307	0	552
Total	110	159	686	10	965

Survey instruments. Three survey instruments were developed to video the capacity from the perspectives of technology providers, educators and learners. The instruments contained the following dimensions

I. General data
II. The capacity elements to teach with disruptive technologies:
- Tools, software and infrastructures - opportunities and constraints from national and institutional infrastructures and tools that promote applying disruptive technologies (T)
  - Infrastructural principles
- Agendas, norms, rules and regulations and roles, funding - constraints and support from national or institutional practices, norms, regulations, curricula that promote applying disruptive technologies (A)
  - Agendas, strategies
  - Roles and responsibilities
  - Regulations, policies
  - Incentives
  - Funding
- Community - collective development of the capacity, embeddedness of sociocultural elements, teaching practices, the value constraints of the professional community, alignment to learners' expectations (C)
  - Teaching and Learning practices
  - Alignment to students
  - Social capital building
  - Communities of practice
  - Support
  - Training
- Personal level - values, attitudes, experiences, competencies related to disruptive technologies (P)
  - Competencies
  - Values, beliefs and attitudes
  - Intentions/ goals, impact

Most of the survey items were presented at likert scale (Strongly disagree -1; Somewhat disagree - 2; Neither agree nor disagree - 3; Somewhat agree - 4; Strongly agree: Do not know - 6). Different respondents (specialists, educators, students) had partially overlapping survey items.

See for more about the survey structures in Annex 3 that is provided in excel sheet.

We formulated the survey questions to the respondents similarly, but the questions were not identical. The differences may be seen in the whole survey structure. Also not all the respondent groups (technology expert, teacher or student) had to answer the same set of questions, but specific questions were answered by several respondent groups. This allowed us to compare the specific items' responses.

Survey full structure is provided in the excel table of Annex 3.

The instrument was directly tested out with the whole sample due to the tense time limits of the study.

The instrument scales were validated with reliability analysis as presented in Table 4. Lower alpha values relate with the constructs where specific respondent groups had few questions (students -technology and norms items).

The lower reliability has the group of disruptive technology critical values' related questions: P 11-Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much resources (time, money, energy consumption, natural resources etc.); P12 - Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much staff training/relearning; P18 Disruptive technologies (VR, AR, AI, robots etc.) should be used in learning only if they brings additional value to the learning process.

Table 4. Chronbach alpha values for the capacity instrument scales

Sample	technology	norms	teaching practices	values P1-P10	values P14-17	values P19-28	values P11,12,18
Expert	.96	.97	.96	.96	.92	.92	.69
Lecturer	.95	.93	.97	.94	.89	.92	.66
Student	.72	.75	.95	.94	.88	.91	.65

Data collection procedures. The ethical agreements were asked from the partner universities. In Netherlands the permission was not granted (item G7 was not permitted despite that the survey was anonymous - G7: Do you have any special needs in participating elearning: Vision issues, Hearing issues, Speaking issues, Motor and balance issues, Cognitive issues of learning (simplified study programme), Other special needs, None. Specify. Do not want to answer).

The online surveys were conducted in the national language. The combined datasets for specialists, educators and students' perspectives were formed from all the received data. This dataset can be used for comparing the respondent profiles and country responses.

Analytical approach. We analysed the dataset considering the capacity dimensions we have built into the survey instruments. We ran the descriptive data analyses for all the survey items (see Annex 4, excel sheets), ANOVA analyses were performed to identify the mean values and significant differences between respondents' perspectives and country perspectives (See Annex 4 and the excel sheets). The discriminant analysis was performed to differentiate the countries' capacity perspectives. Some questions had to be analysed qualitatively to identify the technology names.

As part of the general data we asked about the impairment that might hinder using disruptive technologies (see Figure 11). The participants were free to not answer this question. The proportion of the respondents in the sample who do not have any impairment issues to use disruptive technology or who decide not to answer is 89%. The proportion of respondents (11 % of the sample) who noted some health issues that might influence the use of technology, the most common were vision issues (39%), Motor and balance issues (20%) and cognitive issues (19 %). This information is useful to plan the special needs related appropriations of technologies and learning scenarios. The literature analysis has shown that there are several wellbeing related issues that may arise from using disruptive technologies, particularly related with vision, hearing and motor-balance system.

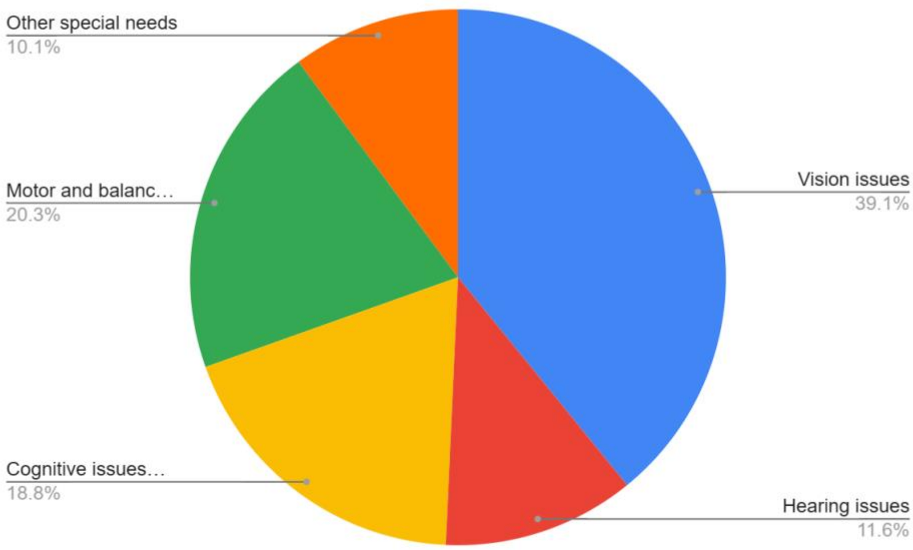


Figure 11. The proportion of respondents who have some physical issues to use disruptive technologies (N=69, 11% of the whole sample)

4.4.2. The capacity for disruptive technologies: different stakeholders' views

The survey research has indicated that different stakeholders in institutions such as the technology specialists, teachers and the learners may have different views and perceptions of the situation. These differences may indicate the gaps in the overall capacity to use disruptive technologies in the learning process. We provide the general overview of mean values of survey items in different stakeholder groups as well as the total mean values. The concrete values of the country specific responses and ANOVA tables are provided in the Annex 4.

4.4.2.1. Tools, software and infrastructures - opportunities and constraints from national and institutional infrastructures and tools that promote applying disruptive technologies

Based on the technology specialists view, certain infrastructural opportunities for using disruptive technologies in higher educational institutions and vocational schools are of higher availability (see Table 5 in Annex 4). These are:

- Regional hosting systems (LMS, LDS, videoconferencing, repositories, clouds)
- Access to institutionally payed cloud repositories
- The sufficient institutional storage space for VR, AR data
- Institutionally provided video-conferencing tools
- Video conferencing tools that have facility to work in groups with shared objects
- Student digital portfolio spaces
- Access to simulation facilities
- Access to robots for lessons

- Sufficient facilities for e-learning lessons
- The lecturing rooms that are fit for group work practices
- Institutionally managed tool and software sharing
- The e-learning ecosystem tools are mutually compatible and interoperable

The institutions rather do not:

- Provide central digital repositories in own server
- Update regularly the devices and tools in the computer labs (see Figure 12)
- Provide sufficient internet speed for METAVERSE learning
- Provide computers to the staff that are fit for processing METAVERSE
- The students do not have adequate computers fit for processing METAVERSE
- Enable devices for presenting small or microscopic objects online
- Provide AI based feedback in LMS systems
- Provide digital data management in institutions empowered by AI to enable adaptive learning paths
- Have the possibility to digitally identify students' identity using biometrics etc.

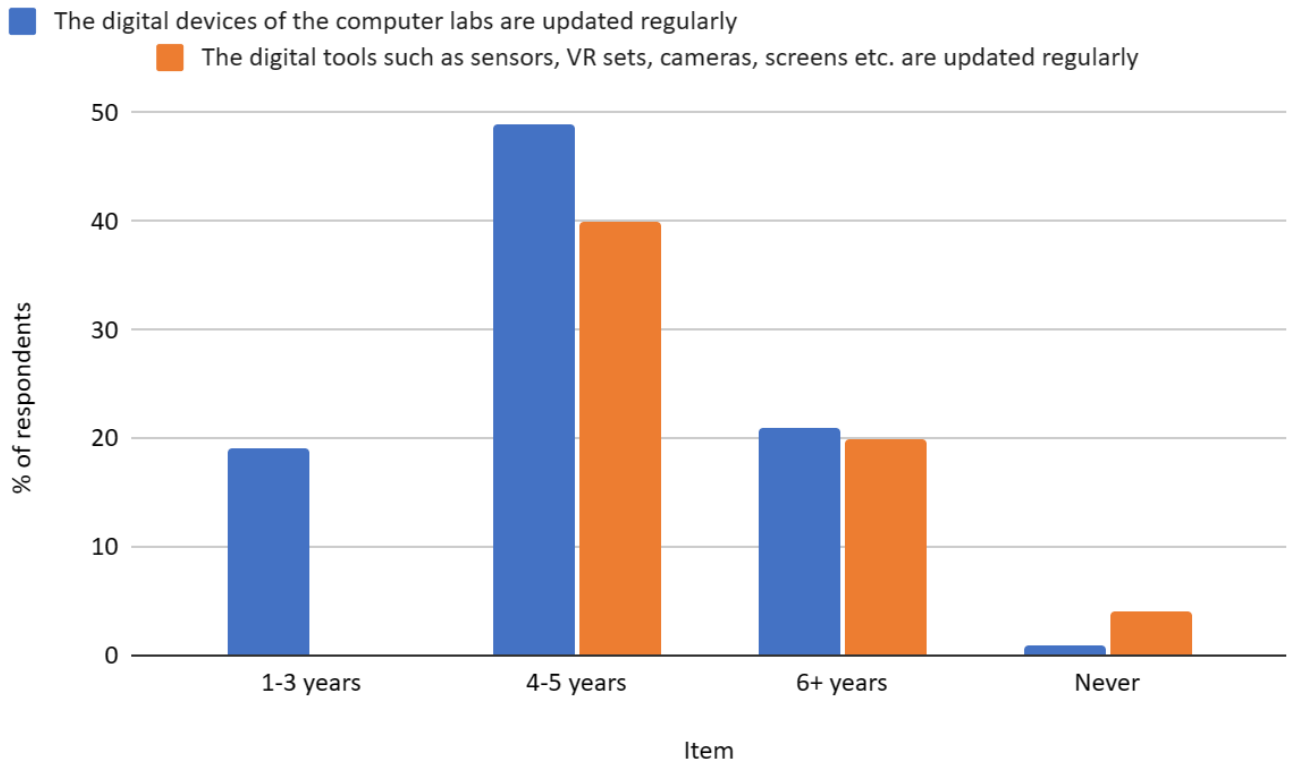


Figure 12. The technical updates in computer labs for technology enhanced learning

The most common way of obtaining technology is buying and obtaining from the project funding, whereas lending from partners and renting is less common.

Some of the infrastructural requirements are not regulated, the responsibility for infrastructure is left on the staff. The staff is using mainly their own repositories.

The ANOVA analysis was performed to compare the mean values among the technology specialists, teachers and students. There are significant differences (see table 5) in how the technology specialists at HEIs and teachers and students see the infrastructural capacity.

The technology specialists generally overestimate the digital opportunities that are actually available to teaching staff and students.

- Personalised digital portfolios ($p<0.013$)
- Facilities for presenting online small and microscopic objects ($p<0.003$)
- The access to simulation facilities for lessons ($p<0.003$)
- The access to robots for lessons ($p<0.001$)

The teaching staff and students overestimate the fitness of the infrastructure for using disruptive technologies compared with the technology specialists.

- The internet connection suitability for METAVERSE lessons (p<0.001)
- The processors of students' computers (p<0.001)
- The storage space of the institution for METAVERSE storing (p<0.001)
- The students overestimate the actual availability of the learning analytics for them in the institution (p<0.009)

4.4.2.2. Agendas, norms, rules and regulations and roles, funding - constraints and support from national or institutional practices, norms, regulations, curricula that promote applying disruptive technologies

The technology specialists (see Table 6 in Annex 4) indicated that there is an increased transition to e-learning as the future educational model. The students also had high expectations to learn in e-learning mode but the teachers' plan to increase e-learning in their teaching practice was significantly lower (p<0.001).

The teachers and students reported having the professional development plans that incorporate digital competences, while the technology specialists had a significantly lower opinion of digital professional development plans of teachers (p<0.001).

There was a significant (p<0.001) gap of teachers feeling encouraged from the institutional incentives to develop online courses and teaching approaches with innovative technologies among teachers and of the actual higher provision level of incentives reported by technology specialists. It is possible that the incentives to motivate e-learning do not arrive to the teaching staff.

Institutions generally have responsible staff members to develop digital policies, and the specific units that developed infrastructure, coordinated training and mentoring didactical support. Institutions reported rather having digital learning related guidelines. The critical issue is having funding for technical and didactical staff to assist the lecturers while using technologies.

Institutions systematically manage device sharing. The resource-sharing processes, and institutional open educational resource policies are at average level at institutions.

Institutions have procurement processes defined for the technology. They also generally have a specified and centrally managed budget for renewing digital infrastructure and software. The critical issue is that they rather do not have well developed processes how the institutions obtain access to use the industrially owned technologies in the teaching process. The cross-institutional workplaces mentoring practices during student internship are in teachers' opinion not enough digitally mediated with portfolio as the technology specialists report it of being. (p<0.001).

There is a significant gap in actually involving competent and technology experienced lecturers into developing digital agendas and regulations for the institutions (p<0.001).The institutions seem to promote the lecturers' full freedom to choose and test new technologies for learning. However, lecturers do not feel that they are invited to recommend the actual technology supply decisions as the technology specialists reported (<0.001). There is a gap of asking from the teaching staff and students which technologies and software they would require (p<0.014). The students requested for the need, and the technology specialists claimed that the institutions choose technologies through the value-based process, but the number of teachers who indicated being engaged in such value assessments of potential technologies was at significantly lower level (p<0.001).

The teachers and students did not feel that the learning process was flexible enough to make dynamic choices of using different forms of e-learning, and testing emerging technologies in lessons, compared with the view of technology specialists who had higher opinions (p<0.001).

The critical issue in education is the lecturer's responsibility for institutionally owned devices and tools that are used at courses.

The lecturers are rather not remunerated for using their own internet facilities for online teaching when conducting lessons from home or other ubiquitous places.

The students believed that their wellbeing and safety are not harmed with technologies they use for learning, and the teachers and technology specialists considered safety and health regulations and personal data privacy important criteria when using disruptive learning technologies. The teachers and technology specialists reported significantly higher levels of personal and organisational data protection adherence than the level of perceived data protection reported by the students ($p<0.004$).

4.4.2.3. Community - collective development of the capacity, embeddedness of sociocultural elements, teaching practices, the value constraints of the professional community, alignment to learners' expectations

The proportion of provided e-learning courses (see Figure 13) is about the same as the number of practice based e-learning courses, indicating that practice based components are rather an integral part of e-learning courses in the sample of this survey. This result may be tilted, as we approached more of the teachers and students in the subject areas where practice based learning is more common. The data also indicate that none of the institutions provided a huge number of e-learning courses. Yet, since we do not know the total number of courses we cannot estimate the proportion of e-learning.

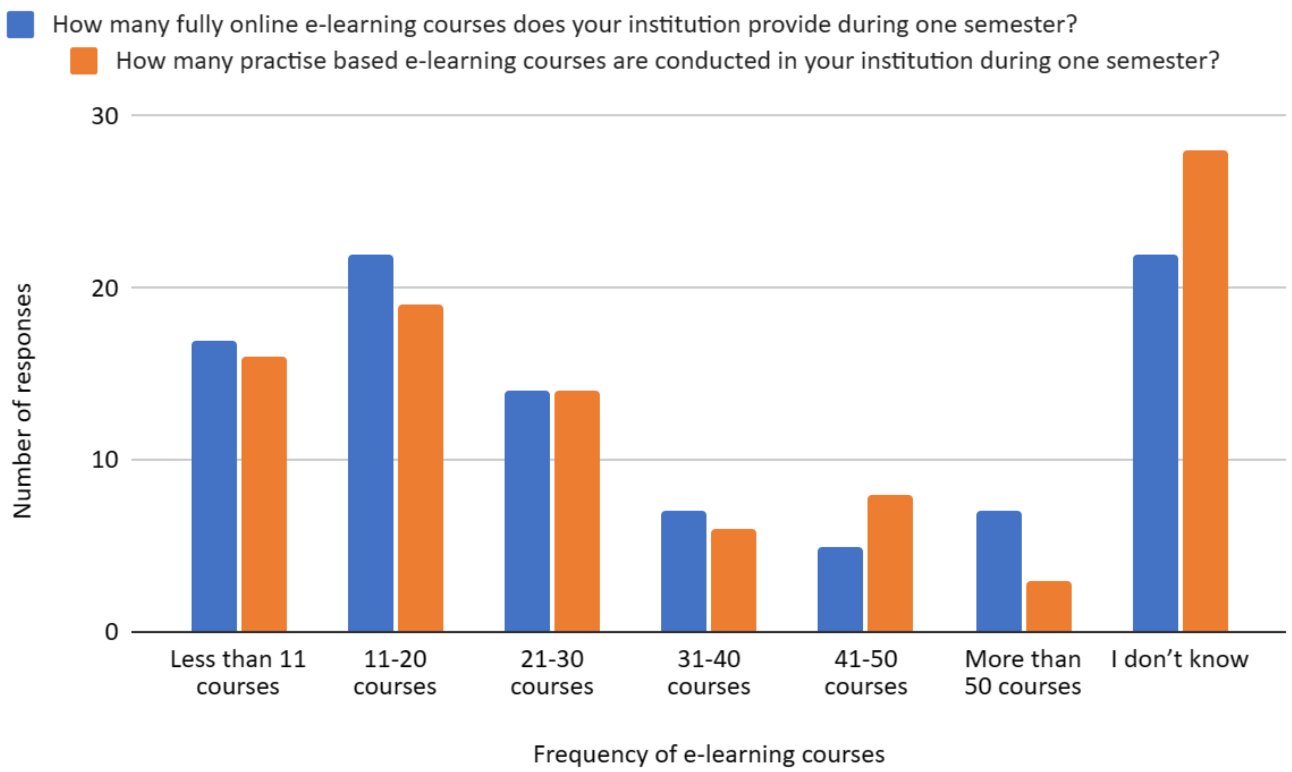


Figure 13. Proportion of conducting e-learning and practice based e-learning in the sample countries

The students reported (see Table 7 in Annex 4) significantly more often participating in online asynchronous and synchronous teaching events, and blended or hybrid and flexible e-learning courses than did the teachers report of conducting such e-learning lessons ($p<0.001$).

The teachers and the students have rather not used disruptive technologies in their classroom, and had experience of learning with these. The teachers and students rather do not provide VR or AR experiences in lessons or conduct lessons with robot technologies and enable students to collaboratively do hands-on activities in distant mode. The students reported significantly less often of having experienced robot technologies in lessons than did the teachers report of conducting robot lessons (p<0.004). The same gap was of participation in collaborative hands-on activities in distance mode where students could build on manipulating something together (p<0.024).

The teachers rather do not conduct role-based learning or team collaboration in distance mode, and the students have rather not experienced such learning. There are low experiences of co-teaching practices with other lecturers and using peer-tutoring, and the students have not been provided the role to be the supporter of other students in lessons or being a peer tutor.

The students reported significantly more often that not enough time was for social engagement within e-learning lessons, while the teachers claimed that they provide social engagement timeslots during e-learning (p<0,008).

The teachers and students had rather not had the opportunity of learning about innovative technologies when observing or assisting the colleagues or teachers. The students reported significantly more frequently that teachers rely on students' digital competencies and help on technology classes than did the teachers admit of relying on students' help and competence (p<0.001).

Providing courses or study modules in which collaboration with external partners is organised to contribute in solving societal issues is rather not common among teachers, and the students have rather not experienced such teaching. The teachers and students had rather not learnt about innovative technologies while visiting workspaces, attending the workshops where technology was tested exploratorily. Yet the average mean results indicated that the students and teachers have learnt about innovative technologies while sharing experiences with the colleagues or other students in the communities of practice. While some of the technology specialists reported having time slots for experience sharing with colleagues about new technologies, the teachers and students rather did not have the technology experience sharing opportunities (p<0.049). The teachers rather did not have access to best practices of digital education in their institution, while this access was significantly more available to technology specialists (p<0.023).

While the technology specialists reported of having access to alumni network as a teaching resource and promoting students’ digital co-production opportunities with external clients, the teachers rather did not have access to enrich their lessons with alumni experiences or co-production with external clients and the students have not had such an opportunity to learn from alumni or coworking with external clients (p<0.001).

The same trend was found that while technology specialists had partners who were experts in disruptive technologies and they had attended experience sharing events about digital education and industrial and public and startup sector technology events, such an expertise and opportunities to attend events were less available for teachers and students (p<0.001). There was a significant difference in technology specialists being involved in coworking with experts of disruptive technologies while the teachers and students were rather not involved in such coworking (p<0.001).

While the teachers reported rather not having an approach developed at institutions for assessing collaborative practice and work results, the students reported significantly higher that collaborative practices have been assessed (p<0.001).

Both the technology specialists and the students reported having attended professional training of using innovative technologies, while the teachers had significantly lower participation in such professional training (p<0.003). Learning of the technology potentials by themselves was about average mean level among teachers, and the students report learning about the technology by themselves less frequently than was the average mean (p<0.003).

The extent that technology specialists provide pre-service and in-service training was about the average, while the teachers were rather not involved in training innovative technologies in pre-service or in-service programmes ($p<0.001$). The teachers and students reported that the training for disruptive technology usage was rather not available. The lecturers themselves had rather not attended courses where the technology principles and functionalities were trained, while the students had more often experienced functionalities focused training. The lecturers had rather not experienced training where they could test the technology both from lecturer's and learners' positions.

While the technology experts reported that technical and educational technology support in developing learning courses is offered, the teachers reported needing such support ($p<0.001$). The technology specialists did report less frequently of offering support for developing complex digital learning resources (e.g. Metaverse simulations) than did the teachers request the need for such support ($p<0.038$).

The technical assistant support before and during the lessons was reportedly available for the lecturers according to the reports of technology specialists, but the teachers reported of not having need for such support quite often. However, the students reported that they did not have opportunities for such support ($p<0.001$). The teachers did not request the need for support of working with disruptive technologies in learning, but the technology specialist reported insufficiency of providing such expertise in institutions.

Few teachers reported choosing new technologies to be tested out in lessons and the students rather do not suggest new technologies to their peer students or lecturers. A seeking mode for new technologies was significantly lower among students than among lecturers. Yet the eagerness to come along with new technologies was reported moderate by the teachers as well as by the students. There was a significant trend that teachers rather than students prefer using technologies they are comfortable with. The students perceived significantly more often that teachers prefer to work with the technologies they are comfortable with, than did the teachers think that the students prefer the use of technologies they are comfortable with ($p<0.001$).

The teachers and technology specialists reported significantly more often of being competent in modifying online lesson scenarios to fit with student needs, than the students actually perceived that such a modification in scenarios was made to fit with their needs ($p<0.001$).

4.4.2.4. Person level - values, attitudes, experiences, competencies related to disruptive technologies.

The technology specialists, lecturers and students (see Table 8 in Annex 4) reported that they do not have sufficient competences for developing learning scenarios and resources for disruptive learning technologies, personalising the learning, adapting learning scenarios for special needs and diversities and attending learning scenarios developed in these. There were significant differences in the competence estimation between specialists, teachers and students, the specialists had more optimistic prognosis to the competence of teachers.

While specialists were on the opinion, that lecturers have sufficient knowledge of the potential and threats of disruptive technologies for humans, and the learning effects, and sustainability issues the teaching staff and students rather did not know what the potential and threats, and sustainability issues of disruptive technologies are for humans and which learning effects may be achieved with these ($p<0.015$).

The technology specialists believed that students have sufficient knowledge for participating in practical courses with disruptive technologies, but the teachers and students themselves did not share this belief ($p<0.009$).

All the participants rather agreed that disruptive technologies should be used when they bring additional value to the learning process. All the interviewed samples responded higher than average that using disruptive technologies in learning would develop students' competences, and provide resilience to the educational sector.

All the respondents estimated the students' knowledge of the pros and cons of using disruptive technologies to make justified decisions about learning choices as low ones.

The specialists and teachers shared the opinion that introducing disruptive technologies in classes is not energy and resource efficient, it is not more cost-effective, and would require too much staff training. The students had more optimistic views ($p<0.001$) of these claims. The specialists generally agreed that institutions are responsible for the sustainability evaluation of the disruptive technology and its health and wellbeing related effects, while the teachers and students did not feel high level concerns ($p<0.001$). The beliefs of participants about the disruptive technologies does not threaten and is promoting ecosystem sustainability, and not threatening the diversity of learning practices were about the average level. The specialists had significantly higher opinions on these value items than educators and the students ($p<0.019$, $p<0.001$). All of the respondent samples were more positive about the statement that the disruptive technologies may bring additional value to the learning process, may advance human abilities, and can advance the social and collaborative dimension of learning. Similarly, they believed that using these technologies may promote students' learning results.

The technology specialists and the teachers did not agree with the statement that introducing disruptive technologies would require too much regulatory changes.

The specialists were more agreeing that the evaluation of the potential and threats of the disruptive technologies, and its learning potential lays upon institutions, but the teachers and students did not support this view ($p<0.001$).

4.4.3. Overview of the capacity for using disruptive technologies in partner countries

The capacity to perform transition to new learning technologies depends on the capacity that is available at the governmental or organisational level (technology, tools and infrastructures, norms, regulations), community level (teaching practices) and personal level (competences, attitudes and values).

For overview we have calculated the overall compound values for the sample countries (see Figure 14). It appears that the weakest is the capacity at community level, which ranks lowest in all countries.

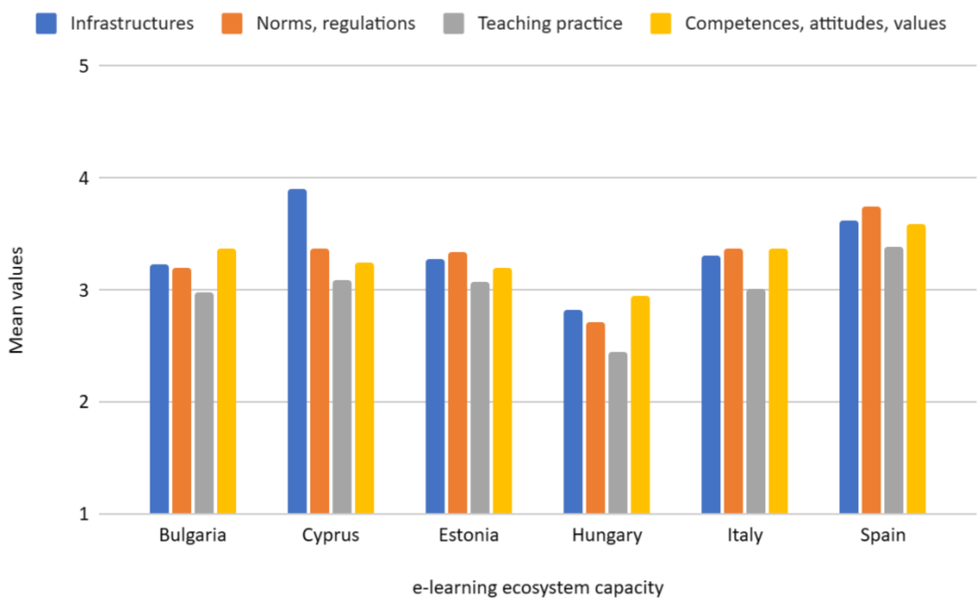


Figure 14. The comparison of the capacities to use disruptive technologies in partner countries

Of the countries, Hungary has the lowest compound values for the capacity constructs, indicating the need for development to enhance teaching and learning with disruptive technologies.

4.4.3.1. Specific technologies used in countries

Below we present the gaps among the specific capacity components in different sample countries.

The institutional provision of e-learning environments in different countries is not similar (See Table 9, 10 the full table can be seen in Annex 4). While Moodle is the institutionally provided system in Estonia, Bulgaria and Italy, several countries' universities and vocational schools use Udemy (Spain, Hungary), Coursera (Estonia, Spain, Cyprus) and Khan academy (Italy, Bulgaria), Codeacademy (Italy, Bulgaria), Microsoft Teams (Estonia, Spain) and Google Classroom (Hungary), Google drive (Estonia), as learning management systems.

Table 9. Learning institutions provide access to build the courses in the following online sites (specialist view).

	Estonia		Spain		Hungary		Bulgaria		Cyprus		Italy	
1.	Moodle	7	Udemy	74	Udemy	7	Khan Academy	23	Coursera	2	Khan Academy	28
2.	Coursera	6	Coursera	32	Google Classroom	3	Udemy	16			Udemy	18
3.	Zoom	5	Microsoft teams	21	YouTube	3	Coursera	7			Coursera	9
4.	Microsoft teams	3	Khan Academy	19	Kahoot	2	Codecademy	6			Codecademy	6
5.	Big blue button, Google Drive, Udemy, LinkedIn learning	2	Classroom	17	Khan Academy	2	Moodle	5			Moodle	6

Table 10. Learning management systems: Summarised student view

	Estonia		Spain		Hungary		Bulgaria		Cyprus		The Netherlands		Italy	
1.	Moodle	53	Moodle	108	Moodle	34	Moodle	67	Blackboard	5	Brightspace	1	Moodle	76
2.	eDidaktikum	9	Canvas	96	Canvas	3	Google Classroom	3	Canvas	1			Google Classroom	3
3.	Canvas	8	Blackboard	37	Microsoft Teams	2	Microsoft Teams	2	CIM Intranet	1			Microsoft Teams	2
4.	Google Drive	5	Canva	18	Google Classroom	2	Blackboard	1	Moodle	1			Shared screen	2
5.	Google Classroom	5	Google Classroom	9			Canvas	1					Virtual classroom	2

In practice the most commonly used video conferencing tools for e-learning lessons in higher educational and vocational schools (see Table 11) are Zoom (more popular in Estonia, Spain), Microsoft Teams (more popular Hungary, Bulgaria, Cyprus, Italy) and Google Meet (Estonia, Spain, Bulgaria, Italy, Hungary). The other environments are most likely used for group meetings, Big Blue Button, Discord and Skype.

Tabel 11. e-learning Video conferencing services: Specialist and student view

	Estonia		Spain		Hungary		Bulgaria		Cyprus		Italy	
1.	Zoom	52	Zoom	149	Microsoft Teams	34	Microsoft Teams	66	Microsoft Teams	5	Microsoft Teams	74
2.	Microsoft Teams	32	Microsoft Teams	91	Google Meet	7	Zoom	35	Zoom	4	Zoom	40
3.	Google Meet	29	Google Meet	71	Zoom	7	Google Meet	22	Google Meet	1	Google Meet	24
4.	Big Blue Button	9	Skype	9			Discord	14	Skype	1	Discord	14
5.	Skype	3	Blackboard	6			Big Blue Button	6			Big Blue Button	7

4.4.3.2. Infrastructure and tools capacity in the sample countries to do practice based e-learning with disruptive technologies

The institutions in sample countries have infrastructures for e-learning (LMS, videoconferencing, repositories) and technology sharing processes, but some gaps exist in centralised provision and availability in specific countries. Yet, there is lower availability of disruptive technologies for the teaching process and general readiness for using METAVERSE for learning purposes.

General e-learning capacity

- Central LMS provision – not available in Bulgaria, Hungary,
- Rooms for e-learning lessons - the availability in all countries
- Rooms for synchronous digital practices – the availability in all countries
- Interoperability between LMS and repository – rather not available in Hungary, Italy

Learning resource capacity

- Central repository in own server - mostly available in all countries
- Institutional repository space in clouds - mostly available in all countries
- Repositories of own choice – common practice in all countries
- Sufficient storage space for metaverse – rather not available in Bulgaria, Hungary

The capacity for teamwork and practice-based work

- Group-work tools, boards in LMS – available in all countries
- Controlling shared objects in LMS – not available in Hungary
- Rooms fit for group-work – less available in Hungary
- Labs with micro-object presentation tools – rather not available in Hungary, Cyprus
- Shared labs to borrow tools, software - mostly available in all countries
- Personal student portfolio – mostly available in all countries

Availability of disruptive technologies

- Robots – In all the countries the availability is rather limited
- Simulation facilities for VR etc. – rather not available in Cyprus

- The availability of VR headsets per country samples is very low (1-3 per institution in few institutions), only in Spain there is better availability ranging 10-20 headsets per institution situated in several institutions
- Availability of learning analytics for lecturers and students – availability in all countries
- Availability of AI empowered feedback, chatbots in LMS systems – partially available in Italy, and Spain
- Special VR rooms are more broadly available in several institutions mostly in Spain, 1-3 rooms are available in few specific applied institutions in every country.
- AI managed data recommendations – available only in Spain and Cyprus
- Biometrics based identification tools – available only in Cyprus and Spain

Capacity to use de Metaverse

- Internet connection speed for metaverse - mostly available in all countries
- Processors of computers of lecturers fit for metaverse – less available in Bulgaria, Hungary, Italy
- Processors of computers of students fit for metaverse – mostly available in all countries

More detailed mean results are provided in the Annex 4.

Using the discriminant analysis we could not discover significant functions and components that would define infrastructural capacity differences in the countries.

4.4.3.3. The regulative capacity in partner countries to use disruptive technologies

In some countries there is not a transition plan, and institutional strategy yet to move towards e-learning mode in higher education. This is accompanied with a rather low level of involvement of lecturers and students to the technology decision making process in the institutions. Also there is a lack of incentive policies in countries to promote e-learning. The digital maturity of institutions has country specific gaps in having specific coordination units for technology training, coordination of edtech, infrastructure and tools. There is openness and flexibility in learning process planning for bringing in new technologies, the lecturers have the freedom to test and use new tools and teaching forms in the teaching process. Industrial technologies are mostly not well accessible in the teaching process in most of the countries except Spain, and technology sharing norms and practices across the university borders such as in internship are rather not developed. The countries have digital maturity at the normative level. The institutions in the countries have unequal availability of budgets for acquiring technologies. More detailed mean results are provided in the Annex 4.

Coordinated e-learning management

- Plans for transition to increased e-learning – not available in Hungary and Estonia
- Institutional e-learning strategies – not available in Bulgaria, Estonia
- Coordination unit for educational infrastructure and tools in institutions - Not available in Hungary and Bulgaria
- Coordination unit of digital training and mentoring – Not available in Hungary and Bulgaria
- Coordination of edtech support unit – Not available in Hungary
- Development team for digital policies in institutions – not available in Hungary

Involvement, flexibility, openness

- Involvement of lecturers to digital policy development – only in Spain
- Student feedback in institutional technology choices – not available in Hungary
- Learning value-based technology choosing process – available in all countries
- Lecturers can choose and test technologies – available in all countries
- Lecturers can suggest technologies for institutions – available in Spain and Estonia
- Lecturers freedom to use tools – enabled in all countries
- Updates made in the polices for new technologies – not made in Hungary
- Constraints in LMS and videoconferencing technology usage- practised in all countries

- Constraints to teach only at institutional rooms – mainly in all countries except Estonia
- Encouragement to teach in own spaces with own internet – not encouraged in Estonia and Hungary
- Flexible learning process planning to choose lesson forms – not available in Hungary
- Flexible learning process to integrate technology opportunities – in all countries
- Approach developed to access industrial technologies for teaching – available in Spain and Italy

Norms

- Specific digitalization of e-learning guidelines – not available in Hungary
- Health and safety guidelines for technology use – practised in all countries
- OER policies – not practised in Estonia and Hungary
- Institutionally managed device sharing – not managed in Hungary
- Mutual resource sharing practice between lecturers – available in all countries
- Data management and privacy policies – established in all countries
- Technology procurement policy in institutions – established in all countries
- Student portfolio sharing norms between practice places – established in Spain and Cyprus

Incentives

- The professional development plans address digcomp – in all countries
- Incentives for lecturers' digcomp development – not available in Bulgaria, Hungary, Italy
- Incentives for e-learning development – available to some extent in Spain

Financial

- Financial responsibility for tools is on lecturers – not in Cyprus and Estonia
- Specific institutional tools budget – not available in Bulgaria, Hungary, Italy
- Institutional central investments to increase digitalization – highest in Spain, available in all countries

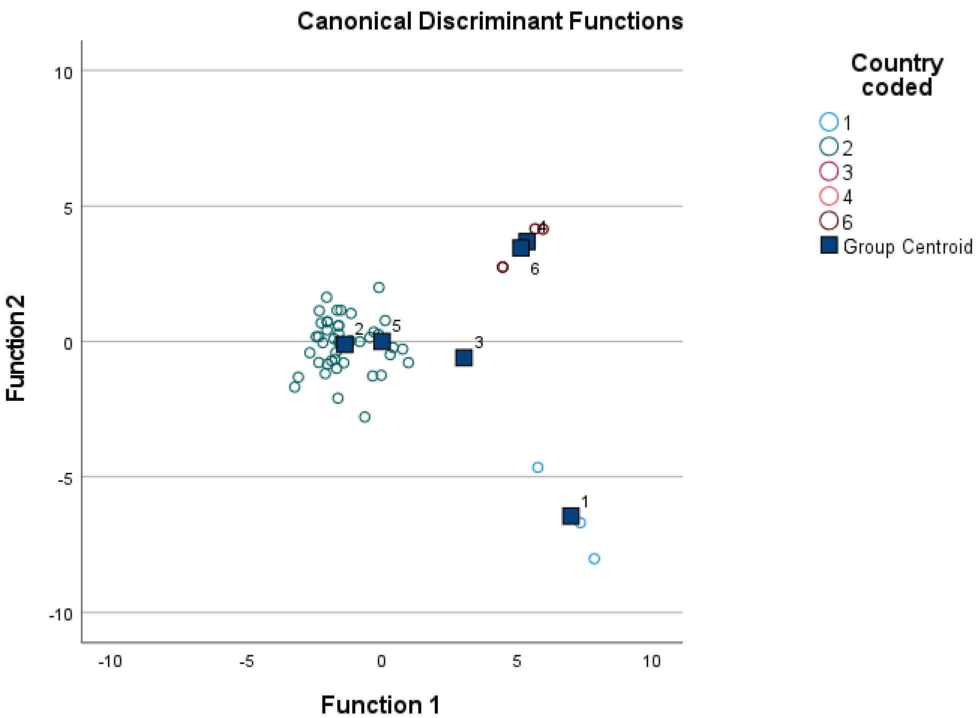


Figure 15. The canonical discriminant functions that distinguish the normative institutional capacity to use disruptive technologies in e-learning in countries (1- Estonia, 2-Spain, 3-Hungary, 4-Bulgaria, 5 - Cyprus, 6-Italy).

Discriminant analysis revealed one significant function about normative institutional capacity (F1 (56% of the variance), Wilks lambda=0.006, df=140, p<0.021).

F1=2.1 institutions have departments that coordinate training and mentoring + 2.1 institutions provide incentives to study digital competence of lecturers + 1.53 institutions promote digitalization of teaching and learning with specific guidelines + 1.87 lecturers have full freedom to choose e-learning tools and technologies + + 0.91 lecturers are invited to suggest innovative technologies to the supply management + 1.2 there is sufficiently flexible learning process planning to grab innovative technology opportunities to lessons + 1.1 lecturers are encouraged to use their own spaces and internet for teaching + 1.0 lecturers are promoted towards OER + 1.0 lecturers follow health and safety guidelines (See Figure 15).

These function components are indicators of managing rather the lecturers competences but being quite bottom-up in enabling teachers' technology choices for lessons. From the countries Estonia represents this type of normative institutional capacity the most.

4.4.3.4. The teaching capacity to use disruptive technologies in practice based e-learning

Characteristic to the teaching capacity in the sample countries was that they are experienced in teaching in different e-learning formats (asynchronously, synchronously, with blended and flexible learning modes). Regarding using disruptive technologies (VR, AR, chatbots, virtual games), they are mostly practised in Spain and to some extent online simulations and games as course activities are also available in Estonia, but rather not in other countries (Cyprus, Bulgaria, Hungary, Italy). Hands-on collaborative learning in distance mode, as well as with team collaboration, role-based group work is also not common in all the sample countries. In Spain and Estonia it is more common and less apparent in Bulgaria, Italy, Hungary and Cyprus. Accessing external from the university capacities such as alumni network, partners with expertise of innovative technologies is more common in Spain and to some extent in Estonia and Cyprus. Organising coursework as a co-creation with external partners is more common in Spain and Estonia. In all the countries lecturers rely on students' technological help, but mostly in Spain the lecturers have used this capacity as a formal activity giving to the students the peer-supporter role. Co-teaching in e-learning is not widespread. In all the countries the lecturers and students prefer using the technologies they are more comfortable with, but learners and teachers in most of the sample countries (except in Hungary) were open to search and test out new technologies and they were able to adapt the technology scenarios to the students' needs. In all sample countries the teaching and learning of technology functions were available (except Hungary), but other learning opportunities (from external experts, experience sharing events, hackathons, workplace visits etc, learning technologies through design) were less available in most of the countries except Spain. In Spain and Cyprus the teachers and students noted their need for technology and educational technology support when preparing for the lessons and during the lessons. There was a need to have support to develop complex learning resources for metaverse and conducting lectures with disruptive technologies.

Below, the specific trends of the teaching capacity components in the countries are noted, the table of mean values to the survey items in countries is provided in the Annex.

e-learning teaching modes

- Teaching and learning in distant courses asynchronously – practised in all countries
- Synchronous teaching and learning in video-conference lessons – practised in all countries
- Blended lessons with synchronous or asynchronous online learning – practised in all countries
- Hybrid learning where some students attend online and others face-to-face – practised in all countries

Using disruptive technologies in lessons

- Online simulations and games as course activities – practised in Estonia and Spain
- AR and VR experiences at courses – rather not practised in any countries

- Lessons with robots as course activities - rather not practised in any countries
- Using VR, AR, chatbots, virtual games in classroom – to some extent in Spain

Collaborative practices
- Hands on collaborative practice-based works in e-learning mode – practised in Spain
- Role-based learning in groups in distance mode – Practised in Estonia and Spain
- Team collaboration practices in e-learning – practised in Estonia and Spain
- Assessment approach developed for assessing collaborative practice-based work results – not developed in Hungary
- Providing time slots for social engagement in e-learning lessons – not in Italy
- Access to alumni networks as a resource for the lessons – available only in Spain
- Access to partners who have expertise of disruptive technologies – in Cyprus, Estonia and Spain
- Students and external partners jointly contributing to the society - in Spain and to some extent in Estonia
- Promoting students' digital co-production with external clients at lesson scenarios – In Spain and Estonia

Sharing teaching responsibilities
- Co-teaching with other lecturers in online sessions or co-supporting other students – not practised in any countries
- Lessons where students act as peer tutors – to some extent in Spain
- Need to rely on students' competence when lecturers conduct technical lessons – in all the countries

Readiness to use technology innovations
- Searching for new technologies to be used in the classroom, or students suggesting new technologies to lecturers – not practised in Hungary
- Learners are eager to test out new technologies in lessons – not practised in Hungary
- Preference among teachers and students to use the same technologies they are comfortable with – in all countries
- Competence to adapt online scenarios to meet students' needs – not practised in Hungary

Learning opportunities from lessons and practice
- Attended trainings about technology functionalities – in all countries except Hungary
- Attended technology trainings where they could test technology from learners' and lecturers' positions – in Cyprus and Spain
- Attending professional training to learn innovative technologies – not available in Estonia and Hungary
- Attending trainings where innovative technology was tested – practised in in Cyprus and Spain
- Teachers conducting pre service trainings about using innovative technologies – available only in Spain
- Teachers conducting in-service trainings about sing innovative technologies – practised to some extent in Spain
- Learning about technologies at workplace visits – not available in Estonia, Hungary
- Attending experience sharing events about digital education – practised in Estonia and Spain
- Attending industrial sector, NGOs or start-up sector events about novel technologies – practised in Italy and Spain
- Dedicated experience sharing events about new technologies with colleagues – Available in Spain
- Coworking experiences with experts of disruptive technologies – not available in any countries
- Access to best practices of digital education in their institutions – not available in Bulgaria and Italy
- Learning of the innovative technologies from colleagues – in all the countries except Hungary
- Leaning about innovative technologies when designing them – practised in Bulgaria, Italy and Spain

- Special training is available for disruptive technology usage – available only in Spain

Need for support
- Need for technical and educational technology support to develop e-learning courses – only in Hungary
- Need for technical assistance to set up lessons with technologies – in Cyprus and Spain
- Need for technical assistant during the lessons with technologies – needed in Spain
- Need for support to develop more complex learning resources in metaverse – in all countries
- Need for support in using disruptive technologies – in all the countries

More detailed mean results are provided in the Annex 4.

The Discriminant analysis with the learning capacity components revealed two functions that significantly differentiate the countries (F1 (56% of variance), Wilks lambda=0.57, df=230, p<0.001; F (20 % variance), Wilks lambda=0.21, df=180, p<0.001).

F1=0.60 there is a dedicated time slot for sharing technology experiences at institutions + 0.54 they have attended trainings where student/teacher roles were tested with technology + 0.79 they are teaching innovative technologies in preservice training + 0.48 they conduct co-teaching at lessons + 0.53 there is organised co-production with external clients in lessons + 0.52 they provide students with social timeslots at e-learning lessons.

First F1 function components indicate the profile of lecturers who themselves teach the technologies and share experiences with their colleagues about technologies. Spain, Italy and Cyprus represent this type of teaching capacity, whereas these teaching profiles are least apparent in Hungary (see Figure 16).

F2=0.46 have attended technology trainings that mainly focus on technology functionalities + 0.38 have learnt technology usage from developing technologies by themselves+0,38 attend experience sharing events about technologies + 0.41 are conducting role-based and game based collaborative e-learning practices + 0.42 need educational technology support for developing metaverse learning resources.

The second function represents lecturers as self-learners about the innovation and highlights the collaboration driven practices they tend to use with students. Estonia and Bulgaria represent this type of teaching capacity.

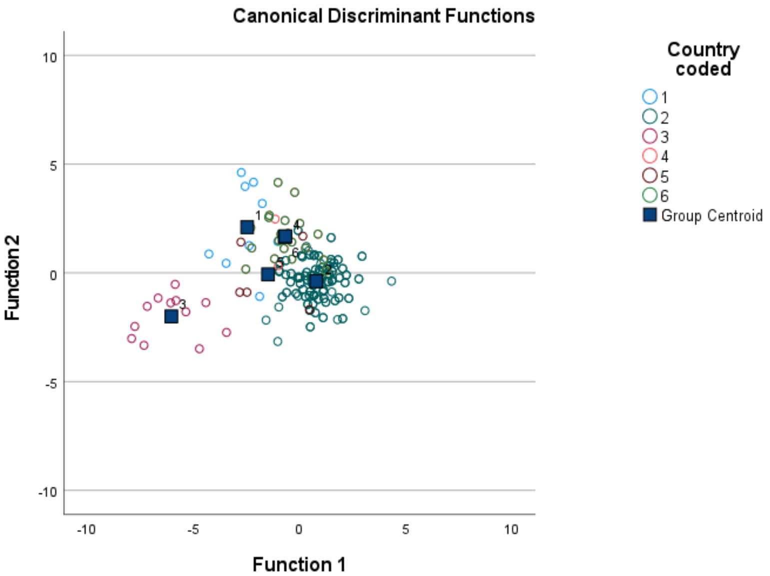


Figure 16. The canonical discriminant functions that distinguish the teaching capacity with practice based e-learning with disruptive technologies in countries (1- Estonia, 2-Spain, 3-Hungary, 4-Bulgaria, 5 - Cyprus, 6-Italy).

4.4.3.5. The personal level capacity to use disruptive technologies - competencies, attitudes, values

The personal level competences among lecturers and students to use disruptive technologies are not equal in the sample countries, and are rather at lower level. The knowledgeability of the disruptive technologies' values is lower in the countries where the competences are lower. In particular, Estonian and Hungarian personal level capacity is lower than in other countries. There is a common understanding that using these technologies is cost effective and also requires training efforts and normative changes in institutions. However, there is generally still an optimistic view of the positive impacts of the disruptive technologies, and not a very high concern level.

Lecturers having competences to develop learning scenarios, learning resources for disruptive technologies and personalising learning with these technologies or adopting learning situations are not apparent in most of the countries, the highest are competencies in Spain.

Students were estimated of not having sufficient competences to participate in practical lessons with disruptive technologies in Estonia, in other countries the mean values reached beyond average.

Lecturers' knowledge of the potentials of disruptive technologies was estimated the lowest in Estonia and Cyprus, in Spain the respondents were most knowledgeable. Students' knowledge of the pros and cons of disruptive technologies was estimated the lowest in Estonia, in other countries the mean values reached beyond average.

Knowing the learning effects and threats of the disruptive technologies, and the sustainability issues was estimated low in Estonia, Cyprus and Hungary, whereas in Spain, Italy and Bulgaria the respondents were more knowledgeable.

All the respondent samples in countries agreed that introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much resources (time, money, energy consumption, natural resources etc.). In Estonia and Cyprus the respondents rather shared the belief that using disruptive technologies in learning would not be more cost-effective.

Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much staff training – only Hungary estimated the training efforts at low level, in other countries the efforts for training were estimated beyond average.

Requiring the needs for changes in norms and regulations to implement disruptive technologies were estimated at low levels in Estonia and Hungary, whereas in other countries the normative needs were estimated above average mean values.

Recognising the educational institutions' role in estimating the learning potentials, threats, sustainability and health and wellbeing issues of learning technologies was estimated lowest in Cyprus. Hungary also had lower mean value about estimating the sustainability concerns of disruptive technologies.

All the partners agreed that disruptive technologies should be brought to educational process if they bring additional value to learning process, they also shared the belief that these technologies may advance human learning abilities, develop students' competences for digitised jobs, and there is no harm to be seen for the diversity of learning practices if the disruptive technologies are implemented.

Most of the sample countries except Hungary had the high opinion that these technologies may increase resilience in the educational sector and may promote ecosystem sustainability and promoting students' learning results and advancing social and collaborative learning dimension.

More detailed mean results are provided in the Annex 4.

The discriminant analysis indicated that two functions significantly determine the distribution of the country cases based on the personal capacity. Function 1 (44 % of the variance) Wilks lambda=0.47, df=140, p<.001; F2 (26% of the variance), Wilks lambda=0.64, df=108, p<0.01.

Function 1=0.58 (see Figure 17) lecturers have sufficient competences for adopting learning scenarios with disruptive technologies to special needs + 0.46 lecturers have sufficient knowledge of the learning effects of disruptive learning technologies + 0.32 using disruptive technologies promotes students learning results - 0.63 using disruptive technologies does not threaten the diversity of learning practices.

Function 1 relates with the positive perception of the effects of disruptive technologies, seeing these as the enriching practices to the other learning practices. This optimistic view characterises most the Spanish respondents and least the Estonian respondents.

Function 2=0.50 using disruptive technologies in classes advances social and collaborative dimension of learning + 0.45 lecturers have sufficient knowledge of the sustainability issues of disruptive technologies in education + 0.42 institutions must evaluate the learning potential and threats of disruptive technologies - 0.65 introducing disruptive technologies in class requires too much resources (time, money, energy consumption, natural resources) - 0.42 using disruptive technologies in learning promotes ecosystem sustainability. Function 2 may be associated with the controversial understandings related with the sustainability concerns and threats of the technology. This more concerned view represents Estonian respondents.

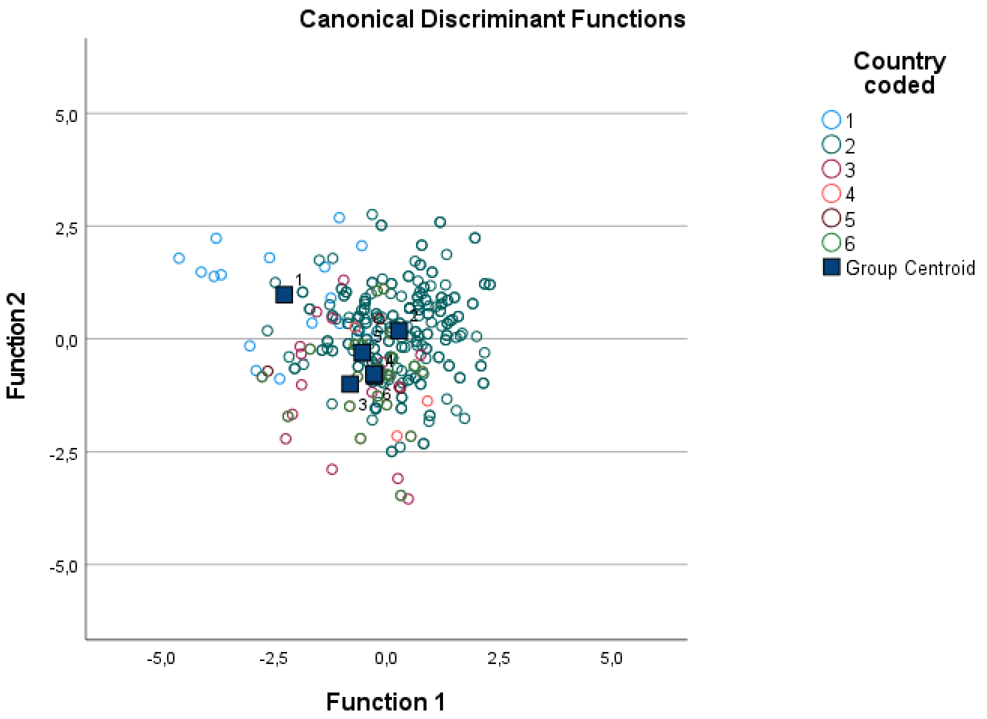


Figure 17. The distribution of sample countries based on personal capacity of competences, attitudes and values

5. Learning design recommendations for practice based e-learning with disruptive technology support

5.1. Recommendations about learning design and interaction for using disruptive technologies

In general, disruptive technologies refer to an innovation that displaces an established technology transforming traditional approaches and significantly altering existing ways of learning and teaching, therefore, having a potential to change the current understanding of education. According to Cambridge dictionary, to disrupt means "to prevent something, especially a system, process, or event, from continuing as usual or as expected". Thus, disruption is usually perceived as a negative occurrence triggered by outside factors (Boucher et al., 2020). Some emerging technologies are able to trigger profound changes and disrupt existing structures and norms, others not.

Our literature analysis has demonstrated that practice based learning supported with disruptive technologies does not show many indications of actually disrupting existing learning and teaching practices. In fact, much of the development in this field seems to still target first-order change, focusing on incremental improvements and changes within existing modes of practice. Drawing from Schuelke-Leech (2018) categorisation of disruption scope and depth, we could observe the first-order disruption, where only certain aspects have undergone the change, while the whole practice based e-learning ecosystem is still not affected. With three analyses (literature analysis, survey and values' workshop) we have collected the empirical data which may be triangulated for having a holistic view of what the readiness of the learning ecosystem for practice based e-learning with disruptive technologies is.

We generalised from the research papers the design elements for learning scenarios with disruptive technologies.

- Develop authentic situations for transfer, provide anchored elements (concepts, scaffolds) (Cognitive)
- Be presentation mode specific: Do not use the overlay text features, control buttons that simulate 2-D or analog situations (Cognitive and Psychomotor)
- Consider the position of the learner in situations, the mediatedness of control over learners' body and movement (Psychomotor)
- Consider that the distribution of objects in 3D space may cause attention and navigation issues with objects (Cognitive and Psychomotor)
- Use instructions that provide several interactions types between agents-contents-objects-technology (Cognitive)
- Focus on student-centred learning models (Metacognitive)
- Increase the level of student agency in a practice based learning with disruptive technologies (Metacognitive)
- Provide the interaction opportunity with the other agents or with the situations to receive feedback and scaffolds (Metacognitive, Cognitive, Affective)
- Use in designs the social learning aspects in the forms of collaborative learning (Affective)
- Develop opportunities for the learner adaptation to the situations, provide adaptive to the learner interactions, learning contents or scaffolds (Cognitive, Metacognitive)
- Make use of the motivation management with gamification elements, avatars, authenticity, interactivity (Affective)

We suggest that these design principles should guide the development of e-DIPLOMA learning modules in the next project phases.

5.2. Considerations about values and sustainability issues for using disruptive technologies

The results from the empirical values' workshops with learning scenario descriptions with disruptive technologies highlighted similar aspects like we have found in the literature analysis: the expectations/opportunities and concerns to these learning situations.

There are specific value dimensions that learners perceive as important related to the learning design. Here we highlight some central concerns and opportunities that need to be considered when designing learning scenarios with disruptive technologies.

Concerns:

- People do not know the sufficiently learning effects, and how to design learning scenarios with disruptive technologies to be effective for learning
- Distractions from learning goals in virtual spaces may occur
- People perceived an external from themselves control over the technology and data, moving towards control society, and that technology has control over learner
- There are harmful effects to the users ranging from cognitive, metacognitive, affective, physical to the social effects
- Lack of flexibility of learning designs, rigidness - may become teacher centred
- Expensive, time consuming and skilful to develop, with sustainability risks
- Have to overcome the distrust to technology, technology resistance in the approaching socio-technical singularity
- Have lack of social dimension opportunities and practices
- May not be inclusively accessible and suitable to all learner groups (age groups, socio-economic groups)

Opportunities:

- Can personalise learning, easing up the learning process
- May improve some kind of learning and performance
- Provides alternative or mixed socio-technical reality, a new space to be, a new identity to adopt
- May increase the trust to the technologies that operate the world
- May enhance future skills for job market
- Can promote learning motivation, affections, values and keep people learning
- May increase learner agency, self-regulation and involvement in learning
- May promote positive emotions and engage learners longer in learning, keep away negative feelings

These concerns and opportunities should be validated in actual learning scenarios.

5.3. Considerations about institutional capacities for using disruptive technologies

Second-order change (Foster-Fishman, Nowell & Yang 2007) and second-order technological disruption (Schuelke-Leech, 2018) in education intends to fundamentally alter how things are done within a specific human activity system with more systematic disruptions affecting multiple aspects. Disruptive technology has potential to actually play an important role in the necessary re-conceptualisation of interventions in current higher education. These emerging learning opportunities, however, need to be embedded into a conceptual framework that possibly integrates concepts from system thinking, system change, and human activity theory.

We have analysed with the survey the institutional learning ecosystem capacities from the organisational, normative, learning culture and personal competences attitudes and values aspects. Here we want to summarise some important trends:

Infrastructural capacity

- The infrastructures for using disruptive technologies in large scale are yet to be developed in countries and institutions
- Most of the institutions do not have availability of using disruptive technologies in learning process, mainly experimental approaches have been tested out
- The costs, FAIR principles and sustainability issues must be regarded when designing in countries and internationally the learning resources in metaverse and learning support mechanisms with AI and gamification

Normative capacity

- The higher education system is on the crossroad to decide if to move towards increased e-learning, this decision should be a collective decision agreed upon justified claims how technologies improve learning and approved by different stakeholders in education
- There is a potential to create normatives and regulations that promote sharing of the disruptive technologies across education-industry borders to be more sustainable and aligned in how and why we use certain technologies in the society

Learning culture capacity

- There is a gap between how the technology specialists, lecturers and students perceive the readiness to use disruptive technologies for learning
- The opportunities of lecturers and students to learn the skills to use and design learning scenarios with disruptive technologies can be extended towards more hands-on cross university-industry forms
- The learning situations can be moved towards more authentic problem based collaborative practices, the potential of disruptive technologies supports authenticity, but is yet rigid in concerns of collaborative practices

Personal capacity

- The lectures, specialists and students do not yet have sufficient skills to develop and use disruptive technologies
- There are rather positive but not evidence based beliefs about the values of disruptive technologies for learning among the higher education institutions
- The concerns to using disruptive technologies in education are not prominent among the specialists, teachers and learners

Drawn from the analysis of extensive literature, value focused workshop results and institutional capacity survey, we can say that we already know some aspects of learning and teaching with disruptive technologies, however, a lot of research and interventions studies still need to be carried out to understand the specifics, the nature and added value of disruptive technologies in education. Nevertheless, we have managed to provide some guiding design considerations for initiating the next step of the e-DIPLOMA project.

Conclusions

The Covid pandemic time outburst of e-learning in European universities raised the e-learning practices. In Chapter 4.1. “State of Art of Practice Based Learning: Brief overview of the learning gap for practice based e-learning" we investigated what way the practice based e-learning was conducted at the pandemic time and which gaps there were for conducting hands-on learning in e-learning mode. The literature analysis (between 2020-2022) revealed that the main issues of e-learning are creating social, emotional, and cognitive engagement, catering to diverse student needs and providing holistic learning experiences in e-learning. Challenges in practice based e-learning were delivering the situated practice and problem-solving. e-learning was found to limit bodily practices, abstract thinking, decrease the intensity of the experience, and slow down the pace of learning. There was a preference for synchronous delivery of practice based class sessions as well as video demonstrations that keep the learners more passive viewers. These findings show that there is the need for developing different approaches to how practice based learning may be mediated in distant learning format in case of emergency situations, but also as an opportunity for the universities to move towards course delivery in an e-learning mode.

e-DIPLOMA project aims testing out disruptive technologies in experiential learning scenarios as an opportunity to find best solutions for practice based distance learning. In this report for Chapter 4.2. "Overview of the literature about disruptive technologies for e-learning" we collected a sample of recent (from the period of 2020-2022) studies of disruptive technologies - virtual learning environments, extended and augmented reality, artificial intelligence and chatbots in learning, gamified virtual learning environments. We explored these empirical and meta-studies regarding what types of learning practices, and scaffolding practices, and interaction types were used with disruptive technologies. Secondly we viewed which learning outcomes were measured and documented in these studies, to discover the opportunities and gaps in cognitive, metacognitive, affective and psychomotor and embodied learning domains. We also reviewed the main theoretical constructs that guide learning designs with disruptive technologies. We found that although there are plenty of experiments with disruptive technologies, there is not sufficient clarity on what way the technologies provide useful changes to practise based digitised learning. The learning experiments with disruptive technologies lack the collaborative coworking dimensions, the interactivity in activities involving learning artefacts falls short of reaching adequate levels, and the learning process results are conceptualised at individual learner level. Research in empirical studies is focusing only on limited types of learning outcomes. Few studies relate psychomotor and embodied learning effects with cognitive, metacognitive and affective effects. The lack of this knowledge constrains the learning designers to understand how the new type of immersive, gamified and with personalised adaptive feedback loops learning medium may impact on learning, and which premises the disruptive environments offer to practise based technology mediated activities.

In Chapter 4.3 "The values and sustainability issues of using disruptive technologies" we provided empirical data of how the practice based example learning scenarios with disruptive technologies are perceived. The data were collected in partner countries from workshops where the users could only read about the scenarios and discuss the values they perceived regarding these. The value space around the practice based learning scenarios was described associating the perceived values and concerns with the learning scenarios, with learners, with the technologies and with the learning effects. This approach demonstrated that understandings of the learning potentials of the disruptive technologies are not clear. The needs coming from future workplaces to use disruptive technologies, and the opportunities to keep learners more engaged and motivated were seen as drivers of designing new practices in education. The designing complexity, the skill-demanding nature and the costs were perceived as threats of disruptive technologies accompanied with the belief that the built environments may be rigid as learning places and may decrease the teachers' and students' flexibility in planning the learning. Both the literature report and the values workshop revealed a number of physical and societal concerns that using disruptive learning environments creates.

The report was investigating the capacities for using disruptive technologies in partner countries' higher educational and vocational institutions. Chapter 4.4. "The training ecosystem capacity for using disruptive technologies in e-learning" provides results of the quantitative survey that we conducted in partner countries. The survey viewed the capacity for practice based e-learning from the perspectives of technology specialists that provide support at institutions, lectures who conduct practice based lessons, and students who participate at practice based lessons. The survey was composed of four blocks of capacity elements: infrastructural capacities, normative and regulatory capacities (institutional level), teaching cultures (community level), and competences, attitudes and values (personal level). The analysis revealed specific gaps in the capacity. We found differences in how the specialists, lecturers and students perceived the capacity elements. Also there were some differences between the countries. The specific findings are also provided in tables of Annex 4. The main message is that there are not yet sufficient infrastructures and tools and competencies for using disruptive technologies in higher and vocational education. The potential is highest in Spain, as other partner countries have significant gaps that hinder the usage of VR, AR, AI in courses.

The D.2.2 report has several weaknesses. The literature review sample was limited within the short time period between 2019-2022. Yet, we included a number of meta-analysis reports that covered the earlier periods. The values' workshop was conducted with one group in each country that did not permit the development of a larger dataset about the values' space. Also, the perceived values about the scenario that people were not testing out by themselves but could only read about might have been different from those values they could have expressed after testing. The survey analysis did not cover the representative sample of institutions in the countries. Thus the generalisations we can make about the capacities in the countries are tentative, but still provide an insight to the lack of capacities in the participant countries to teach with disruptive technologies. Overall, we can conclude that despite these limitations the report provided for the next phases of the e-DIPLOMA project a more in-depth view about potential, opportunities, barriers, accessibility issues and sustainability and ethical risks of using emerging technologies for teaching and learning.

This research report opened up several gaps in planning practice based learning with disruptive technologies. e-DIPLOMA project research with the development of e-learning modules with disruptive technologies for experiential practice based learning will make an attempt to use the learning design elements, and enhance the capacities for learning with disruptive technologies in institutions. The project will plan in the next steps which learning effects to measure during the learning scenarios with disruptive technologies, and which cognitive, affective, metacognitive and psychomotor and behavioural learning outcomes each learning module should target. We see the need to explore the collaborative dimensions of practice based learning with disruptive technologies, since the design approaches, learning effects and learning outcomes at interpersonal level are less known.

References

Ahmad, F., Zongwei, L., Ahmed, Z., & Muneeb, S. (2020). Behavioral profiling: a generationwide study of players' experiences during brain games play. Interactive Learning Environments, 1-14.

Ahn, S. J. G., Nowak, K. L., & Bailenson, J. N. (2022). Unintended consequences of spatial presence on learning in virtual reality. Computers & Education, 186, 104532.

Akgün, M., & Atici, B. (2022). The Effects of Immersive Virtual Reality Environments on Students' Academic Achievement: A Meta-analytical and Meta-thematic Study. Participatory Educational Research, 9(3), 111-131.

Alamäki, A., Dirin, A., & Suomala, J. (2021). Students' expectations and social media sharing in adopting augmented reality. The International Journal of Information and Learning Technology, 38(2), 196-208.

Alawajee, O. (2021). Influence of Covid-19 on students' sign language learning in a teacher-preparation program in Saudi Arabia: Moving to e-learning. Contemporary Educational Technology, 13(3), ep308.

Alexander, C. (1977). A pattern language: towns, buildings, construction. Oxford university press.

Alfadil, M. (2020). Effectiveness of virtual reality game in foreign language vocabulary acquisition. Computers & Education, 153, 103893.

Anderson, N. H. (1971). Integration theory and attitude change. Psychological Review, 78, 171–206.

Arayaphan, W., Sirasakmol, O., Nadee, W., & Puritat, K. (2022). Enhancing Intrinsic Motivation of Librarian Students using Virtual Reality for Education in the Context of Culture Heritage Museums. TEM Journal, 11(2), 620.

Argyriou, L., Economou, D., & Bouki, V. (2020). Design methodology for 360 immersive video applications: the case study of a cultural heritage virtual tour. Personal and Ubiquitous Computing, 24, 843-859.

Armstrong, T. R. (1970, August). Training for the Production of Memorized Movement Patterns[1]. In Proceedings (Vol. 6, p. 449). Scientific and Technical Information Division, National Aeronautics and Space Administration.

Apps, T., Beckman, K., Bennett, S., Dalgarno, B., Kennedy, G., & Lockyer, L. (2019). The role of social cues in supporting students to overcome challenges in online multi-stage assignments. The Internet and Higher Education, 42, 25–33. https://doi.org/10.1016/j.iheduc.2019.03.004.

Asad, M. M., Naz, A., Churi, P., Guerrero, A. J. M., & Salameh, A. A. (2022). Mix method approach of measuring VR as a pedagogical tool to enhance experimental learning: motivation from literature survey of previous study. Education Research International, 2022.

Asad, M. M., Naz, A., Churi, P., & Tahanzadeh, M. M. (2021). Virtual reality as a pedagogical tool to enhance experiential learning: a systematic literature review. Education Research International, 2021, 1-17.

Azila-Gbettor, E. M. , Mensah, C., Abiemo, M. & Bokor. M. | (2021) Predicting student engagement from self-efficacy and autonomous motivation: A cross-sectional study, Cogent Education, 8:1, 1942638

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In Psychology of learning and motivation (Vol. 2, pp. 89-195). Academic press.

Ayedoun, E., Hayashi, Y., & Seta, K. (2017). Communication strategies and affective backchannels for conversational agents to enhance learners' willingness to communicate in a second language. In Artificial Intelligence in Education: 18th International Conference, AIED 2017, Wuhan, China, June 28–July 1, 2017, Proceedings 18 (pp. 459-462). Springer International Publishing.

Baceviciute, S., Terkildsen, T., & Makransky, G. (2021). Remediating learning from non-immersive to immersive media: Using EEG to investigate the effects of environmental embeddedness on reading in Virtual Reality. Computers & Education, 164, 104122.

Baddeley A. D. (1986). Working memory London: Oxford University Press.

Bahari, A. (2022). Affordances and challenges of teaching language skills by virtual reality: A systematic review (2010–2020). E-Learning and Digital Media, 19(2), 163-188.

Baldauf, M., Brandner, A., & Wimmer, C. (2017). Mobile and gamified blended learning for language teaching: Studying requirements and acceptance by students, parents and teachers in the wild. In Proceedings of the 16th International Conference on Mobile and Ubiquitous Multimedia (pp. 13-24).

Banakou, D., Groten, R., & Slater, M. (2013). Illusory ownership of a virtual child body causes overestimation of object sizes and implicit attitude changes. Proceedings of the National Academy of Sciences, 110(31), 12846-12851.

Bandura, A. (1962). Social learning through imitation.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. Annual review of psychology, 52(1), 1-26.

Bandura, A. (1971). Social Learning Theory. General Learning Corporation. Archived from the original (PDF) on 24 October 2013. Retrieved 25 December 2013.

Banfield, J., & Wilkerson, B. (2014). Increasing student intrinsic motivation and self-efficacy through gamification pedagogy. Contemporary Issues in Education Research (CIER), 7(4), 291-298.

Barrett, A.J., Pack, A., Quaid, E.D. (2021). Understanding learners' acceptance of high-immersion virtual reality systems: Insights from confirmatory and exploratory PLS-SEM analyses. Computers & Education, 169. https://doi.org/10.1016/j.compedu.2021.104214

Baylor, A.L (2011). The design of motivational agents and avatars. Educational Technology Research and Development, 59(2), 291–300.

Belland, B. R. (2014). Scaffolding: Definition, current debates, and future directions. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of research on educational communications and technology (4th ed., pp. 505–518). New York, NY: Springer.

Benckendorff, P., Lohmann, G., Pratt, M., Reynolds, P., Strickland, P., & Whitelaw, P. (2015). Enhancing student learning outcomes with simulation-based pedagogies. In T. Reiners, B. R. von Konsky, D. Gibson, V. Chang, L. Irving, & K. Clarke (Eds.), Australasian society for computers in learning and tertiary education (ascilite) (pp. 618–620). Tugun, Queensland, Australia: Australasian Society for Computers in Learning in Tertiary Education.

Berti, M., Maranzana, S., & Monzingo, J. (2020). Fostering Cultural Understanding with Virtual Reality: A Look at Students' Stereotypes and Beliefs. International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 10(1), 47-59.

Bhagat, K. K., & Huang, R. (2018). Improving learners' experiences through authentic learning in a technology-rich classroom. Authentic Learning Through Advances in Technologies, 3-15.

Blakemore, S. J., Wolpert, D. M., & Frith, C. D. (2002). Abnormalities in the awareness of action. Trends in cognitive sciences, 6(6), 237-242.

Blanke, O., & Metzinger, T. (2009). Full-body illusions and minimal phenomenal selfhood. Trends in cognitive sciences, 13(1), 7-13.

Blanke, O., Slater, M., & Serino, A. (2015). Behavioral, neural, and computational principles of bodily self-consciousness. Neuron, 88(1), 145-166.

Bless, H., Fiedler, K., & Forgas, J. P. (2006). Mood and the regulation of information processing and behavior. Affect in social thinking and behavior, 6584.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals—Handbook I, cognitive domain. New York, NY: David McKay.

Boucher, P., Bentzen, N., Lațici, T., Madiega, T., Schmertzing, L., Szczepan´ski, M., (2020). Disruption by Technology: Impacts on Politics, Economics and Society, European Parliamentary Research Service. https://www.europarl.europa. eu/stoa/en/document/EPRS_IDA(2020)652079.

Botvinick, M., & Cohen, J. (1998). Rubber hands 'feel'touch that eyes see. Nature, 391(6669), 756-756.

Bourke, B. (2020). Using Gamification to Engage Higher-Order Thinking Skills. In I. Management Association (Ed.), Research Anthology on Developing Critical Thinking Skills in Students (pp. 632-652). IGI Global. https://doi.org/10.4018/978-1-7998-3022-1.ch033

Brophy, J. (1999). Toward a model of the value aspects of motivation in education: Developing appreciation for.. Educational psychologist, 34(2), 75-85.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. 1989, 18(1), 32-42.

Buijs-Spanjers, K.R., Harmsen, A., Hegge, H.H. et al. (2020). The influence of a serious game's narrative on students' attitudes and learning experiences regarding delirium: an interview study. BMC Medical Education, 20(289). https://doi.org/10.1186/s12909-020-02210-5

Buyego, P., Katwesigye, E., Kebirungi, G., Nsubuga, M., Nakyejwe, S., Cruz, P., ... & Jjingo, D. (2022). Feasibility of virtual reality based training for optimising COVID-19 case handling in Uganda. BMC Medical Education, 22(1), 274.

Cagiltay, K. (2006). Scaffolding strategies in electronic performance support systems: Types and challenges. Innovations in Education and Teaching International 43(1), 93-103. DOI:10.1080/14703290500467673

Calder, N., Jafri, M., & Guo, L. (2021). Mathematics education students' experiences during lockdown: Managing collaboration in e-learning. Education Sciences, 11(4), 191.

Candiotto, I. & Dreon, R. (2021). Affective Scaffoldings as Habits: A Pragmatist Approach. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.629046

Chan, C-S. Chan, Y-h. & T Agnes Fong, T. H. (2020). Game-based e-learning for urban tourism education through an online scenario game. International Research in Geographical and Environmental Education, 29:4, 283-300, DOI:10.1080/10382046.2019.1698834.

Chang, C-C. & Hwang, G-J. (2021): An experiential learning-based virtual reality approach to fostering problem-resolving competence in professional training. Interactive Learning Environments, DOI: 10.1080/10494820.2021.1979049

Cheddak, A., Ait Baha, T., El Hajji, M., & Es-Saady, Y. (2021, May). Towards a Support System for Brainstorming Based Content-Based Information Extraction and Machine Learning. In Business Intelligence: 6th International Conference, CBI 2021, Beni Mellal, Morocco, May 27–29, 2021, Proceedings (pp. 43-55). Cham: Springer International Publishing.

Chen, C.-J. (2021). Immersive virtual reality to train preservice teachers in managing students' challenging behaviours: A pilot study. British Journal of Educational Technology, 53, 998-1024. DOI: 10.1111/bjet.13181

Chen, Y. L., Hsu, C. C., Lin, C. Y., & Hsu, H. H. (2022). Robot-Assisted Language Learning: Integrating Artificial Intelligence and Virtual Reality into English Tour Guide Practice. Education Sciences, 12(7), 437.

Chen, C. Y., Chang, S. C., Hwang, G. J., & Zou, D. (2021). Facilitating EFL learners' active behaviors in speaking: A progressive question prompt-based peer-tutoring approach with VR contexts. Interactive Learning Environments, 1-20.

Chen, Y. L., & Hsu, C. C. (2020). Self-regulated mobile game-based English learning in a virtual reality environment. Computers & Education, 154, 103910.

Chen, Y., Zhang, L., & Yin, H. (2022). A Longitudinal Study on Students' Foreign Language Anxiety and Cognitive Load in Gamified Classes of Higher Education. Sustainability, 14(17), 10905.

Chhibber, N., & Law, E. (2019). Using conversational agents to support learning by teaching. arXiv:1909.13443.

Ciubotaru, A. N., Devos, A., Bozorgtabar, B., Thiran, J. P., & Gabrani, M. (2019). Revisiting few-shot learning for facial expression recognition. arXiv preprint arXiv:1912.02751.

Clack, L., Hirt, C., Kunz, A., & Sax, H. (2021). Experiential training of hand hygiene using virtual reality. Recent Advances in Technologies for Inclusive Well-Being: Virtual Patients, Gamification and Simulation, 31-42.

Clancey, W. J. (1997). The conceptual nature of knowledge, situations, and activity. Human and machine expertise in context, 247, 291.

Clark, A., and Chalmers, D. (1998). The extended mind. Analysis 58, 7–19. doi: 10.1093/analys/58.1.7.

Coban, M., Bolat, Y. I., & Goksu, I. (2022). The potential of immersive virtual reality to enhance learning: A meta-analysis. Educational Research Review, 100452.

Colreavy-Donelly, S., Ryan, A., O'Connor, S., Caraffini, F., Kuhn, S., & Hasshu, S. (2022). A Proposed VR Platform for Supporting Blended Learning Post COVID-19. Education Sciences, 12(7), 435.

Cooper, V. A., Forino, G., Kanjanabootra, S., & von Meding, J. (2020). Leveraging the community of inquiry framework to support web-based simulations in disaster studies. The Internet and Higher Education, 47, 100757.

Coronado, M., Iglesias, C.A., Carrera, Á., & Mardomingo, A. (2018). A cognitive assistant for learning java featuring social dialogue. International Journal of Human-Computer Studies, 117, 55–67.

Cowans, M. (2018). Virtual reality in ESL. English Australia Journal, 33(2), 57-61.

Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (Eds.). (1992). Optimal experience: Psychological studies of flow in consciousness. Cambridge university press.

Cummings, J. J., Tsay-Vogel, M., Cahill, T. J., & Zhang, L. (2022). Effects of immersive storytelling on affective, cognitive, and associative empathy: The mediating role of presence. New Media & Society, 24(9), 2003-2026.

Curley, E., Lee, J., Kwak, D. H., & Polites, G. (2020). An Empirical Examination of Dual-Congruity Perspectives in the Gamified ERP Training. In 26th Americas Conference on Information Systems, AMCIS 2020. Association for Information Systems.

Dalim, C. S. C., Sunar, M. S., Dey, A., & Billinghurst, M. (2020). Using augmented reality with speech input for non-native children's language learning. International Journal of Human-Computer Studies, 134, 44-64.

Damasio AR (1989). "Time-locked multiregional retroactivation: a systems-level proposal for the neural substrates of recall and recognition". Cognition. 33 (1–2): 25–62.

da Silva, R. L. (2021). The Process of Moral Decision-Making in a Game-Based Narrative Scenario through the Experience of Future Government Workers. TechTrends, 65(4), 511-523.

David, N., Newen, A., and Vogeley, K. (2008). The "sense of agency" and its underlying cognitive and neural mechanisms. Conscious. Cogn. 17, 523–534. doi: 10.1016/j.concog.2008.03.004

Davis, K., & Singh, S. (2015). Digital badges in afterschool learning: Documenting the perspectives and experiences of students and educators. Computers & Education, 88, 72–83.

Deci, E. L. and Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behavior. New York: Plenum Press.

Dehghanzadeh, H., Fardanesh, H., Hatami, J., Talaee, E., & Noroozi, O. (2021). Using gamification to support learning English as a second language: a systematic review. Computer Assisted Language Learning, 34(7), 934-957.

Delamarre, A., Shernoff, E., Buche, C., Frazier, S., Gabbard, J., Lisetti, C. (2021). The Interactive Virtual Training for Teachers (IVT-T) to Practice Classroom Behavior Management. International Journal of Human-Computer Studies, 152. https://doi.org/10.1016/j.ijhcs.2021.102646.

DeWitt, D., Chan, S. F., & Loban, R. (2022). Virtual reality for developing intercultural communication competence in Mandarin as a Foreign language. Educational technology research and development, 70(2), 615-638.

Dhimolea, T. K., Kaplan-Rakowski, R., & Lin, L. (2022). A systematic review of research on high-immersion virtual reality for language learning. TechTrends, 66(5), 810-824.

Di Natale, A. F., Repetto, C., Riva, G., & Villani, D. (2020). Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research. British Journal of Educational Technology, 51(6), 2006-2033.

Divekar, R. R., Drozdal, J., Chabot, S., Zhou, Y., Su, H., Chen, Y., … Braasch, J. (2021). Foreign language acquisition via artificial intelligence and extended reality: design and evaluation. Computer Assisted Language Learning, 1-29.

Dobricki, M., Kim, K. G., Coppi, A. E., Dillenbourg, P., & Cattaneo, A. (2021). Perceived Educational Usefulness of a Virtual-Reality Work Situation Depends on the Spatial Human-Environment Relation. Research in Learning Technology, 29.

Dozio, N., Marcolin, F., Scurati, G. W., Ulrich, L., Nonis, F., Vezzetti, E., ... & Ferrise, F. (2022). A design methodology for affective Virtual Reality. International Journal of Human-Computer Studies, 162, 102791.

Dreger, K. C., & Ticknor, B. (2022). Situational XR: Are There More Than Absolutes? Journal of Educators Online, 19(2). https://doi.org/10.9743/JEO.2022.19.2.4

Drigas, A., Mitsea, E., & Skianis, C. (2022). Virtual reality and metacognition training techniques for learning disabilities. Sustainability, 14(16), 10170.

Driscoll, M. P., & Burner, K. J. (2005). Psychology of learning for instruction.

Dubois, C., Vynohradova, A., Svet, A., Eckardt, R., Stelmaszczuk-Górska, M., & Schmullius, C. (2022). Impact of COVID-19 on e-learning in the Earth Observation and Geomatics Sector at University Level. Education Sciences, 12(5), 334.

Dubovi, I. (2022). Cognitive and emotional engagement while learning with VR: The perspective of multimodal methodology. Computers & Education, 183, 104495.

Dudley-Marling, C. (2012). Social Construction of Learning. In: Seel, N.M. (eds) Encyclopedia of the Sciences of Learning. Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-1428-6_96

Dunlosky, J., & Tauber, S. U. K. (Eds.). (2016). The Oxford handbook of metamemory. Oxford University Press.

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., ... & Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. International Journal of Information Management, 66, 102542.

Ebadi, S., & Ebadijalal, M. (2022). The effect of Google Expeditions virtual reality on EFL learners' willingness to communicate and oral proficiency. Computer Assisted Language Learning, 35(8), 1975-2000.

Ebert, D., Gupta, S., & Makedon, F. (2016, June). Ogma: A virtual reality language acquisition system. In Proceedings of the 9th ACM international conference on pervasive technologies related to assistive environments (pp. 1-5).

Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed.

Ehrsson, H. H. (2012). 43 The concept of body ownership and its relation to multisensory integration. The New handbook of multisensory process.

Eiris, R., Jain, A., Gheisari, M., & Wehle, A. (2020). Safety immersive storytelling using narrated 360-degree panoramas: A fall hazard training within the electrical trade context. Safety science, 127, 104703.

Elzie, C. A., & Shaia, J. (2021). A pilot study of the impact of virtually embodying a patient with a terminal illness. Medical Science Educator, 31, 665-675.

Erdogmus, E., Ryherd, E., Diefes-Dux, H. A., & Armwood-Gordon, C. (2021, October). Use of virtual reality to improve engagement and self-efficacy in architectural engineering disciplines. In 2021 IEEE Frontiers in Education Conference (FIE) (pp. 1-7). IEEE.

Fabini, J., Hartl, A., Meghdouri, F., Breitenfellner, C., & Zseby, T. (2021, August). SecTULab: A Moodle-Integrated Secure Remote Access Architecture for Cyber Security Laboratories. In Proceedings of the 16th International Conference on Availability, Reliability and Security (pp. 1-11).

Feldon, D. F., Jeong, S., & Clark, R. E. (2021). Fifteen Common but Questionable Principles of Multimedia Learning. Mayer and Fiorella, 25-40.

Fernández Galeote, D., & Hamari, J. (2021). Game-based climate change engagement: analyzing the potential of entertainment and serious games. Proceedings of the ACM on Human-Computer Interaction, 5(CHI PLAY), 1-21.

Fiorella, L., & Mayer, R. E. (2022). Principles based on social cues in multimedia learning: Personalization, voice, image, and embodiment principles. The Cambridge handbook of multimedia learning, 277-285.

Franck, N., Farrer, C., Georgieff, N., Marie-Cardine, M., Daléry, J., d'Amato, T., & Jeannerod, M. (2001). Defective recognition of one's own actions in patients with schizophrenia. American Journal of Psychiatry, 158(3), 454-459.

Frederiksen, J. G., Sørensen, S. M. D., Konge, L., Svendsen, M. B. S., Nobel-Jørgensen, M., Bjerrum, F., & Andersen, S. A. W. (2020). Cognitive load and performance in immersive virtual reality versus conventional virtual reality simulation training of laparoscopic surgery: a randomized trial. Surgical endoscopy, 34, 1244-1252.

Fryer, L. K., Ainley, M., Thompson, A., Gibson, A., & Sherlock, Z. (2017). Stimulating and sustaining interest in a language course: An experimental comparison of Chatbot and Human task partners. Computers in Human Behavior, 75, 461-468.

Fernández Galeote, D., & Hamari, J. (2021). Game-based climate change engagement: analyzing the potential of entertainment and serious games. Proceedings of the ACM on Human-Computer Interaction, 5(CHI PLAY), 1-21.

Gallagher, S. (2000). Philosophical conceptions of the self: implications for cognitive science. Trends in cognitive sciences, 4(1), 14-21.

Garcia, S., Laesker, D., Caprio, D., Kauer, R., Nguyen, J., & Andujar, M. (2019). An immersive virtual reality experience for learning Spanish. In Learning and Collaboration Technologies. Ubiquitous and Virtual Environments for Learning and Collaboration: 6th International Conference, LCT 2019, Held as Part of the 21st HCI International Conference, HCII 2019, Orlando, FL, USA, July 26–31, 2019, Proceedings, Part II 21 (pp. 151-161). Springer International Publishing.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. Computers in entertainment (CIE), 1(1), 20-20.

Ghinea, G., Timmerer, C., Lin, W., & Gulliver, S. R. (2014). Mulsemedia: State of the art, perspectives, and challenges. ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 11(1s), 1-23.

Gibson, E.J. (1988). "Exploratory Behavior in the Development of Perceiving, Acting, and the Acquiring of Knowledge". Annual Review of Psychology. 39 (1): 1–42.

Giummarra, M. J., Gibson, S. J., Georgiou-Karistianis, N., & Bradshaw, J. L. (2008). Mechanisms underlying embodiment, disembodiment and loss of embodiment. Neuroscience & Biobehavioral Reviews, 32(1), 143-160.

Govender, T., & Arnedo-Moreno, J. (2021). An analysis of game design elements used in digital game-based language learning. Sustainability, 13(12), 6679.

Griffiths, P., and Scarantino, A. (2008). Emotions in the wild. the situated perspective on emotions. In P. Robbins and M. Aydede (Eds.). The Cambridge Handbook of Situated Cognition, 437–453. New York, NY: Cambridge University Press. doi: 10.1017/CBO9780511816826.023

Griffiths, P., and Scarantino, A. (2008). "Emotions in the wild. the situated perspective on emotions, "in The Cambridge Handbook of Situated Cognition, eds. P. Robbins and M. Aydede (New York, NY: Cambridge University Press), 437–453.

Guaqueta, C. A., & Castro-Garces, A. Y. (2018). The use of language learning apps as a didactic tool for EFL vocabulary building. English Language Teaching, 11(2), 61-71.

Gündüz, A. Y., & Akkoyunlu, B. (2020). Effectiveness of gamification in flipped learning. Sage Open, 10(4), 2158244020979837.

Hakkarainen, K. A. I. (2003). Emergence of progressive-inquiry culture in computer-supported collaborative learning. Learning Environments Research, 6(2).

Halligan, P. W., Fink, G. R., Marshall, J. C., & Vallar, G. (2003). Spatial cognition: evidence from visual neglect. Trends in cognitive sciences, 7(3), 125-133.

Hannafin, M. J., Land, S. & Oliver, K. (1999). Open learning environments: foundations, methods, and models, in: C. M. Reigeluth (Ed.) Instructional design theories and models: a new paradigm of instructional theory (vol. II) (London, Lawrence Erlbaum Associates), 115–140.

Belland, B.R., Kim, CM & Hannafin, M.J. (2013). A Framework for Designing Scaffolds That Improve Motivation and Cognition, Educational Psychologist, 48(4),243-270, DOI: 10.1080/00461520.2013.838920

Hartfill, J., Gabel, J., Neves-Coelho, D., Vogel, D., Räthel, F., Tiede, S., ... & Steinicke, F. (2020, September). Word Saber: An effective and fun VR vocabulary learning game. In Proceedings of the Conference on Mensch und Computer (pp. 145–154).

Hayes, A. T., Dhimolea, T. K., Meng, N., & Tesh, G. (2021). Levels of immersion for language learning from 2D to highly immersive interactive VR. In Contextual Language Learning: Real Language Learning on the Continuum from Virtuality to Reality (pp. 71-89). Singapore: Springer Singapore.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. Educational psychologist, 41(2), 111-127.

Hill, J. R., & Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. Educational technology research and development, 49(3), 37-52.

Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. European Journal of Education, 57(4), 542-570.

Homer, R., Hew, K. F., & Tan, C. Y. (2018). Comparing digital badges-and-points with classroom token systems: Effects on elementary school ESL students' classroom behavior and English learning. Journal of Educational Technology & Society, 21(1), 137-151.

Hopp, P., Smith, C. A. P., & Hayne, S. C. (2002). Literature review of shared cognition. Retrieved May, 16, 2006.

Hsu, C. L., & Chen, M. C. (2021). Advocating recycling and encouraging environmentally friendly habits through gamification: An empirical investigation. Technology in Society, 66, 101621.

Hutchins, E. (1995). Cognition in the Wild. MIT press.

Infantes, T. A., Hurtado, A. F., Sánchez V., F., & Martínez G., J. E. (2022). Mindfulness in health education: from physical to virtual presence during the pandemic, an anthropological study in Spain. Sustainability, 14(5), 2547.

Isen, A. M., & Reeve, J. (2005). The influence of positive affect on intrinsic and extrinsic motivation: Facilitating enjoyment of play, responsible work behavior, and self-control. Motivation and emotion, 29, 295-323.

Jeannerod, M. (2007). Being oneself. Journal of Physiology-Paris, 101(4-6), 161-168.

Johnson-Glenberg, M. C., Bartolomea, H., & Kalina, E. (2021). Platform is not destiny: Embodied learning effects comparing 2D desktop to 3D virtual reality STEM experiences. Journal of Computer Assisted Learning, 37(5), 1263-1284.

Kaplan-Rakowski, R., & Wojdynski, T. (2018). Students' attitudes toward high-immersion virtual reality assisted language learning. Future-proof CALL: Language learning as exploration and encounters—short papers from EUROCALL, 124-129.

Kester, L. & Merrienboer, J. 2022. Implications of the Four-Component Instructional Design Model for Multimedia learning. The Cambridge Handbook of Multimedia Learning (pp.100-120)

Kétyi, A. (2016). From mobile language learning to gamification: an overlook of research results with business management students over a five-year period.

Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. Presence: Teleoperators and Virtual Environments, 21(4), 373-387.

Kirschner, P. A. (2017). Stop propagating the learning styles myth. Computers & Education, 106, 166-171.

Knowles, M. S. (1975). Self-directed learning: A guide for learners and teachers.

Kolb, D.A. (1984). Experiential learning: Experience as the source of learning and development: FT press.

Kuhail, M. A., Alturki, N., Alramlawi, S., & Alhejori, K. (2022). Interacting with educational chatbots: A systematic review. Education and Information Technologies, 28(1), 973-1018.

Kulik, J.A, & Fletcher, J.D. (2016). Effectiveness of intelligent tutoring systems: a meta-analytic review. Review of Educational Research, 86(1), 42–78.

Kulkarni, P., Gokhale, P., Satish, Y. M., & Tigadi, B. (2022). An empirical study on the impact of learning theory on gamification-based training programs. Organization Management Journal.

Kwak, D.-H., Ma, X., Polites, G., Srite, M., Hightower, R., and Haseman, W. D. 2019. "Cross-Level Moderation of Team Cohesion in Individuals' Utilitarian and Hedonic Information Processing: Evidence in the Context of Team-Based Gamified Training," Journal of the Association for Information Systems (20:2), pp. 161–185.

Lakoff G, Johnson M (1999). Philosophy In The Flesh: The Embodied Mind and its Challenge to Western Thought. Basic Books

Lazarus, R. S., Option, E. M., & Spielberg, C. D. (1966). The study of psychological stress Anxiety and Behavior.-N.

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge university press.

Lavoie, D. R. (1999). Effects of Emphasizing Hypothetico-Predictive Reasoning within the Science Learning Cycle on High School Student's Process Skills and Conceptual Understandings in Biology. Journal of Research in Science Teaching, 36(10), 1127-1147.

Law, E., Baghaei Ravari, P., Chhibber, N., Kulic, D., Lin, S., Pantasdo, K.D, Ceha, J., Suh, S., & Dillen, N. (2020). Curiosity notebook: A platform for learning by teaching conversational agents. In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1–9).

Leenaraj, B., Arayaphan, W., Intawong, K., & Puritat, K. (2023). A gamified mobile application for first-year student orientation to promote library services. Journal of Librarianship and Information Science, 55(1), 137-150.

Ley, T., Seitlinger, P., & Pata, K. (2016). Patterns of meaning in a cognitive ecosystem: Modeling stabilization and enculturation in social tagging systems. Mass collaboration and education, 143-163.

Li, M., Chau, P. Y., & Ge, L. (2021). Meaningful gamification for psychological empowerment: exploring user affective experience mirroring in a psychological self-help system. Internet Research, 31(1), 11-58.

Li, P., Fang, Z., & Jiang, T. (2022). Research Into Improved Distance Learning Using VR Technology. In Frontiers in Education (Vol. 7, p. 32). Frontiers.

Liew, T. W., Tan, S. M., Tan, T. M., & Kew, S. N. (2020). Does speaker's voice enthusiasm affect social cue, cognitive load and transfer in multimedia learning? Information and Learning Sciences, Online First, 117–135. https://doi.org/10.1108/ILS-11-2019-0124.

Linnenbrink, E. A., & Pintrich, P. R. (2002). Motivation as an enabler for academic success. School psychology review, 31(3), 313-327.

Liu, D., Bhagat, K. K., Gao, Y., Chang, T. W., & Huang, R. (2017). The potentials and trends of virtual reality in education: A bibliometric analysis on top research studies in the last two decades. Virtual, augmented, and mixed realities in education, 105-130.

Lopez, C., Halje, P., & Blanke, O. (2008). Body ownership and embodiment: vestibular and multisensory mechanisms. Neurophysiologie Clinique/Clinical Neurophysiology, 38(3), 149-161.

López, Ó., González, A., Álvarez, F. J., & Rodríguez, D. (2021). A comparative study on teaching methodologies applied in engineering and manufacturing process subjects during the COVID-19 pandemic in 2020 and 2021. Applied Sciences, 11(23), 11519.

Lui, M., Kuhn, A. C., Acosta, A., Quintana, C., & Slotta, J. D. (2014, April). Supporting learners in collecting and exploring data from immersive simulations in collective inquiry. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2103-2112).

MacWhinney, B. (2017). A shared platform for studying second language acquisition. Language Learning, 67(S1), 254-275.

Magner, U. I., Schwonke, R., Aleven, V., Popescu, O., & Renkl, A. (2014). Triggering situational interest by decorative illustrations both fosters and hinders learning in computer-based learning environments. Learning and instruction, 29, 141-152.

Makransky, G., Terkildsen, T. S., & Mayer, R. E. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. Learning and instruction, 60, 225-236.

Mayer, R. E. (2001). Multimedia Learning. Cambridge University Press.

Mayer, R. E. (2014). The Cambridge Handbook of Multimedia Learning. 2nd edition. Cambridge University Press.

Mayer R. E. (2010). Cognitive theory of multimedia learning. Cambridge Handbook of.
Sweller, J., Ayres, P., Kalyuga, S., Sweller, J., Ayres, P., & Kalyuga, S. (2011). Measuring cognitive load. Cognitive load theory, 71-85.

Mayer, R. E., Mautone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. Journal of Educational Psychology, 94(1), 171–185. doi:10.1037//0022-0663.94.1.171.

Mayer, R. E., Sobko, K., & Mautone, P. D. (2003). Social cues in multimedia learning: Role of speaker's voice. Journal of Educational Psychology, 95, 419–425. https://doi.org/10.1037/0022-0663.95.2.419.

Mayer, R. E. (2005). Principles of multimedia learning based on social cues: personalization, voice, and image principles. In R. E. Mayer (Ed.), The Cambridge Handbook of multimedia learning (pp. 201-212). Cambridge: Cambridge University Press.

McNamara, S. W., Bittner, M., Katz, H., & Hangauer, K. (2022). Addressing literature gaps in online learning and adapted physical education: A scoping review. Kinesiology Review, 11(2), 191-196.

Medina, E. G. L., & Hurtado, C. P. R. (2017). Kahoot! A digital tool for learning vocabulary in a language classroom. Revista Publicando, 4(12 (1)), 441-449.

Mendez, S., Johanson, K., Martin Conley, V., Gosha, K., A Mack, N., Haynes, C., & A Gerhardt, R. (2020). Chatbots: A tool to supplement the future faculty mentoring of doctoral engineering students. International Journal of Doctoral Studies, 15.

Meyers, M., Hughes, C., Fidopiastis, C., & Stanney, K. (2020). Long duration ar exposure and the potential for physiological effects. MODSIM World 2022.

Monteiro, A. M. V., & Ribeiro, P. N. D. S. (2020). Virtual reality in English vocabulary teaching: an exploratory study on affect in the use of technology. Trabalhos em Linguística Aplicada, 59, 1310-1338.

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments: Special issue on interactive learning environments: Contemporary issues and trends. Educational psychology review, 19, 309-326.

Moro, C., Štromberga, Z., Raikos, A., & Stirling, A. (2017). The effectiveness of virtual and augmented reality in health sciences and medical anatomy. Anatomical sciences education, 10(6), 549-559.

Munafo, J., Diedrick, M., & Stoffregen, T. A. (2017). The virtual reality head-mounted display Oculus Rift induces motion sickness and is sexist in its effects. Experimental brain research, 235, 889-901.

Murphy, P. K., & Alexander, P. A. (2000). A motivated exploration of motivation terminology. Contemporary educational psychology, 25(1), 3-53.

Müller, A. M., Goh, C., Lim, L. Z., & Gao, X. (2021). Covid-19 emergency e-learning and beyond: Experiences and perspectives of university educators. Education Sciences, 11(1), 19.

Myers, D.G.; Lamm, H. (1975). The polarizing effect of group discussion. American Scientist, 63 (3): 297–303. Bibcode:1975AmSci..63..297M. PMID 1147368.

Noë, A., & Noë, A. (2004). Action in perception. MIT press.

Normand, J. M., Giannopoulos, E., Spanlang, B., & Slater, M. (2011). Multisensory stimulation can induce an illusion of larger belly size in immersive virtual reality. PloS one, 6(1), e16128.

O'regan, J. K., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. Behavioral and brain sciences, 24(5), 939-973.

Paavola, S., Engeström, R. & Hakkarainen, K. (2012). Trialogical approach as a new form mediation. In A.Moen, A.I. Morch, S. Paavola (Eds.), Collaborative Knowledge Creation: Practices, Tools, Concepts, 1-14.

Pack, A., Barrett, A., Liang, H. N., & Monteiro, D. V. (2020). University EAP students' perceptions of using a prototype virtual reality learning environment to learn writing structure. International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 10(1), 27-46.

Peck, T. C., Seinfeld, S., Aglioti, S. M., & Slater, M. (2013). Putting yourself in the skin of a black avatar reduces implicit racial bias. Consciousness and cognition, 22(3), 779-787.

Peeters, W., & Pretorius, M. (2020). Facebook or fail-book: Exploring "community" in a virtual community of practice. ReCALL, 32(3), 291-306.

Petkova, V. I., & Ehrsson, H. H. (2008). If I were you: perceptual illusion of body swapping. PloS one, 3(12), e3832.

Pierce, L. M., Weber, M. J., Klein, C. J., & Stoecker, B. A. (2020). Transitioning an advanced practice fellowship curriculum to e-learning during the COVID-19 pandemic. Journal of Nursing Education, 59(9), 514-517.

Plass, J. L., Homer, B. D., & Hayward, E. O. (2009). Design factors for educationally effective animations and simulations. Journal of Computing in Higher Education, 21(1), 31–61. doi:10.1007/s12528-009-9011-x.

Plass, J. L., & Kaplan, U. (2016). Emotional design in digital media for learning. In Emotions, technology, design, and learning (pp. 131-161). Academic Press.

Plass, J. & Schwartz, R. (2014). Multimedia Learning with Simulations and Microworlds. In E. R. Mayer (Ed.). Cambridge Handbook of Multimedia Learning, Ed. 2, 729-761. 10.1017/CBO9781139547369.036.

Pärnpuu, M. (2020). Designing for values: value elicitation toolkit. Master's thesis.Tallinn University.

Qin, C., Huang, W., & Hew, K. F. (2020, November). Using the Community of Inquiry framework to develop an educational chatbot: lesson learned from a mobile instant messaging learning environment. In Proceedings of the 28th International Conference on Computers in Education.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education, 147, 103778.

Rapp, A. (2017). From games to gamification: A classification of rewards in World of Warcraft for the design of gamified systems. Simulation & Gaming, 48(3), 381-401.

Renniger & Järvelä, (2022). Designing for meaningful learning: Interest, motivation and engagement. The Cambridge handbook of Learning sciences. (pp.602-618). Cambridge University Press.

Reynolds, M. (2011). Reflective Practice: Origins and Interpretations. Action Learning: Research and Practice, 8(1), 5–13.

Revans, R. W. (1998). ABC of action learning. London: Lemos and Crane.

Rey-Becerra, E., Barrero, L. H., Ellegast, R., & Kluge, A. (2021). The effectiveness of virtual safety training in work at heights: A literature review. Applied Ergonomics, 94, 103419.

Richards, D., & Taylor, M. (2015). A Comparison of learning gains when using a 2D simulation tool versus a 3D virtual world: An experiment to find the right representation involving the Marginal Value Theorem. Computers & Education, 86, 157-171.

Rieber, L. (2005). Multimedia learning in games, simulations, and microworlds. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (pp. 549–567). New York: Cambridge University Press.

Rizvic, S., Boskovic, D., Bruno, F., Petriaggi, B. D., Sljivo, S., & Cozza, M. (2019, September). Actors in VR storytelling. In 2019 11th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games) (pp. 1-8). IEEE.

Rizzetto, F., Rantas, S., Vezzulli, F., Cassin, S., Aseni, P., & Vertemati, M. (2023). New Trends in Surgical Education and Mentoring by Immersive Virtual Reality: An Innovative Tool for Patient's Safety. In The High-risk Surgical Patient (pp. 657-667). Cham: Springer International Publishing.

Roeser, S. (2018). Socially Extended Moral Deliberation About Risks: A Role for Emotions and Art. In J. A. Carter, A. Clark, J. Kallestrup, S. O. Palermos, D. Pritchard (Eds.). Socially Extended Epistemology, 157–172. Oxford: Oxford University Press.

Roseman, I. J. (1984). Cognitive determinants of emotion: A structural theory. Review of personality & social psychology.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological monographs: General and applied, 80(1), 1.

Saleme, E. B., Santos, C. A., Falbo, R. A., Ghinea, G., & Andres, F. (2018, September). Towards a reference ontology on mulsemedia systems. In Proceedings of the 10th International Conference on Management of Digital EcoSystems (pp. 23-30).

Sato, A., & Yasuda, A. (2005). Illusion of sense of self-agency: discrepancy between the predicted and actual sensory consequences of actions modulates the sense of self-agency, but not the sense of self-ownership. Cognition, 94(3), 241-255.

Saye, J. W., & Brush, T. (2002). Scaffolding critical reasoning about history and social issues in multimedia-supported learning environ- ments. Educational Technology Research and Development, 50, 77–96. doi:10.1007/BF02505026.

Scherer, K. R. (2009). The dynamic architecture of emotion: Evidence for the component process model. Cognition and emotion, 23(7), 1307-1351.

Schneider, S., Beege, M., Nebel, S., Schnaubert, L. & Rey, G. D. (2021). The Cognitive-Affective-Social Theory of Learning in digital Environments (CASTLE). Educational Psychology Review, 34, 1–38, https://doi.org/10.1007/s10648-021-09626-5

Schnotz, W., & Bannert, M. (2003). Construction and interference in learning from multiple representation. Learning and instruction, 13(2), 141-156.

Schrader, C., Kaljyuga, S., and Plass, J.L. (2022). Motivation and affect in multimedia learning. The Cambridge handbook of Multimedia learning. (pp.121-131)

Schuelke-Leech, B. (2018). A Model for Understanding the Orders of Magnitude of Disruptive Technologies. Technological Forecasting & Social Change 129, 261–274.

Schunk, D. H., & Zimmerman, B. J. (1994). Self-regulation in education: Retrospect and prospect. Self-regulation of learning and performance: Issues and educational applications, 13, 305-314.

Shapiro, L. A. (2011). Embodied cognition: lessons from linguistic determinism. Philosophical Topics, 39(1), 121-140.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. Psychological review, 84(2), 127.

Schouten, D. G., Venneker, F., Bosse, T., Neerincx, M. A., & Cremers, A. H. (2017). A digital coach that provides affective and social learning support to low-literate learners. IEEE Transactions on Learning Technologies, 11(1), 67-80.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. Contemporary educational psychology, 19(4), 460-475.

Schrier, K., & Farber, M. (2021). A systematic literature review of 'empathy'and 'games'. Journal of Gaming & Virtual Worlds, 13(2), 195-214.

Selco, J. I., & Habbak, M. (2021). Stem students' perceptions on emergency online learning during the covid-19 pandemic: Challenges and successes. Education Sciences, 11(12), 799.

Seligman, M. E., Kaslow, N. J., Alloy, L. B., Peterson, C., Tanenbaum, R. L., & Abramson, L. Y. (1984). Attributional style and depressive symptoms among children. Journal of abnormal psychology, 93(2), 235.

Shimada, S., Fukuda, K., & Hiraki, K. (2009). Rubber hand illusion under delayed visual feedback. PloS one, 4(7), e6185.

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1535), 3549-3557.

Slater, M., Spanlang, B., & Corominas, D. (2010). Simulating virtual environments within virtual environments as the basis for a psychophysics of presence. ACM transactions on graphics (TOG), 29(4), 1-9.

Slater, M., Spanlang, B., Sanchez-Vives, M. V., & Blanke, O. (2010). First person experience of body transfer in virtual reality. PloS one, 5(5), e10564.

Slater, M. (2014). Grand challenges in virtual environments. Frontiers in Robotics and AI, 1, 3.

Smith, J.L., Harrison, P.R., Bryant, F.B. (2014). Enjoyment. In: Michalos, A.C. (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht.

Spence, C., & Ho, C. (2015). Multisensory information processing. In D. A. Boehm-Davis, F. T. Durso, & J. D. Lee (Eds.), APA handbook of human systems integration (pp. 435–448). American Psychological Association. https://doi.org/10.1037/14528-027

Steinert, S., Marin, L., & Roeser, S. (2022). Feeling and thinking on social media: emotions, affective scaffolding, and critical thinking. Inquiry (United Kingdom). https://doi.org/10.1080/0020174X.2022.2126148

Sterelny, K. (2010). Minds: extended or scaffolded? Phenomenology and the Cognitive Sciences, 9, 465–481. doi: 10.1007/s11097-010-9174-y

Sulema, Y. (2016, May). Mulsemedia vs. Multimedia: State of the art and future trends. In 2016 International conference on systems, signals and image processing (IWSSIP) (pp. 1-5). IEEE.

Sun, J.C-Y. & Hsieh, P-H. (2018). Application of a Gamified Interactive Response System to Enhance the Intrinsic and Extrinsic Motivation, Student Engagement, and Attention of English Learners. Educational Technology & Society, 21(3), 104-116.

Sunstein, C.R. (1999). The law of group polarization. University of Chicago Law School, John M. Olin Law & Economics Working Paper, doi: 10.2139/ssrn.199668.

Sutton, J. (2008). Distributed cognition. Domains and dimensions. In E. Itiel, S.R. Harnad (Eds.) Cognition Distributed: How Cognitive Technology Extends Our Minds (pp. 45 – 56). Amsterdam: John Benjamins Publishing Co.

Säljö, R. (2001). Concepts, Learning and the Constitution of Objects and events in Discursive Practices. The Situated Nature of Human Understanding. Socio-Cultural Theory and Methods. An Antology, 119-144.

Sweller, J., Ayres, P. & Kalyuga, S. (2011). Cognitive load theory. DOI:10.1007/978-1-4419-8126-4_7

Škola, F., Tinkova, S., & Liarokapis, F. (2019). Progressive Training for Motor Imagery Brain-Computer Interfaces Using Gamification and Virtual Reality Embodiment. Frontiers in Human Neuroscience 13, 329. DOI:10.3389/fnhum.2019.00329

Thagard, P. and Cameron S..(2005). Abductive reasoning: Logic, visual thinking, and coherence.Waterloo, Ontario: Philosophy Department, University of Waterloo, 1997. 2.

Thorndike, E. L. (1932). The fundamentals of learning.

Tsakiris, M., & Haggard, P. (2005). The rubber hand illusion revisited: visuotactile integration and self-attribution. Journal of experimental psychology: Human perception and performance, 31(1), 80.

Tsakiris, M., Haggard, P., Franck, N., Mainy, N., & Sirigu, A. (2005). A specific role for efferent information in self-recognition. Cognition, 96(3), 215-231.

Tsakiris, M., Prabhu, G., & Haggard, P. (2006). Having a body versus moving your body: How agency structures body-ownership. Consciousness and cognition, 15(2), 423-432.

Tulving, E. (1972). Episodic and semantic memory.

Töpper, J., Glaser, M., Schwan, S. (2014). Extending social cue based principles of multimedia learning beyond their immediate effects. Learning and Instruction, 29, 10-20. http://dx.doi.org/10.1016/j.learninstruc.2013.07.002

Ummihusna, A. & Zairul, M. (2021). Investigating immersive learning technology intervention in architecture education: a systematic literature review. Journal of Applied Research in Higher Education. ahead-of-print. 10.1108/JARHE-08-2020-0279.

Vaishnavi, S., Calhoun, J., & Chatterjee, A. (2001). Binding personal and peripersonal space: Evidence from tactile extinction. Journal of Cognitive Neuroscience, 13(2), 181–189. https://doi.org/10.1162/089892901564243

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. Educational Psychol- ogy Review, 22, 271–296.

Varela, F. J., Thompson, E., & Rosch, E. (2017). The embodied mind, revised edition: Cognitive science and human experience. MIT press.

Vázquez, C., Xia, L., Aikawa, T., & Maes, P. (2018, July). Words in motion: Kinesthetic language learning in virtual reality. In 2018 IEEE 18th International Conference on advanced learning technologies (ICALT) (pp. 272-276). IEEE.

Villegas-Ch, W., Arias-Navarrete, A., Palacios-Pacheco, X. (2020). Proposal of an architecture for the integration of a Chatbot with artificial intelligence in a smart campus for the improvement of learning. Sustainability (Switzerland), 12(4).

von Holst, E., & Mittelstaedt, H. (1950). Das reafferenzprinzip: Wechselwirkungen zwischen zentralnervensystem und peripherie. Naturwissenschaften, 37(20), 464-476.

Väljataga, T., Fiedler, S.H., Laanpere, M. (2015). Re-thinking Digital Textbooks: Students as Co-authors. In: Li, F., Klamma, R., Laanpere, M., Zhang, J., Manjón, B., Lau, R. (eds) Advances in Web-Based Learning -- ICWL 2015. ICWL 2015. Lecture Notes in Computer Science(), vol 9412. Springer, Cham. https://doi.org/10.1007/978-3-319-25515-6_13

Väljataga, T. (2010). Learner Control and Responsibility: Expanding the Concept of Self-direction in Higher Education. Tampere: Tampere University of Technology.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Wambsganss, T., Winkler, R., Söllner, M., & Leimeister, J. M. (2020). A conversational agent to improve response quality in course evaluations. In Extended Abstracts of the 2020 CHI conference on human factors in computing systems (pp. 1–9).

Wenger, E. (1998). Communities of practice: Learning, meaning, and identity. Cambridge University Press. https://doi.org/10.1017/CBO9780511803932

Willems T. (2018). Seeing and sensing the railways: A phenomenological view on practice-based learning. Management Learning, 49, 23–39. doi: 10.1177/1350507617725188.

Winne, P. H., and Azevedo, R. (2022). Metacognition. In K. Sawyer (Ed.). Cambridge Handbook Of The Learning Sciences, third edition. Cambridge, MA: Cambridge University Press.

Wolf, M. A., Pizanis, A., Fischer, G., Langer, F., Scherber, P., Stutz, J., ... & Fritz, T. (2022). COVID-19: a catalyst for the digitization of surgical teaching at a German University Hospital. BMC Medical Education, 22(1), 1-7.

Wong, L. H., & Looi, C. K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. Computers & Education, 57(4), 2364-2381.

Yang, Q. F., Chang, S. C., Hwang, G. J., & Zou, D. (2020). Balancing cognitive complexity and gaming level: Effects of a cognitive complexity-based competition game on EFL students' English vocabulary learning performance, anxiety and behaviors. Computers & Education, 148, 103808.

Yang, F., & Goh, Y. M. (2022). VR and MR technology for safety management education: An authentic learning approach. Safety science, 148, 105645.

Yee, N., & Bailenson, J. (2007). The Proteus effect: The effect of transformed self-representation on behavior. Human communication research, 33(3), 271-290.

Yu, Z., & Hao, J. (2022). Heart rate, perceived stress and prosocial behaviour: real-time psychophysiological correlates of prosocial behaviour. Current Psychology, 1-12.

Zhang, H., Cui, Y., Shan, H., Qu, Z., Zhang, W., Tu, L., & Wang, Y. (2020, June). Hotspots and trends of virtual reality, augmented reality and mixed reality in the education field. In 2020 6th International Conference of the Immersive Learning Research Network (iLRN) (pp. 215-219). IEEE.

Zheng, D., Newgarden, K., & Young, M. F. (2012). Multimodal analysis of language learning in World of Warcraft play: Languaging as values-realizing. ReCALL, 24(3), 339-360.

Zimmerman, B. J., & Schunk, D. H. (Eds.). (2001). Self-regulated learning and academic achievement: Theoretical perspectives (2nd ed.). Lawrence Erlbaum Associates Publishers.

Zhou, L., Yu, J., & Shi, Y. (2017). Learning as adventure: An app designed with gamifi-cation elements to facilitate language learning. In International Conference on HCI inBusiness, Government, and Organizations (pp. 266–275). Springer, Cham.

Annex 1. Literature review methodology and tables

The sample of e-learning studies was formed from 106 papers from the period 2020-2022 (Covid pandemia period), from which 11 relevant papers were selected that focused on practice based e-learning aspects. The results of analysis are presented in section 4.1.

The sample of research papers of disruptive technologies was driven from SCOPUS database using the keywords of VR, AR, chatbot, virtual games, using multimedia new approaches, collaborative e-learning, and constraint period of 2020-2022. The sample of learning effects papers was formed of 226 papers, from which 67 papers were selected for further analysis. We also observed the recent Horizon projects about technology based learning, and the related research papers associated with the projects.

The analytical process was structured with the questions:

- What were the research questions of the articles?
- Type of technologies and media used in experiments
- The goal of the learning scenarios in the experiments
- The purpose of technology in the experiments
- The type of practice-based learning that was used in the experiments
- Interactivity level of learning activities
- Scaffolding types in learning activities
- Type of learning effects (Cognitive, metacognitive, affective, psychomotor and embodied)
- Description of the learning effects
- Description of the learning obstacles

The literature analysis was done by three researchers. The coding process was tested for interrater reliability with some sample articles.

The data analysis was done using the sorting method (the results are mostly presented in tables) and qualitative synthesis of the findings. Tables 1-5 provide specific information sorted from the research papers. The synthesis of the findings is provided in section 4.2.

Table 1. Positive cognitive learning effects in disruptive learning environments

	Interactive media technologies (AR, VR, XR, MR)	Adaptive support technologies (AI)	Motivation technologies (game)
Cognitive processing	VR primarily employs minimising cognitive load and processing energy. The multi-sensory channels (vision, audition, haptics)	AI empowered learning path designed to students learning styles (Kuhail et al. 2022).	

	enable the brain to behave as it would in a real-life situation and may play a crucial role for people with sensory disabilities (Drigas et al 2022). Learning content migration from non-immersive to immersive formats might impose different cognitive load demands on the learner's cognitive apparatus (Baceviciute et al 2021). There is better concentration in the virtual environment with no interruptions (Buyego et al 2022).		
Attention. Awareness. Situation awareness.	The rich VR environments did not seem to be a problem for the students. They got to learn more in-depth details, and it captured their interest (DeWitt et al 2022).	A teachable agent which starts by asking students low or high-level questions about a specific topic to evoke their curiosity. (Kuhail et al. 2022). The embodied conversational agents in VR in developing listening skills (Bahari, 2022).	
Knowledge. Knowledge retrieval. Knowledge retention. Knowledge rehearsal. Recall. Remembering.	Meaningful textual information in VR environments (Hayes et al., 2021). More cognitive resources can be allocated for reading in immersive media (Baceviciute et al 2021). Students' prior knowledge can be activated by	Students are supposed to act as "tutors" and provide the chatbot with examples and feedback, chatbot that learns from students' answers and activities (Kuhail et al. 2022).	The use in the game of a cognitive retrieval mnemonic (memory cards) (Rey-Becerra et al. 2021). Performance feedback (indication of the correct answer), appeared to improve long-term retention (Rey-Becerra et al. 2021).

	experiencing such an environment (Asad et al 2021). The diversified exposure to practical knowledge in immersive virtual reality would improve the capacity of memory to recall (Asad et al. 2021). Learners might use the surrounding environment to anchor and help encode their learning (Baceviciute et al 2021). Participants managed inappropriate behaviours were significantly improved as a consequence of the repeated practice (Chen 2021). Better retention in the immersive VR condition compared to the PC (Johnston-Glenberg et al. 2020). An informal learning environment, adopting VR, AR and MR can enhance students' performance in acquiring knowledge (Zhang et al. 2020). Assessment in teaching integrating AR technology into evaluation and feedback can improve students' learning effect (Zhang et al. 2020)..		Game-based learning demonstrated obvious improvement in knowledge retention capability (Zhang et al. 2020).
Understanding. Comprehension. Deep learning.	Even though the learners did not recall more details implied in	The embodied chatbot mimics the conversation	Provide students with options, to make choices, and

Bloom's taxonomy: remember, understand, create, apply, analyse and evaluate. Higher order thinking skills. The processes of analysis and synthesis, deducing, inferring and abducting. Critical thinking.	learning, in VR they were able to build a better overall understanding of the learning material (Baceviciute et al 2021) Immersive storytelling, the exposure to the realistic simulation under analogous conditions (Eiris et al 2020). The context and the virtual characters' body language help to guess the meaning (Akgün & Atici 2022). The immersive and interactive features of the VR system that allowed learners to use their hands to pick up and examine the organs promoted their understanding and knowledge retention (Di Natale et al 2020). Minimal content manipulation in VR compared to PC, reported no learning differences between the VR condition (single hand controller) and PC condition with the mouse (Johnston-Glenberg et al. 2020). VR facilitates step-by-step skill procedural learning, which if experienced as successful can trigger the outcome related emotion of joy (Dubovi, 2022).	movements of human tutors who advise students in gradually developing explanations to problems. The chatbot provides a variety of questions by filling a predefined sentence template. To confirm its learning and make the conversation interesting, the chatbot seeks feedback from students by asking questions such as, "Am I smart?"(Kuhail et al. 2022). The chatbot provides voice and text-based scaffolds when needed (Kuhail et al. 2022).	opportunities to make corrections based on feedback (e.g. learning by failing) (Bourke 2020). Apply game mechanics and dynamics to non-game context to enhance learners to guide them follow specific behaviour (Dehghanzadeh et al., 2021).

	Comfort level is a significant confounding factor that influences knowledge gained (Yang & Goh, 2022).		
Conceptual knowledge. Misconceptions (did not occur) Understanding abstract concepts. Cognitive coherence.	The interaction with people in the virtual world gives a deeper impression of the learning content (Yang & Goh, 2022). Enabling students to actively explore and interact with learning objects improved conceptual knowledge (Di Natale et al., 2020). The interactive and immersive environment was crucial for the understanding of abstract concepts (Di Natale et al., 2020). VR time and space affect students' understanding and imagination (Li et al., 2022). Students became aware of the need to coordinate the information or demands of all the various disciplines (Erdogmus et al., 2021). To learn something specific about materials, greater understanding of the complexity (Bahari, 2022). Web simulations provide students opportunities not only		

	to acquire and apply knowledge in their own discipline but to also understand how this contributed to cross-disciplinary ways (Cooper et al., 2020).		
The processes of classification, associating and transformation. Association of past knowledge. Knowledge transfer. Perceived authenticity.	Virtual laboratories can play many advantages in experiment teaching (Zhang et al., 2020). VR/MR simulation is perceived to operationalise authenticity better than the recorded video lesson. 3D multi-user virtual environments offer language immersion experiences (Yang & Goh, 2022). A higher level of perceived authenticity and group work significantly increases motivation to learn and continued motivation to learn (Yang & Goh, 2022).		The realism in serious games made it easier to transfer what was learnt to real practice (Buijs-Spanjers et al,. 2020). A serious game that presented a story in a virtual location based on authentic content increased players' concern (Galeote & Hamari, 2021).
Knowledge visualisation. Knowledge mapping on situations. Creative visualisation. The modelling processes from one knowledge representation to another. (did not occur)	AR and MR have been used to help students with object visualisation and provide a promising approach to solve problems and improve visualisation skills (Zhang et al., 2020). Sense of being immersed in an unmediated reality may help put an individual in a suitable frame of mind to perceive non-existent things, tapping VR's		

	ability to activate cognitive apparatuses that help stimulate users' imaginative capacities (Barrett et al., 2021).		
Group knowledge. Collaborative knowledge. Community practice. Collective knowledge. Common ground in shared cognition (did not occur)			

Table 2. Cognitive learning obstacles in disruptive learning environments

	Interactive media technologies (AR, VR, XR, MR)	Adaptive support technologies (AI)	Motivation technologies (game)
Lack of attention, distractedness, feeling bored, sensory problems	I felt I was distracted a lot of times while using virtual reality, and I forgot to pay attention to the learning objective (Arayaphan et al 2022). The richness of authentic learning environments and the immersiveness of VR/MR are known to be a cause of distractions during learning (Bhagat & Huang, 2018). A further drawback of using VR tools in EFL classrooms might be that some students become extensively absorbed in the technology at the expense of language use (Ebadi & Ebadijalal 2022).	Distractions (Qin et al., 2020). Popup messages distracted the students from the essential tasks (Kuhail et al 2022).	

	People become bored easily when they remain in the same virtual space without different stimuli being supplied (Chen 2021). Participants with visual challenges expressed extra concerns on visibility of the artifacts (Buyego et al 2022). The image quality observed by subjects was relatively low and presented fuzziness for very small details (Eiris et al 2020). “The view was not clear, The items could not be seen clearly (DeWitt et al 2022). The challenge of the noise level when it is too high and deteriorates learners’ speech recognition (Dalim et al. 2020). The slower reading speed of readers in the virtual world lies in differences between 3D text in virtual world versus flat text in liquid crystal display (LCD) that affects the readability (Bahari 2021). Insufficient graphic quality (Galeote & Hamari, 2021).		
Cognitive information processing issues, Cognitive load problems, fatigue	Students in the IVR condition significantly learned less and had higher cognitive load than students in the		Excessive difficulty led to feelings of fatalism, which could have hindered behaviour change (Galeote & Hamari, 2021)

	desktop condition (Di Natale et al 2020). Students learned significantly less when using an IVR system than when they watched a slideshow on a desktop computer and suggested that this effect could be due to the increased cognitive load that the learners experienced when immersed in constant 360° animations (Di Natale et al., 2020) Cognitive overload for children in VR learning environment (Bahari, 2021). Due to gender differences of the participants, AR technology can be used to support female students to improve their visual-spatial abilities by reducing cognitive load [17]. in (Zhang et al., 2020) A cognitive overload happens caused by the overprocessing of extraneous information, which are non-essential to the learning outcome, in the virtual environments (Liu et al., 2017; Richards & Taylor, 2015) The challenges of this VR tool in terms of integration difficulties, distraction, and being		

	time-consuming (Bahari, 2021). The complex scenarios slow down the learning process by increasing students' cognitive load regarding visual-spatial problem-solving strategies (Frederiksen et al., 2020; Rizzetto et al., 2020). Immersive media demands more cognitive engagement, is less time efficient, and is perceived as more difficult to learn from (Baceviciute et al., 2021). There may be fatigue effects over time associated with extended learning in a VR HMD. (Johnston-Glenberg et al., 2020). High-dimensional characteristics can have a negative impact on the learning process. VR causes higher cognitive loads and physiological discomfort for learners (such as dizziness and unrealistic controller interaction). (Li et al., 2022)		
Expressive output issues, physical discomfort, retention	Participants' mobility in the VR condition was limited (Ahn, 2022). The control scheme required subjects to		

	look at a specific interface or object and press the button to trigger the interactions. Subjects noted verbally that this type of control sometimes interfered with their ability to perform tasks within the platform (Eiris et al., 2020) I personally prefer the online-based game not the physical activity because it was very tiring. (Leenaraj et al., 2023). Resources fail to provide learners with opportunities for spoken language production (MacWhinney, 2017). Students in the IVR group scored significantly higher on visual information retention, but significantly lower on auditory information retention (Di Natale et al 2020). It was challenging for the participants to remember the name of specific exhibits, names, and dates (Ebadi & Ebadijalal, 2022). Difficult questions would increase the student's eyeblinks (Dwivedi et al., 2022). The simulation would be more realistic and the participants would not feel a distance		

	when touching things in the virtual environment (Chen, 2021) On micro gestures or interactions, it is not clear how to interpret and react to the enhanced information on student behaviour knowledge on which students are attentive, puzzled etc. in the metaverse (Dwivedi et al., 2022). Physical discomfort (Bahari, 2021). Fear at heights, anxiety, cybersickness stress, risk-taking behaviour increase (Rey-Becerra et al., 2021). Participants in the IVR groups experienced more adverse effects such as discomfort, headache, dizziness, nausea and disorientation as well as blurred vision, difficulty focusing and double vision, compared to those in the control group (Di Natale et al., 2020). Eyestrain and dizziness among some students (DeWitt et al., 2022). A few students felt dizzy when learning with VR (Chang & Hwang, 2021). There are gender differences in cognitive functions.		

	When women use head-mounted displays, motion sickness susceptibility is more likely to occur (Munafo et al., 2017). Two students failed to complete the modules due to motion sickness or fear on induction of a migraine. (Elzie & Shaia, 2021) Real walking becomes challenging, however, when the virtual world outsizes the available physical space (Clack et al., 2021).		
Learning gains are not achieved Misunderstandings (did not occur)	A statistically significant negative effect of VR on vocabulary learning when compared to the results of control groups (Ebert et al., 2016; Hartfll et al., 2020; Vázquez et al., 2018). The implementation of mobile gamification orientation to promote library service cannot support knowledge acquisition better (Leenaraj, et al., 2021). Students who experienced the VR simulation as mentally difficult were more likely to achieve low post-test scores (Duhovi, 2022). Loss of productivity, gait performance (Rey-Becerra et al., 2021).	There is a lack of dataset training which caused frustration and learning difficulties (Kuhail et al., 2022)	Results indicate a negative relationship with regards to the game elements of gamification training program and learning outcomes (Kulkarni et al. 2022) Placing too much emphasis on the accumulation of points through multiple assignments rather than on pushing for deep learning in a few can have adverse effects on student learning (Bourke, 2020) These respondents worried a great deal about the tests in the game and when they did the tests in the game, they thought how poorly they were. They were so nervous during the tests in the game that they could not remember facts

	With Samsung GearVR HMD with lab simulation content it was found that participants learned significantly less in the VR condition compared to desktop (though the test on transfer knowledge was not significantly different). (Makransky et al., 2019).		they have learned. They had an uneasy, upset feeling when they did the tests in the game (Chen & Hsu, 2020). Negative feeling of experiencing worriedness, nervousness, or uneasiness during brain games play declines younger adults' level of engagement to a certain extent; however, totally disengages older adults and elders from the activity as well as decreases their acceptability towards brain games (Ahmad et al. 2020).
Learning distractions	A short exposure to VR often caused much excitement, leading to distraction from learning (Hartfill et al., 2020).		The use of narratives in education and serious games seems promising, but researchers argue that it also can result in the player losing the focus on learning experiences and outcomes (Buijs-Spanjers et al., 2020).
Social constraints, negative social behaviours, isolation, lack of collaboration and support, cybersecurity issues, privacy violation	Being anxious of losing face in front of their classmates when asked to perform while the whole class was present (Yang et al., 2020). Asymmetric interactions - In the Panoramic Scenes, that some students consistently didn't provide help or collaborate with their		In fully online asynchronous environments, students might experience greater feelings of isolation through gamified courses (Rapp, 2017). Social comparison pressure - emotions triggered by social comparison, such as shame or pride,

	partners. The high-scoring partner would complete most of the interactions and move ahead to new scenes, thereby limiting the learning opportunities of the struggling student (Divekar et al., 2021) The participants struggled somewhat when interacting with the student avatars because the facial expressions of these avatars were fixed and the mouths of the avatars did not move (Chen, 2021). Cybersecurity vulnerabilities, privacy violations - Due to complex and sophisticated features such as more graphic, 3D design, immersive visual and auditory experience, when unwanted and privacy-invasive contents proliferate in the metaverse, they may be felt as more intrusive and are likely to have a greater negative impact on the users or victims (Dwivedi et al., 2022) VR headsets can collect more and richer data about users compared to traditional screens (Dwivedi et al., 2022) The lack of preparedness to deal		increased the students' anxiety levels. Introversion and strong collective consciousness worsened these effects because social anxiety was aggravated by interpersonal communication difficulties (Chan et al., 2020).

	with privacy and security challenges in the metaverse, boundaryless GDPR. The GDPR is applied based on where the subject is located when their data is processed. When an avatar's data is being processed, a confusion that can arise is whether the location is determined based on the person operating the avatar, or the avatar itself (Dwivedi et al., 2022).		
Pedagogical approaches that induce specific learning, lack of well designed content	Without well-designed content that provides students with improved and deep learning, the uniqueness of technology's use will revert to novelty instead of being used for a successful learning experience (Asad et al., 2021). The challenge of converting the established technology-based learning theories into new pedagogical practices to reduce cognitive load (Bahari, 2021). Because the teachers are not digitally literate and are unable to understand the practicality of virtual reality in education, also, parents are unable to afford technological expenses at their end (Asad et al., 2022).	The imposition of particular approaches to pedagogy—at present often instructionist and behaviourist—as embedded in most current commercial tutoring systems. (Kuhail et al., 2022).	

Table 3. Positive and negative metacognitive learning effects with disruptive technologies

	Interactive media technologies (AR, VR, XR, MR)	Adaptive support technologies (AI)	Motivation technologies (game)
Autonomy	Students had autonomy as they could decide the cultural elements to explore (DeWitt et al., 2022). The autonomy-relevant and social relatedness –relevant aspects, such as sense of enjoyment and empathy, are stronger predictors of user system usage outcome than the perceived competence aspects (Li et al., 2021).		
Self-reflective feedback practices and actions lack of feedback, to search answers, to make insights	Debriefing after a training scenario offers HCPs an opportunity to reflect on their performance and develop insights that can inform later (Clack et al., 2021). Perceived repeated practice in the immersive VR simulations as helping them to reflect on their methods and become more familiar with their teaching materials (Chen, 2021). Participants mentioned that the patient's responses and the progression of the delirious episodes had triggered them to reflect on their actions and how these had	Experiencing the patient's perspective also made participants reflect on their actions as a healthcare professional.Two perspectives made learners aware of the consequences of their actions as a healthcare professional Interactivity engaged them and actively involved them in the study material, which made them reflect on their actions in the game and the consequences of these actions (DeWitt et al., 2022).	Lack of feedback (Villegas-Ch et al., 2020).

	influenced both the patient and the narrative. They used the feedback derived from the patient's responses to actively search for answers on why something was wrong or how to improve themselves (Buijs-Spanjers et al., 2020).		
Self-efficacy, overcoming obstacles, less time spent, perform well, reported comfortability	Teachers' professional growth is addressed along with the improvement of technology infusion competence and self-efficacy, aiming for overcoming obstacles and grasping rewards in incorporating virtual reality innovations into the teaching and learning program (Asad et al., 2021). The efficacy of virtual interactive tasks in improving linguistic competence, situated learning, and learning motivation (Bahari, 2021). Pre-test questionnaires measured their motivation, self-efficacy, and anxiety. Self-efficacy of the experimental group was better than that of the control group (Chen et al., 2021 (2)). I spent much less time preparing for the classes using this tool [compared to the previous terms wherein they did not make use of Google		(Mendez et al., 2020) conducted two focus groups to evaluate the efficacy of chatbot used for academic advising. While students were largely satisfied with the answers given by the chatbot, they thought it lacked personalization and the human touch of real academic advisors (Kuhail et al., 2022).

	Expeditions] (Ebadi & Ebadijalal, 2022). The experience resulted in students' self-reported increase in comfortability with talking about end-of-life issues (Elzie & Shaia, 2021). VADER module will improve their self-efficacy in regards to their commitment to continuing the AE degree and studying a particular sub-discipline (Erdogmus et al., 2021). Users' senses of trust and perceived usefulness were found to be not statistically significant in predicting these empowerment outcomes (Li et al., 2021).		
Self-regulation skills such as self-observation, attentional flexibility, inhibition control, and other executive functions, for self-regulation	Other studies have revealed improvements in self-regulation skills such as self-observation, attentional flexibility, inhibition control, and other executive functions // it helps users to develop attentional awareness, that is, the realization that they possess and can utilize in various ways a powerful mental tool responsible for self-regulation (Drigas et al., 2022). Self-regulated learning (SRL) and self-regulation (SR) was at a moderate		

	level. // Students who had higher confidence believed that they were competent, they were using cognitive strategies, and were increasingly self-regulating using metacognitive strategies (Chen & Hsu, 2020). The students who were provided with appropriate scaffolding tended to be able to regulate their focus of attention to the target learning content and perform well in speaking, (Chen et al 2021., (2)).		
Monitoring based customised supportive actions, perceived self-control.	Existence of a general pattern of lower perceived control in those scenarios characterised by negative emotions (i.e., sad, anger, fear, and disgust) compared to the baseline and the happy scenarios (Dozio et al., 2022).	In the study in (Coronado et al., 2018) students' learning process is monitored by collecting information on all interactions between the students and the chatbot. Thus, direct and customised instruction and feedback are provided to students. In (Villegas-Ch et al., 2020), used AI for activity recommendation, depending on each student's needs and learning paths. The chatbot evaluates and identifies students' weaknesses and allows the AI model to be used in personalised learning (Kuhail et al., 2022).	
Dialogic interactions identity	Low-achieving students practised		Fryer et al. (2017) found that students'

	dialogic interactions in computer-generated VR environments for 4 weeks, leading to significant improvements in their communicative abilities. (Dhimolea et al., 2022) The behaviour analysis results also revealed that the tutors and tutees in the experimental group made more frequent and better use of the three negotiation strategies, confirmation checks, clarification requests, and comprehension checks. (Chen et al., 2021 (2)) Interaction with non-playable characters in virtual worlds may foster players' self-reflection as they navigate different worldviews and conflicting intentions (Schrier, 2017). As a result, one's virtual and real identities are, in play, in a process of constant negotiation that contributes to the development of a projective identity that fosters learning that is critical and situated (Gee, 2003) in (da Silva, 2021).		interest in communicating with the chatbot significantly dropped in a longitudinal study (Kuhail et al. 2022). Villegas-Ch et al. (2020) noted that the lack of assessments and exercises coupled with the absence of the feedback mechanism negatively affected the chatbot's success (Kuhail et al., 2022).
Learning from mistakes	Participants valued the possibility to make choices within 'The Delirium Experience', because it allowed them to make mistakes and learn from these mistakes		

	without harming a patient. Finally, the interactivity made the participants curious to explore other options and made them want to play the game multiple times (Buijs-Spanjers et al. 2020).		
Agency, being psychologically engaged, have sense of control over actions, progression, pervasiveness, persistence, confidence	They were more persistent when dealing with dull or difficult tasks. / When students accomplished more tasks, they became more confident and developed a sense of SE in the VR mobile learning (Chen & Hsu, 2020). The participants had more confidence to stop challenging behaviours by approaching the students, taking actions and using oral commands (Chen 2021). Furthermore, the interactivity made participants more involved, because it gave them a feeling of control over the course of the narrative (DeWitt et al., 2022). Embodying a character and navigating a simulated world can increase players' perception of agency, which may lead to improved learning outcomes (Zheng et al. 2012). The majority (73%) agreed they were		Students often expressed that engaging in gamified LESL environments is enjoyable, fun, attractive, interactive, and interesting (Baldauf, Brandner, & Wimmer, 2017; Guaqueta & Castro-Garces, 2018; Hasegawa et al., 2015; Homer, Hew, & Tan, 2018; Ketyi, 2016; Medina & Hurtado, 2017; Sun & Hsieh, 2018; Zhou, Yu, & Shi, 2017), because it provides them with an opportunity to psychologically get involved in the learning processes (Guaqueta & Castro-Garces, 2018) and have a sense of control over actions, progression, and pervasiveness (Homer et al., 2018; Lui, 2014).

	more confident in their top choice compared to before VADERs (Erdogmus et al., 2021).		

Table 4. Affective learning effects in disruptive learning environments

	Interactive media technologies (AR, VR, XR, MR)	Adaptive support technologies (AI)	Motivation technologies (game)
extrinsic and intrinsic motivation	Virtual reality was found to help transform the conventional method of teaching architectural engineering. It enhances students' motivation, interest (Asad et al., 2021). Virtual world is realistic, which motivates me to learn English vocabulary"(Akgün & Atici, 2022). Immersive media can help language learners identify and address new cultural layers generally not encountered using traditional pedagogical methods, which can promote learning motivation and increase their cultural competence. The learners reported high levels of perceived usefulness of this medium and increased motivation due to the social nature of language learning associated with the VR technologies. (Hayes et al., 2021)	Ayedoun et al. (2017) provided various types of affective feedback depending on the situation: congratulatory, encouraging, sympathetic, and reassuring. When a problematic situation arises, to increase their learning motivation (Kuhail et al. 2022)	17 articles also reported other learning outcomes (engagement, motivation, satisfaction). Engagement with nine frequencies, motivation with 12 frequencies, and satisfaction with four frequencies were, respectively, the most commonly reported positive learning outcomes of the gamification for LESL. (Dehghanzadeh et al., 2021) Components such as badges, points, levels, and virtual products contribute to extrinsic motivation, whereas components such as social graphs, team building, and unlocking content can function as intrinsic motivations for students who adopt these components with personal meaning (Banfield & Wilkerson, 2014).(Gündüz & Akkoyunlu, 2020)

	Motivation was found to be the dominant emotional state, and most of the interventions deal with a higher cognitive level. (Ummihusna & Zairul, 2021) Studies gave positive feedbacks in terms of users' satisfaction level, degree of motivation, adaptation to the technology, and the ILT performance (Ummihusna & Zairul, 2021) The desktop VR group scored significantly higher on enjoyment and intrinsic motivation than the text group [Makransky et al., 2019]. (Zhang et al. 2020) A similar experiment discovered that users of game-based learning demonstrated obvious improvement in knowledge retention capability, motivation, and engagement. (Zhang et al. 2020) In research of China, with a VR-enhanced English learning game, learners' motivation is influenced by factors including evaluation and feedback, technical feasibility, interactivity,		

	immersive experience and confirmation. (Zhang et al., 2020) Compared with the traditional formative assessment, AR-based formative assessment can not only improve students' academic performance, but also improve their motivation (Zhang et al., 2020) Fifteen out of the 18 studies included in the present review analysed the motivational outcomes of using IVR for learning in terms of engagement, attitude, satisfaction, enjoyment and interest. Almost all of them highlighted the benefits of the third IVR affordance, in terms of motivation elicitation. (Di Natale et al., 2020). The intrinsic motivation of the VR group has been shown to be significantly different from the Non-VR group on all three subscales from intrinsic motivation; ‘interest’, ‘perceived competence’, and ‘effort’. (Arayaphan et al., 2022). Self-location positively contributed to the affective and associative dimensions of empathy. That is, the more users perceive		

	themselves as occupying the story environment, the greater their response to a character's emotional state and their vicarious experience of those same emotions. (Cummings et al., 2022). The results showed that the VR/MR simulation is more beneficial to the participants' motivation than the video lesson, but not for knowledge improvement and perceived lesson effectiveness. The VR/MR simulation is perceived to be more effective than the recorded video lesson in improving continued motivation to learn. (Yang & Goh, 2022)		
positive emotions: happiness, decreased nervousness, reduced anxiety, enjoyment, excitement, fun, sense of empathy, learning satisfaction, hedonism,	The affordance of virtual world anonymity of oral interaction that resulted in decreased nervousness (Bahari, 2021) Dalim et al. (2020) reported the affordance of allowing interactivity and physical activities, boosting enjoyment, offering age-appropriate content, collaboration, and small group learning by immersive experience. (Bahari, 2021)	Allowing students to ask the chatbot to tell jokes, fun facts, or talk about unrelated content such as the weather to take a break from the main learning activity. (Kuhail et al. 2022).	Experiencing learning activities as fun can help propel students to want to do and learn more, and to dig deeper. As students engage through gamification to go farther and dig deeper, they become emotionally involved in their learning. Bourke, 2020 The most commonly used describing words for gamified LESL environments were 'enjoyable', 'fun', 'attractive', 'interactive', and 'interesting'.

	Participants attributed their optimistic perceptions to high levels of excitement and engagement (Alfadil, 2020), (Dhimolea et al., 2022) Perceiving VR experience as more enjoyable and fun than traditional methods of learning (Dhimolea et al., 2022) Can ease nervousness and reduce anxiety associated with speaking a foreign language in front of others, especially when working in small groups (Dhimolea et al., 2022) Learners focusing on communication skills also enjoyed dynamic conversations and immersive experiences in VR which helped them feel prepared for encountering similar situations in the future (Dhimolea et al., 2022) Being able to see the difference between the character's imagination and reality, while having corresponding thought bubbles to delineate these elements of the experience, made the experience more enjoyable and		Students often expressed that engaging in gamified LESL environments is enjoyable, fun, attractive, interactive, and interesting (Baldauf, Brandner, & Wimmer, 2017; Gaikwad & Jain, 2017; Guaqueta & Castro-Garces, 2018; Homer, Hew, & Tan, 2018; Ketyi, 2016; Medina & Hurtado, 2017; Sun & Hsieh, 2018; Zhou, Yu, & Shi, 2017), because it provides them with an opportunity to psychologically get involved in the learning processes (Guaqueta & Castro-Garces, 2018) and have a sense of control over actions, progression, and pervasiveness (Homer et al., 2018; Lui, 2014). (Dehghanzadeh et al., 2021) VIM-based meaningful gamification leads to various positive user effects at the basic level, including a higher sense of empathy, enjoyment, trust and perceived usefulness. Li et al., 2021 Declining anxiety about criticism as she saw the positivity brought by constant rewards (Chen et al., 2022)

	informative in the context of seeing the technique represented from the book in a virtual format. (Colreavy-Donelly et al., 2022) Some participants indicated that virtual reality tools can provide enjoyable and engaging courses for librarians which they feel are very boring otherwise. (Arayaphan et al., 2022) VR might be perceived to be a more fun and motivational activity than learning with traditional media (Baceviciute et al 2021) The participants felt less nervous in the virtual classroom (Chen, 2021). The results revealed a significant interaction between the type of emotions derived from the facial expressions analysis and the six VR simulation (Duhovi, 2022) VR also facilitates step-by-step skill procedural learning, which if experienced as successful can trigger the outcome related emotion of joy (Duhovi, 2022) Google Expeditions presumably boosted the participants' confidence as well, by offering them a relaxed environment		The avatars helped to allay worries about being judged negatively. (Chen et al., 2022) Suh and Wagner (2017) found that visibility of achievement, competition, and rewardability implemented in an enterprise collaboration system influence employees' perceived hedonic system value. (Curley et al., 2020). Armstrong and Landers (2017) have shown that trainees are more satisfied with training that includes game fiction than training lacking any game elements. (Curley et al., 2020). Gamified ERP training has been shown to increase both user learning and satisfaction (Alcivar and Abad 2016). (Curley et al., 2020) The results reveal that effectiveness, efficiency, playfulness, and confirmation contribute to cognition- and affect-based attitudes and satisfaction. Collectivistic versus individualistic user orientations moderate the effects of value on attitudes in a gamification context (Hsu & Chen, 2021)

	from which they could draw reliable information. (Ebadi & Ebadijalal 2022) The VADER mission was fun" (78%) // included multiple occurrences of words of engagement/interest such as enjoy, fun, and excite/exciting. (Erdogmus et al., 2021) A short exposure to VR often caused much excitement, leading to distraction from learning (Hartfll et al., 2020). (Dhimolea et al., 2022)		Thus, the utilitarian and hedonic values of a website are the most significant antecedents of user attitude and satisfaction; in other words, higher utilitarian and hedonic values evoke stronger attitudes and higher satisfaction levels. (Hsu & Chen, 2021)
negative emotions: anger, fear, sadness, anxiety, learning pressure, psychological safety Cooper et al., 2020	The affordances of the system in terms of developing speaking performance and reducing anxiety as part of learners' cognitive abilities. (Bahari, 2021) Creating an environment where expression of affective aspects is facilitated and where open communication processes are supported is important to ensure disaster responders operating in uncomfortable situations, feel secure. This finding is aligned with the concept of psychological safety: students were able to not only experience emotional responses but also reported	Schouten et al. (2017) built their conversation agent to categorize four basic emotions: anger, fear, sadness, and happiness. Depending on the situation, the chatbot shows students an empathetic reaction. The researchers showed that this is helpful for learners and agents to express themselves, especially in the event of difficulty. (Kuhail et al., 2022) Wished that the robot was more user-friendly so that people would feel more comfortable using it. But an obvious weakness of the robot is that it can't correct the user right away if he or she makes a	experienced tension and negative emotion. // (Chen & Hsu, 2020) A negative impact of anxiety over usability is common among children, younger adults and older adults; whereas in contrast, elders' negative impact of enjoyment over usability is ironic and needs further investigation. (Ahmad et al., 2020) Game competition may encourage further learning engagement by evoking emotions such as anxiety and stress. (Chen et al., 2022) The game environment formed by the magic world

	physical symptoms they experienced such as increased heart rate, difficulty breathing/speaking, pain, fatigue, loss of alertness, and nausea. (Elzie & Shaia, 2021) One of the main challenges that can cause anxiety among the learners in VR environment is reportedly "the type of virtual audience" (Bahari, 2021) If one feels embodied in a virtual body, insults or praise regarding this body, referring to properties that would not be true for the biological body, should cause emotional arousal. (Kilteni et al., 2012) Users mentioned frustrations when interacting with the web-based version rather than VR. Even though the features and functionality were the same, the application was described as "boring" and complicated to use. (Ciubotaru et al., 2017)	mistake. Also, if the user doesn't understand something, it's very likely that the robot can't help them clear up their confusion because it's programmed in advance and doesn't have any flexibility in the learning (Chen et al., 2022)	narrative, the gems, and the avatars decentralises students' learning pressure. This compound learning–gaming experience introduced a self-distanced perspective to the students, which helped to manage their negative emotions. (Chen et al., 2022) People become bored easily when they remained in the same virtual space without different stimuli being supplied (Chen, 2021)
interest, curiosity, engagement, enthusiasm	Affordance of interactive switching of scenarios that enhanced learners' engagement and willingness in the learning process. 3D vocabulary learning program plus improving learners'	Programming students in the control group have improved their learning and gained more interest in learning. (Benotti et al., 2017) (Kuhail et al., 2022)	The interactivity made the participants curious to explore other options and made them want to play the game multiple times. (Buijs-Spanjers et al., 2020)

	autonomy, active engagement, and collaboration with partners. (Bahari, 2021) Feeling interested and motivated (Pack et al., 2020) Studies by Barrett et al. (2020), Berti et al. (2020), Cowans (2018), Garcia et al. (2019), Kaplan-Rakowski and Wojdynski (2018), and Monteiro and Ribeiro (2020) have demonstrated ways in which immersive learning experiences can increase curiosity and motivation (Hayes et al., 2021) In classroom learning, the VR system with wearable technology can improve the effectiveness of education and teaching, as well as the enthusiasm of students. (Zhang et al. 2020) The exploratory approach triggers the users' curiosity motivating them to master the rules and affordances of the game by supporting them to level up and advance in the game, making the whole experience more engaging. // All the participants commented that the virtual experience was interesting, and they would like to	The students appreciated that the robot was attentive, curious, and eager to learn (Law et al., 2020),(Kuhail et al. 2022). Found that students' interest in communicating with the chatbot significantly declined in an 8-week longitudinal study where a chatbot was used to teach English (Kuhail et al. 2022).	Levels of empathic engagement were found to be conditioned upon participants' approaches to play. (da Silva, 2021) The results show that students participate more in activities with gamification, and they report the course as both more motivating and interesting than nongamified courses.(Gündüz & Akkoyunlu, 2020) Mobile gamification orientation material can improve intrinsic motivation from the perspective of interest but not perceived competence or effort. (Leenaraj, et al., 2021) The authors find that game-based learning makes training more engaging, immersive and contextual for the learners. (Kulkarni et al., 2022)

	have similar experiences in the future as also that they were engaged and remained focused throughout the experience. (Argyriou et al., 2020) Students were persistent and interested in their research: This engagement with VR was followed by research in the culture (DeWitt et al., 2022). Students experienced significantly higher levels of positive than negative emotions // there were positive associations between presence and interest level and attentiveness; and a negative association between presence and jitteriness (Duhovi, 2022)		
self-efficacy, subjective satisfaction, attitudes towards learning	The efficacy of virtual interactive tasks in improving linguistic competence, situated learning, and learning motivation. (Bahari, 2021) Exploring the affordances of virtual communities of practice, Peeters and Pretorius (2020) reported the efficacy of it for improving academic writing. They emphasised that for developing online instructional interaction and participation, teachers and learners		The gameful hero role-play enhances students' self-efficacy, makes them feel capable of completing learning tasks, and leads the team to win the learning challenges. (Chen et al., 2022) Kwak et al. (2019) have shown that perceived quality and enjoyment of ERPsim increase attitudes toward learning about ERP systems.(Curley et al., 2020)

	need to “find their place within the spaces that have been created”(p.13). (Bahari, 2021)		
social motivation	The use of metaverse in education will enable students and educators to interact in the virtual world while mimicking the social and emotional realms of the physical world. (Dwivedi et al., 2022) Provide an arena for effective learner-centred social and emotional interactions that offer valuable opportunities for target language practice. (Hayes et al., 2021). Human actors efficiently integrated in the scene, taking the role of narrator or used to motivate the user to look around, could provide an element of social engagement supporting users to immerse in the story. // (Argyriou et al., 2020) Co-presence among users, and not self-location, was found to facilitate cognitive empathy. (Cummings et al., 2021) Expression of affective aspects such as moods, feelings and attitudes,	A few surveyed chatbots have used social dialog to engage students. For instance, some chatbots engaged students with small talk and showed interest and social presence. Other chatbots used affective learning in the form of sympathetic and reassuring feedback to support learners in problematic situations (Kuhail et al., 2022)	Autonomy-relevant and social relatedness–relevant aspects, such as sense of enjoyment and empathy, are stronger predictors of user system usage outcome than the perceived competence aspects of the PSS. (Li et al., 2021). The joint use of collaboration and competition can enhance team cohesion by creating shared goals and can motivate individual contribution by intensifying intragroup competition at the same time [36]. (Chen et al., 2022) Anxiety sourced from lacking confidence was alleviated by the team setting with intense collaborative competition, which advocated collective honour and created close bonds among team members, like players in gaming guilds. (Chen et al., 2022) In fully online asynchronous environments, students might experience greater feelings of isolation through gamified

	was seen to help students feel that they are part of the CoI and support engagement with complex disaster scenarios and the WBS. (Cooper et al., 2020) A higher level of perceived authenticity and group work significantly increases motivation to learn and continued motivation to learn. (Yang & Goh, 2022) Emotions triggered by social comparison, such as shame or pride, increased the students' anxiety levels. Introversion and strong collective consciousness worsened these effects because social anxiety was aggravated by interpersonal communication difficulties and a sense of responsibility(Chen et al., 2022).		courses (Rapp, 2017) (Bourke, 2020)

Table 5. Psychomotor and embodied learning processes with disruptive technologies

	Interactive media technologies (AR, VR, XR, MR)	Adaptive support technologies (AI)	Motivation technologies (game)
Immersion Seamless Spatial presence Virtual presence	Virtual Reality (VR) storytelling enhances the immersion of users into virtual environments (VE) (Rizvik et al., 2019) VR-enhanced English learning game, learners' motivation is influenced by factors including evaluation and feedback, technical feasibility,		

	interactivity, immersive experience and conformation. (Akgün & Atici, 2022) Human actors efficiently integrated in the scene, taking the role of narrator or used to motivate the user to look around, could provide an element of social engagement supporting users to immerse in the story. (Argyriou et al., 2020) Because virtual reality only helps in understanding the environment, we cannot feel it or touch it. So, for me, students' experiential learning occurs better when they fully experience the environment. Virtual reality provides an immersive and fully interactive platform that allows visualisation of the world and contributes to experiential learning. Thus, from a learning point of view, it can be witnessed that virtually create scenarios facilitate learning by implying experiential approaches where both physical and cognitive involvement are evident (Dhimolea et al., 2022) Within a VR environment, we can, for example, perform the action of turning our heads to view the environment from different perspectives just as we would in a physical reality. The sensation of immersion in VR rapidly activates the brain to support a user's natural inclination to engage these sensorimotor contingencies (Dwivedi et al., 2022). Huang indicates that an intelligent learning environment should enhance learners' capabilities of perceiving, monitoring and controlling the physical environment and integrate the virtual environment and physical environment seamlessly by applying augmented reality technology (Akgün & Atici, 2022). VR technology that is high on interaction or imagination, but low on immersion, such as desktop VR, may still be found quite useful and easy to use by learners but will of course lack the educational benefits of high-immersion VR, such as using natural		

	sensorimotor contingencies and having an egocentric point of view which improves skills transfer to real world situations (Barrett et al., 2021). The authors suggested that due to the high visual immersion in the IVR condition, participants perceived higher feelings of spatial presence and paid more visual attention to the mediated environment and thus collected more information through that sensory modality than through others (Bahari, 2021) Students who participated felt like they were physically present in the VRE and actually experiencing its scenarios (Hayes et al., 2021) VR technologies was a new experience which made me feel like I was at that place; I felt like I was at the actual place, and felt the real world (Ummihusna & Zairul, 2021) Both subject populations felt that the virtual assessment experience enabled presence by reporting average scores over 80% for all the different presence evaluation categories (realism, possibility to act, possibility to examine, and self-evaluation of performance) (Govender & Arneda-Moreno, 2021).		
Cognitive disability Physical discomfort Sensory disability	According to the BCI-illiteracy phenomenon an estimated 15–30% of the population cannot develop the ability to control brain-computer interfaces (BCIs) systems based on mental imagery or event-related potentials (Škola et al., 2019). A small proportion of those who wore corrective eyeglasses experienced minor discomfort in wearing the HMD (Barrett et al., 2021). The visibility issue might have been the reason for complaints such as eyestrain and dizziness among some students (DeWitt et al., 2022).		

	Helmet, glasses did not fit and felt uncomfortable while using virtual reality (Arayaphan et al., 2022). VR glasses should be adjusted for the person's eye. I do not wear glasses, but I had watering eyes, the volume is sometimes not very clear (Akgün & Atici 2022). Two students with severe visual deficits were unable to see clearly using the VR goggles (Elzie & Shaia, 2021) High-speed internet connectivity was required: "When the internet speed is slow, the VR is also slow (DeWitt et al., 2022)		
Motion-sickness, dizziness, claustrophobia, migrain	One participant mentioned that he/she only uses the web-based version of VR instead of the one with headsets because of motion sickness (Ciubotaru et al. 2017). Students were able to not only experience emotional responses but also reported physical symptoms they experienced as increased heart rate, difficulty breathing/speaking, pain, fatigue, loss of alertness, and nausea (Radianti, 2020). Some users experienced negative things such as dizziness, nausea, blurred eyes, insufficient sound in the virtual reality environment, and anxiety. [...] there were complaints such as dizziness, headache, and fatigue (Akgün & Atici, 2022) The challenge of technical limitations such as physical discomfort (Bahari, 2021). VR technologies can cause health problems (e.g., cybersickness, eye strain, safety hazards (Coban et al., 2022). Only two studies (Meyers et al., 2019; Moro et al., 2017) pointed to cybersickness. The authors found that participants in the IVR groups		

	experienced more adverse effects such as discomfort, headache, dizziness, nausea and disorientation as well as blurred vision, difficulty focusing and double vision, compared to those in the control group (Di Natale et al., 2020). The unpleasant effects of motion sickness and claustrophobia were experienced in 360 degree videos. (iMareculture project) A few of participants commented that they felt a bit dizzy at some point when experiencing locomotion (Arayaphan et al., 2022). Besides the effect of locomotion integrated in the form of simulating movement through waking in the scene, the results indicated that participants did not feel dizzy. (Coban et al., 2022) A VR environment has physiological discomfort for learners (such as dizziness and unrealistic controller interaction).(Li et al., 2022) Two students failed to complete the modules due to motion sickness or fear of induction of a migraine. (Elzie & Shaia, 2021)		
Manipulation of objects, Coordination, kinestesis, Motor problems	Virtual body representation with different morphology with respect to one's own biological properties (e.g., morphological appearance, number of limbs, size), would probably have psychological or even motor consequences (Kilteni et al., 2012). The participants enjoyed the fact that they could use the handheld controllers to pick up and manipulate objects in the classroom with their virtual hands (Rey-Becerra et al. 2021). Real walking becomes challenging, however, when the virtual world outsizes the available physical space (Clack et al., 2021) If the hand of the teacher avatar could act like a human hand, rather than a		"Improving technical skills", "increasing mind-muscle coordination", "Improving fitness" were created. ("I believe that virtual reality improves reaction, attention, technique, speed, and can improve fitness by increasing training levels.") (Kuhail et al. 2022).

	robot hand, the simulation would be more realistic and the participants would not feel a distance when touching things in the virtual environment. (Chen, 2021) This control scheme required subjects to look at a specific interface or object and press the button to trigger the interactions. Subjects noted verbally that this type of control sometimes interfered with their ability to perform tasks within the platform (Eiris et al., 2020).		Psychomotor: that the virtual reality environment is formulated as a sensory-motor contact with the world, with the organ serving as the mediator in the process. It is the sensation and vision organ and the kinesthetic structure that constructs knowledge; // digital reality [...] allows for complete body interaction, allowing users to visualise the world by perceptual learning (Kuhail et al 2022).
Identity confusion	Intense feelings of self presence during virtual experience (...) might create some types of identity or reality confusion (Kilteni et al., 2012)		
Spacial location 3D movement time and space	The fully 3D virtual museum with Oculus quest 2 - It is something fully immersive, it feels like it physically puts you in that position" (Arayaphan et al., 2022) It is known that I-VR has the potential to allow surgeons to view the human body from different angles and to facilitate understanding of the spatial relationships between organs (Holmes & Tuomi, 2022) Geometric visualization, spatial perception of problems and geometric reasoning (Akgün & Atici, 2022) The possibility of navigating and interacting with the structures might facilitate the comprehension of complex spatial relations between different structures of the brain and		Spherical views facilitated creating real-world–like situations to enhance learning process (Kuhail et al., 2022)

	thus facilitate encoding and retrieval of knowledge (Bahari, 2021). Multiple researchers have shown that real walking, as opposed to teleportation using handheld controllers, for navigating VEs improves the user's cognitive map and thus helps understanding the context of the training scenario (Dreger & Ticknor, 2022) The results of this study indicated that Chinese calligraphy studies in VR time and space affect students' understanding and imagination but not their operational abilities (Zhang et al., 2020)		
Training skills	Warming up in the VRSS before going to the operating room shows benefit in surgical performance Virtual laboratory based on AR, VR and MR technology can maximize the time and space of medical teaching activities, and virtual laboratory can play many advantages in medical experiment teaching (Akgün & Atici., 2022)		

Annex 2. Methodology for the values' workshop

The goal: Group interview-workshop for discovering ethical and sustainability dimensions of learning scenarios with disruptive technologies

Requirements

The group interview is held as a workshop at 2,5 h.

The participants of the group workshop should be heterogeneous: students, educators, technical support personnel at institutes, educational technology developers.

There should be 4 groups with 4-5 persons with mixed roles.

The workshop should be conducted in the national language.

Workshop agenda

Phase 1. 30 min

Introduction to the workshop goal. Providing project information sheets. Filling in and signing the informed consents on paper.

Phase 2. 60 min

- Each group receives a 1 page description of one learning scenario with disruptive technologies (see below)
- Groups read the scenario printouts in a group (Print for every person a copy of the scenario) and imagine themselves as students or teachers in this learning scenario (about 20 min).
- Next each group gets a set of value cards (see below). The task is to read the cards and select up to 5-8 values that relate with the learning scenario with disruptive technology. Necessary value cards may be added by the participants if missing in the set.
- Groups discuss the selected cards by answering the question: what kind of considerations regarding ethics and sustainability did emerge when reading the scenario? (about 40 min)
- Next the groups receive the template for value descriptions. The group formulates for every selected value 3-5 sentences how this value relates with the scenario (e.g. with interactions of people, interaction between people and the system, with algorithms, data, at society level).

Phase 3. 40 min

40 min reflective feedback between groups.

Every group introduces orally 5 min the scenario and explains how the values relate with this scenario. The open discussion for 5 min is held to complement and elaborate the group work by other groups. If some new value aspect emerges in the discussion, the group adds it to the value analysis (in google forms).

After the workshop

The organising team translates the contents at worksheets (may be in an excel spreadsheet)

The informed consents are processed by the organiser team according to the institutional ethical requirements as well as following e-DIPLOMA requirements.

ANNEXES FOR THE METHOD

INSTRUCTIONS

Phase 1. Introduction - 30 min

Group formation. Introduction to the workshop goal.

Provide project information sheets.

Sign the informed consents on paper.

Phase 2. Scenarios and values - 60 min

- Read the scenario and imagine yourself as students or teachers in this learning scenario (about 5 min).
- Select 5-8 value cards that relate with the scenario (or add a value that is missing). What kind of considerations regarding ethics and sustainability did emerge for you when reading the scenario? Discuss it with your team! (about 15 min)
- Please discuss the values you have selected with the team. Try to formulate 3-5 sentences about the value of how it relates with this scenario. Please submit (provide link to use survey form in mobile phone) your response about each selected value separately. (40 min)

Phase 3. - 40 min reflective feedback between teams

10 minutes for each team!

- Please introduce the scenario with the values that evoked in you to the other teams.
- Listen to their impressions about values they feel are related to your scenario and add more value dimensions if needed (submit each new value digitally).

SCENARIOS

Provide each group with one scenario only. Provide several printouts for the group to read.

Virtual reality (VR) for fire extinguisher training

Ref: Saghafian, M., Laumann, K. Sadaf Akhtar, R., Skogstad, M. R. (2020). The evaluation of virtual reality fire exinguisher training. Frontiers in Psychology, 11

Description of the Fire Extinguisher VR application:
Includes virtual scenes with different fire types (hotel room, warehouse, kitchen, etc.) that consists of colored static 3D objects with realistic size and shape, the exit sign, the dynamic simulated flames and smoke, and the fire extinguisher that can be controlled by the trainee. The application has a rotating option in order to locate the exit sign and the source of fire, moving toward fire extinguisher, lifting it, moving and aiming the hose of the fire extinguisher to the source of flames. The fire extinguisher capsule is customized to resemble a standard capsule of approximately six kilograms filled with water. It also included the discharge nozzle, discharge lever and carrying handle. The training room is approximately 49 m squared. It has two levels: 'easy' and 'expert' mode referring to the difficulty level such as the reaction speed needed to put out the fire. The duration of the training sessions was approximately 45 min per session.

Learning scenario:
Aim of the learning activity is to gain an awareness of the scenario (fire in different locations, such hotel room, kitchen, etc.), the direction of the exit route, the spotting of fire, aiming at the fire through suitable body positioning, spraying fire extinguisher agent and moving around accordingly to put out the fla

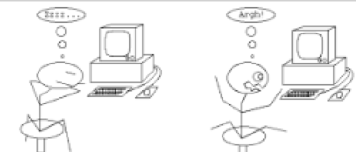
1. A teacher provides an introductory lecture on VR (basic navigation and manipulation methodologies; basic representations, scenarios in the application, etc) and a theory-based lecture by introducing strategies, different fire types and extinguishers to extinguish fire.

2. One by one learners (7 learners) can practice extinguishing fire with the help of VR in different virtual locations with different fire types starting from the easy level and the rest could watch what the person sees on the screen. The trainer stands in a corner with a laptop to administer the scenarios while giving instructions and feedback on what to look for (where the flame is, where the exit door is, what type of extinguisher users hold in their hand, distance adjustment, posture adjustment such as kneeling to put out the fire and speed adjustment for putting out the fire).

3. A joint discussion and reflection on experiences, challenges and learning gains.

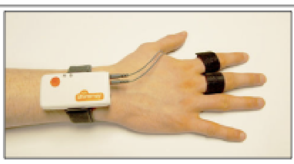
4. After completing the easy and expert level in VR the learners will practice extinguishing fire in real settings.

Supporting learning progress with AI (artificial intelligent) in physics



https://cecas.clemson.edu/~ahoover/ameter/

Description of the AI tools:
Shimmer 3 sensors to measure physiological arousal, GoTrack to record students collaborative activities (discussions), which allows to generate data on who is speaking and writing into a joint document, for how long, content of the discussion, etc.). Shimmer3 data will be continuously accessible for a learner and teacher. GoTrack data will be displayed only to the teacher via a teacher's dashboard.



https://www.researchgate.net/figure/The-Shimmer3-GSR-wearable-sensor-with-skin-conductance-electrodes-attached-to-the-index_fig3_337389935

Learning scenario (flipped classroom and collaborative experiential learning):
Aim of the learning activity is to gain knowledge on light, vision, lenses and reflection.

Prior to the course: Students familiarize themselves with the topic of the day as home- work prior to the lesson.

During the course:
Students are instructed on how to use Shimmer3 sensors independently and measure physiological arousal before and after every learning episode, and what kind of data GoTrack records as well as who has access to this.

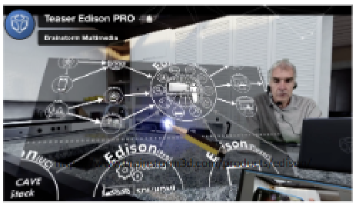
https://www.facultyfocus.com/articles/effective-teaching-strategies/students-riding-coattails-group-work-five-simple-ideas-try/

Learning episodes:
1. Teacher makes an introduction to the course topic, explains main concepts related to the topic light, vision, lenses and reflection and initiates discussion with students to ensure that students had familiarized themselves with the topic.
2. Students are divided into groups for the collaborative learning tasks with the aim of co-constructing a more profound and shared understanding of the topic. The students are asked to use different types of lenses and hypothesize how the beam of light would pass through different types of lenses and examine that by doing real experiments with the lenses.
3. Group work presentations of their experiment with results.
4. A joint discussion and reflection on experiences, challenges and learning gains.

Ref: Malmberg, Haataja, Järvelä (2022). Exploring the connection between task difficulty, task percpetions, physiological arousal and learning outcomes in collaborative learning situations. Metacognition and Learning. DOI: https://doi.org/10.1007/s11409-022-09320-z.
Kasepalu, R.; Prieto, L.; Ley, T.; Chejara, P. (2021). Do Teachers Find Dashboards Trustworthy, Actionable and Useful? A Vignette Study Using a Logs and Audio Dashboard. Technology Knowledge and Learning, 1–19. DOI: 10.1007/s10758-021-09522-5.

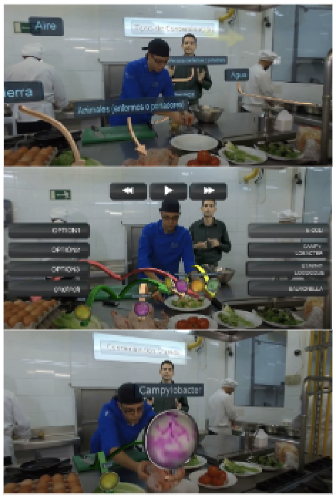
Practical activity in the cooking class in zoom with the augmented reality (AR) elements

Description of zoom and AR:
Zoom allows to connect people to provide flexible learning modalities for students: Zoom Meetings, Team Chat, Phone, and Rooms, etc.
Edison PRO allows to create live or online presentations adding rich media like pictures, sound, video and even 3D objects and animations. Presenters are shown immersed in a virtual, photorealistic environment and easily run the presentation with remote devices.
Chatbot is a computer program that simulates an intelligent spoken or written conversation with one or more people making the person feel like they are talking to another person, not a program



Learning scenario (distance learning):
Aim of the distance learning activity is to gain knowledge on different food related bacteria.

Learning episodes:
1. Teacher and students meet in the Zoom environment.
2. Teacher gives a theoretical lecture on bacteria in the kitchen while preparing food. He creates a virtual space – a kitchen - in the Zoom and using his presentation with augmented reality, he gives a lecture. During the lecture he demonstrates potential threats in the food making.
3. To keep students engaged he asks them from time to time some questions by embedding the questions in the presentation.
4. Next students are divided into groups and every group gets its own virtual augmented reality space, where they have to solve some tasks related to the content of the lecture presented before. The teacher can switch between these spaces and follow students activities. In case students have questions and the teacher is not available, they can use a chatbot.
5. In the end the groups will gather in the same virtual space in the Zoom they were in the beginning to reflect on their group work



https://www.youtube.com/watch?v=WSTnO6bvPGg&ab_channel=Brainstorm

Practical activity with telepresence robot in foreign language course

Description of the telepresence robot:
The telepresence robot – Romo – allows learners to control its movement via a mobile app, to adjust the view angle of its camera, to see what it captures on the screen of the smartphone, and to start a live video chat with the camera. Students can press a button that causes the robot's lights to flash indicating they have their hand raised, like an in-class student might do. The user has full control of the robot. Romo has a "head" with a built-in monitor that can be controlled by the remote user, an obstacle avoidance, and a self-navigation feature where one can click on an area of the screen to have the Romo drive there safely. Others see the face of the Romo user and the Romo user can see others. The robot becomes the user' "avatar," which can be present at the lesson, listen and take notes of lectures, look at experiments, answer questions from the teacher, perform tests, interact with others. The student can take photos of written works and send them to the teacher for checking.

Image credit: Meredith S. in Cedar Hills ISD in Texas logged in and participating in class.)

https://telepresencerobots.com/education-telepresence-robot/

Learning aim and context:
Aim of the learning activity is to practice foreign language with the native speaker (teacher). The lesson takes place in the campus of a large public university. Native speaker is physically present in the campus, the students participate from distance through Romo telepresence robot.

Learning episodes:
1. Teacher makes an introduction to the course (talking to 10 robots in the campus).
2. Students are divided in pairs to get to know each other. They move to separate places not to disturb other pairs. Each pair practice foreign language while getting to know each other.
3. The teacher invites students to gather around him. He makes a campus tour to the whole group by introducing the buildings, history, and culture of the campus to the remote students who participate through Romo.
4. After that the students report what they learned one by one practicing their foreign language. Other students can ask additional questions and provide comments.
5. Next students are divided into groups and they are asked to create a group presentation for the campus tour guide.
6. The groups present their work to the others. Other groups can ask questions and comment.

Ref: Liao, J., Lu, X. (2018). Exploring the affordances of telepresence robots in foreign language learning. Language learning and technology, 22(3), 20-32.

VALUE CARDS

1. Involvement - The state of agents being engaged with other agents or into a process or situation.
2. Autonomy - The capacity of an agent or system to govern themselves and act on their motives and intentions.
3. Privacy - The state of an agent, asset or system where it regulates its level of openness to external disturbances and relations to minimal.
4. Confidentiality - The state of agents or assets that secludes or restricts access to other agents
5. Individual and collective agency - The capacity of an agent (e.g human or nonhuman) to actuate (put things in action, transform) in a given environment, to control own or other agents' actions in the environment. A way of intentional acting of an agent or agents with the perception of holding the control for changing their environment.
6. Surveillance - The state of agents or systems being observed externally.
7. Coercion - The quality of agents using force to persuade other agents to do something that they are unwilling to do.
8. Control - The state of agents or systems being governed by other agents or systems
9. Accessibility - TThe state of all agents open access to assets
10. Vulnerability - The quality or state of an agent or system being exposed to the possibility of being attacked or harmed, either physically or emotionally.
11. Equity - The quality of an agent or a system having similar status, rights, or opportunities as others. The quality of an agent or a system having similar status, rights, or opportunities as others. The quality of a system to be fair and impartial regarding all agents, the state of the system being free from bias or favoritism of agents
12. Dignity - The quality of an agent considering himself worthy and esteemed because other agents respect them.
13. Fairness - The quality of agents being impartial to other agents in their interactions
14. Trust - The quality of an agent or system that is provided to it by other agents and indicates the perceived extent of the reliability of an agent or system.
15. Inclusiveness - The quality agents or systems of including different agents or assets and treating them all fairly and equally.
16. Beneficence - The quality or state of agents doing or producing good, active goodness or kindness to other agents.
17. Respect - The capacity of an agent having own or other agents' feelings, wishes, needs or rights regarded according to norms, values and roles.
18. Empathy - A way of assigned, transferred or representative acting when agents act on behalf of other agents for changing their environment.
19. Enjoyment - a state of feeling pleasure
20. Happiness - The state of an agent or a system describing changeable subjective wellbeing and experiencing positive emotions.
21. Effectivity - The quality of agents and systems performing the best possible manner with the least waste of time, resources and effort.
22. Effectiveness - The quality of agents and systems to produce or accomplish the intended or expected result
23. Productivity - The quality of agents or systems to efficiently transform inputs into useful outputs.
24. Responsibility - The capacity of an agent feeling duty in circumstances; or being in charge of other agents' actions or of the system behaviour.
25. Satisfaction - a state of an agent feeling fulfilment of one's wishes, expectations, or needs
26. Consistency - The quality agents or systems of being coherent in actions.
27. Continuity - The quality of agents and systems of performing without interruption or disconnection.
28. Accuracy - A state or quality of agents' or systems' freedom from error, correctness.
29. Credibility - The quality of an agent or system to be trusted, relied upon and and believed in.

30. Creativity - the agents' state of inventiveness of using imagination and creating original ideas or doing original acts
31. Enhancement - The state of agents or systems to raise to the higher degree; intensify; magnify by the intervention of other agents or systems.
32. Sustainability - The state of maintaining change in a balanced environment, in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.
33. Agility - The quality of agents or systems to quickly and dynamically recognizing, acting and benefitting from changing environments.
34. Flexibility - The quality of agents or systems adapting or responding to internal or external changes.
35. Adaptability - The agents' or systems' quality of adjusting to new conditions or changed environments to be fitting.
36. Openness - the agents' or systems' state of not concealing, being accessible of, and being receptive
37. Connectivity - a state or capability of being connective
38. Transparency - The state of openness of system's or agent's actions to others.
39. Wellbeing - A way of assigned, transferred or representative acting when agents act on behalf of other agents for changing their environment.
40. Resilience - ability to withstand or recover quickly from difficult conditions
41. Power-sharing - the state of sharing responsibilities and power
42. Common sense - sound and prudent judgement making based on the simple perception of the situations
43. Consensus - The state of agents where an agreement about something was achieved among them that every agent actively supports.
44. Dependability - The quality of an agent or a system to be relied upon because of predictability of their future behaviours
45. Challenging - The quality of agents rising problematic or concurrent issues

Note. It was also possible to add the missing values during the workshop.

Annex 3. Survey structure

Provided in excel format Annex 3.

Annex 4. Survey data about specific countries

Provided in excel format Annex 4

Table 5. General comparison of tools, software and infrastructures between technology specialist, educator and student views (ANOVA analysis).

expert	Mean	lecturer	Mean	student	Mean	Total	Sum of Squares	df	Mean Square	F	Sig.
There is central regional or country level hosting of online learning system (e.g. LMS, LDS, videoconferencing, resource repositories or clouds) for educational institution	3.71					3.71					
The LMS system of the institution provides automatized feedback opportunities to the students (e.g. Chatbots, AI based adaptive support)	3.03					3.03					
The video-conferencing tool that the institution provides has a built in group work tool (e.g. annotating whiteboard or other digital boards)	3.95	I have used at video conferencing sessions a group work tool (e.g. annotating whiteboard or other digital boards)	3.99			3.98	0.087	1	0.087	0.050	0.823
The video conferencing tool that the institution provides has a built in group work tool for working with shared objects (e.g. turning, pointing and controlling the shared objects)	3.72	I have used at video conferencing sessions a group work tool for working with shared objects (e.g. turning, pointing and controlling the shared objects)	3.57			3.60	1.651	1	1.651	0.765	0.382
The students are provided with the personal digital portfolio space for their different courseworks at the institution	3.81	I have used with my students a digital portfolio space for their different courseworks	3.83	I can use the personal digital portfolio space for my courseworks at the institution	3.57	3.69	15.145	2	7.572	4.355	0.013
There are labs with the facilities for online presentation of the small and microscopic objects in the institution	3.49	I can present the small and microscopic objects in my online lessons	2.98			3.09	17.846	1	17.846	9.223	0.003

There is access to the simulation facilities for lessons in the institution	3.94	I can use the simulation facilities for lessons at my institution	3.46			3.56	16.077	1	16.077	8.712	0.003
There is access to different robot technologies (e.g. education robots, industrial robots, cobots, telepresence robots, robots with digital twin) for lessons in the institution	3.73	I can use different robot technologies (e.g. education robots, industrial robots, cobots, telepresence robots, robots with digital twin) for lessons in the institution	2.71			2.94	72.912	1	72.912	36.214	0.000
There is enough specified space for conducting e-learning lessons in the institution facilities	3.73	There is enough specified space for conducting e-learning lessons in the institution facilities	3.50			3.55	3.773	1	3.773	2.286	0.131
The lecturing rooms of the institution are technologically sufficiently equipped for enhancing synchronous digital learning practices	3.67	The lecturing rooms of the institution are technologically sufficiently equipped for enhancing synchronous digital learning practices	3.46			3.51	3.435	1	3.435	2.040	0.154
The lecturing rooms at the institution are fit for group work practices	3.97	The lecturing rooms at the institution are fit for group work practices	3.79			3.83	2.464	1	2.464	1.667	0.197
There are shared labs in the institution where the software and tools for courses can be used or borrowed by every lecturer	3.78	There are shared labs in the institution where the software and tools for courses can be used or borrowed by every lecturer	3.58			3.62	2.954	1	2.954	1.759	0.185
The internet connection at the institution is sufficient for large group of students using METAVERSE simultaneously (a virtual-reality space in which users can interact with a computer-generated environment and other users) e.g. for using Augmented Realit	3.60	The internet connection at the institution is sufficient for a large group of students for lessons	3.92	The internet connection at the institution is sufficient for support METAVERSE experiences (a virtual-reality space in which users can interact with a computer-generated environment and other users)	3.15	3.49	118.382	2	59.191	35.231	0.000
The processors of the lecturers' computers are adequate to support METAVERSE development (a virtual-reality space in which users can interact with a computer-generated environment and other users)	3.41	The processor of my computer is adequate to support METAVERSE development (a virtual-reality space in which users can interact with a computer-generated environment and other users)	3.11			3.18	5.616	1	5.616	2.985	0.085

(Minimum: Intel Core i7 Processor; RAM 16 GB; Graphic Card											
The processors of the students' and lecturers' computers are adequate to support METAVERSE experiences (a virtual-reality space in which users can interact with a computer-generated environment and other users) (Minimum: Intel Core i7 Processor; RAM 16 GB	3.37	My students' computer's processors are adequate to support students METAVERSE experiences (a virtual-reality space in which users can interact with a computer-generated environment and other users)	3.01		3.54	3.34	50.772	2	25.386	15.579	0.000
The learning institution provides a central repository for digital learning resources in its own server	3.51	I can use central repository for digital learning resources in the server of the institution	3.65			3.62	1.573	1	1.573	0.979	0.323
The learning institution provides an institutionally payed access to the repository for digital learning resources in the cloud	3.86	I can use the institutionally payed access to the repository for digital learning resources in the cloud	3.72			3.75	1.288	1	1.288	0.841	0.360
Every lecturer mainly uses repositories of their own choice (e.g. intranet, clouds) for storing digital learning resources	3.76	I mainly use repositories of my own choice (e.g. intranet, clouds) for storing digital learning resources	3.95			3.91	2.459	1	2.459	1.948	0.163
The storage space of the learning institution is sufficient for storing VR and AR data (average space occupied by a VR application: 20 GB (only one))	3.72	The storage space provided by the institution is sufficient for storing VR and AR data (average space occupied by a VR application: 20 GB (only one))	3.30			3.39	11.083	1	11.083	6.100	0.014
The e-learning ecosystem elements (repository, LMS, LDS, videoconferencing) chosen by the educational institution are mutually compatible to transfer digital	3.74	I can use central repository for digital learning resources in the server of the institution	3.60			3.63	1.229	1	1.229	0.982	0.322

learning resources											
There is some type of learning analytics from e-learning available for the lecturers in the learning institution	3.83	I can use the institutionally payed access to the repository for digital learning resources in the cloud	3.70			3.73	1.105	1	1.105	0.820	0.366
There is some type of learning analytics from e-learning available for the students in the learning institution	3.56	I can use learning analytics of students' work in e-learning lessons	3.50	Students can use learning analytics of their learning process in e-learning	3.75	3.65	13.113	2	6.556	4.698	0.009
Digital learning data management is developed in the institution using some level of AI support (e.g. recommendation mechanisms, adaptive learning paths are provided for the students)	3.24	Students can use learning analytics of their learning process in e-learning lessons	2.97			3.03	4.856	1	4.856	2.525	0.113
The lecturers have specific systems to identify the students' identity (e.g. biometrics) for taking online exams	3.11	I can use specific systems to identify the students' identity (e.g. biometrics) for taking online exams	2.83			2.89	5.753	1	5.753	2.661	0.104

Table 6. General comparison of Agendas, norms, rules and regulations and roles, funding between specialist, educator and student views (ANOVA analysis).

expert	Mean	lecturer	Mean	student	Mean	Total	Sum of Squares	df	Mean Square	F	Sig.
The institution has determined the transition to the increased e-learning mode as their future teaching model	3.66	I have planned the transition to the increased e-learning mode in my teaching	3.16	I expect the institution to start using more e-learning as the main mode of teaching	3.57	3.43	39.477	2	19.739	11.962	0.000
The institution has a specific digital strategy for digital transformation in education	3.62					3.62					
The institution has a department that coordinates developing digital infrastructure and tools for education	3.82					3.82					
The institution has a department that coordinates training and mentoring the digital transformation	3.68					3.68					

The institution has a department that coordinates technological-didactical support for lecturers to conduct digitally mediated practices	3.71					3.71					
There is a group of staff members in the institution who are in charge of advancing and implementing digital learning policies and programs	3.78					3.78					
The lecturers who use innovative digital software and tools are involved into the development of the digital agendas and regulations of the institution	3.74	I have been involved into the development of the digital agendas and regulations of the institution	2.85			3.04	57.407	1	57.407	29.167	0.000
The students' feedback is centrally collected and considered in choosing the technologies for learning	3.63	I have involved my students into making choices for the technologies for learning	3.26	The students' opinions are centrally collected and considered in choosing the technologies for learning	3.19	3.26	14.855	2	7.428	4.286	0.014
The lecturers have full freedom of choice to test out new technologies for learning	4.02	I have full freedom of choice to test out new technologies for learning	3.70			3.77	7.299	1	7.299	5.835	0.016
The lecturers are invited to recommend to the supply management the software/tools/licences and devices they would need in their teaching and research process	3.87	I have been invited to recommend to the supply management the software/tools/ licences and devices for the teaching and research process	2.91			3.11	64.124	1	64.124	33.234	0.000
The financial responsibility for institutionally owned devices and tools that are used at the courses is on lecturers	3.26	I take the financial responsibility for institutionally owned devices and tools that my students use at my lectures	2.64	I am ready to take the financial responsibility for institutionally owned devices and tools that are used at the lectures	3.17	2.99	62,991	2	31.49	15.80	0.000
The institution has a digital student portfolio sharing process between different mentors inside and external	3.64	I have used a digital student portfolio sharing between different	2.89			3.04	37.286	1	37.286	18.552	0.000

from the university to manage students' internship		mentors inside and external from the university to manage students' internship									
The institution promotes digitalization of teaching and learning with specific regulations and guidelines	3.70	I am knowledgeable of the specific institutional regulations and guidelines for teaching and learning with technology	3.60			3.62	0.735	1	0.735	0.555	0.457
Institution uses a value-based assessment process to choose the educational technologies	3.70	I have assessed the educational technologies for the learning based on its values	3.53	The educational technologies for learning should be assessed based on values	3.87	3.73	24.349	2	12.175	9.185	0.000
The lecturers can freely choose different digital tools for building their courses	3.84	I can freely choose different digital tools for building my courses	3.78			3.79	0.210	1	0.210	0.162	0.687
There are health and safety regulations developed regarding digital technologies' usage (e.g. VR sets, robots, and other)	3.61	I consider the health and safety regulations regarding digital technologies' usage (e.g. VR sets, robots, and other)	3.91	My wellbeing and safety is not harmed at the institution when using digital technologies for learning	4.13	4.00	25.747	2	12.874	10.425	0.000
Institutional policy promotes the Open Educational Resource (OER)	3.56	I follow the Open Educational Resource (OER) strategy in e-learning	3.53			3.54	0.056	1	0.056	0.036	0.849
There are policies and processes in place to protect personal and organisational data	4.04	I follow the policies and processes to protect personal and organisational data	4.19	My personal data are protected at the institution	3.94	4.04	12.741	2	6.370	5.683	0.004
The regulations for digital data and infrastructure management are regularly updated as the new technology opportunities (robots, AI, VR etc) become available for the lecturers and students	3.69					3.69					

The device sharing and infrastructure sharing is systematically managed in the institution	3.93	I know the device sharing and infrastructure sharing regulations of my institution	3.88			3.89	0.233	1	0.233	0.173	0.678
The institution has a procurement policy for obtaining educational technology	3.84					3.84					
There is a policy for lecturers to use a specified set of LMS, LDS, videoconferencing tools and repositories only	3.85	I know which educational systems (LMS, LDS, video conferencing tools) I should use in my institution	4.22			4.15	9.563	1	9.563	9.347	0.002
There is a learning resource sharing policy and technical approach applied at the institution for mutual sharing of learning resources between lecturers	3.55	I share digital learning resources with other lecturers using the available systems of the institution	3.90			3.83	8.180	1	8.180	6.300	0.012
There is a policy for lecturers to use mainly the institutional rooms for conducting e-learning lessons	3.67	I am allowed to use mainly the institutional rooms for conducting e-learning lessons	3.77			3.75	0.746	1	0.746	0.462	0.497
The lecturers are encouraged to use their own spaces and internet for conducting e-learning lessons	3.66	I am encouraged to use my own spaces and internet for conducting e-learning lessons	3.40			3.45					
The learning process planning and organisation in the institution is sufficiently flexible to support making dynamic choices for learning forms (face-to-face, fully online, blended, hybrid) in needs based ways	3.68	The learning process planning and organisation in the institution is sufficiently flexible to make dynamic choices for learning forms (face-to-face, fully online, blended, hybrid) in needs based ways	3.22	I prefer that learning process is sufficiently flexible to choose learning forms (e.g. face-to-face, fully online, blended, hybrid) in needs based ways	4.21	3.80	200.923	2	100.461	65.253	0.000

The learning process planning and organisation is sufficiently flexible to grab the chances to integrate emerging technological opportunities into lessons (testing new software or tools, participating in digital projects, working with the industry clients	3.71	The learning process planning and organisation is sufficiently flexible to grab the chances to integrate emerging technological opportunities into lessons (e.g. testing new software or tools, participating in digital projects, working with the industry clients)	3.48	I prefer that learning process is sufficiently flexible to integrate emerging technological opportunities into lessons (e.g. testing new software or tools, participating in digital projects, working with the industry clients)	4.24	3.92	121.477	2	60.738	53.403	0.000
The professional development plans address digital competence of lecturers	3.82	My professional development plans address my digital competence	4.00	My professional development plan addresses digital competences	4.26	4.12	22.765	2	11.382	10.828	0.000
Incentives provided by the institution are in place to develop digital competence of lecturers	3.41	Institutional incentives (e.g. requirements in the accreditation system, free training vouchers) are at place that encourage me developing my digital competence	3.09			3.16	7.079	1	7.079	3.786	0.052
The institution has applied a specific system of incentives to motivate the staff to develop online courses and teaching approaches with innovative technologies (e.g. awards for quality courses, extra payment to develop online courses, teaching grants etc	3.22	Institutional incentives (e.g. awards for quality courses, extra payment to develop online courses, teaching grants etc.) are at place that encourage me developing online courses and teaching approaches with innovative technologies	2.85			2.93	9.155	1	9.155	4.764	0.030
The institution has a specified budget for buying, renting or renewing the digital devices, software and tools	3.71					3.71					
The institution makes centrally investments in increasing the	3.83					3.83					

digitalization of teaching and learning											
There is a specific approach developed and applied how the institution obtains access to the innovative software or tools from the industrial sector	3.45					3.45					
There is funding for technical didactic staff available at the institution who assist the lecturers	3.45					3.45					
The lecturers are remunerated if using their own internet facilities and digital tools for conducting online lessons from home or other ubiquitous places	2.98	I have been remunerated for using my own internet facilities and digital tools for conducting online lessons from home or other ubiquitous places	2.47			2.58	18.248	1	18.248	8.324	0.004

Table 7. General comparison of learning aspects between specialist, educator and student views (ANOVA analysis)

expert	Mean	lecturer	Mean	student	Mean	Total	Sum of Squares	df	Mean Square	F	Sig.
		I conduct full distance learning courses asynchronously (e.g. independent self-study, forum discussions)	2.96	I have participated in distance learning courses asynchronously (independent self-study, forum discussions)	3.98	3.56	211.665	1	211.665	122.018	0.000
		I conduct full distance learning courses synchronously (e.g. videoconferencing lessons, group discussions)	3.27	I have participated in full distance learning courses synchronously (videoconferencing lessons, group discussions)	4.04	3.73	124.364	1	124.364	70.430	0.000

		I conduct blended learning courses (contact learning is blended with synchronous or asynchronous online learning lessons)	3.25	I have participated in blended learning courses (contact learning is blended with synchronous or asynchronous online learning lessons)	3.97	3.68	106.128	1	106.128	60.581	0.000
		I conduct hybrid/flexible learning courses (simultaneously some students attend face to face and some are provided learning online)	3.12	I have participated in hybrid/flexible learning courses (simultaneously some students attend face to face and some are provided learning online)	3.68	3.45	66.098	1	66.098	29.433	0.000
		I conduct online simulations and games as course activities	3.26	I have participated in online simulations and games as course activities	3.14	3.19	3.130	1	3.130	1.442	0.230
		I conduct situated augmented reality and VR experiences as course activities	2.53	I have participated situated augmented reality and VR experiences as course activities	2.48	2.50	0.388	1	0.388	0.164	0.685
		I conduct learning with robots (e.g. robots as cooperation partners, telepresence robots, robots with digital twin) as course activities	2.48	I have participated in learning with robots (e.g. robots as cooperation partners, telepresence robots, robots with digital twin) as course activities	2.18	2.30	17.800	1	17.800	8.209	0.004

		I conduct collaborative hands on activities in distance mode as course activities (e.g. building or manipulating something together)	3.08	I have participated in collaborative hands on activities in distance mode as course activities (e.g. building or manipulating something together)	2.84	2.94	12.056	1	12.056	5.101	0.024
		I conduct role-based learning practices in groups in distance mode (e.g. 7-thinking hats, roleplay or simulation, team-roles division)	3.10	I have participated in role-based learning practices in groups in distance mode (e.g. 7-thinking hats, roleplay or simulation, team-roles division)	3.00	3.04	2.267	1	2.267	0.993	0.319
		I conduct e-learning lessons where students collaborate in teams during the activity (e.g jigsaw learning, World cafe)	3.14	I have participated e-learning lessons where I collaborate other students in teams during the activity (e.g jigsaw learning, World cafe)	2.99	3.05	4.843	1	4.843	2.021	0.155
		I conduct co-teaching in online sessions with other lecturers (e.g. to lead groupwork in separate group sessions)	2.68	I have participated in online sessions as a supporter to other students	2.61	2.64	1.085	1	1.085	0.471	0.493
		I conduct e-learning lessons where student tutors or peer tutoring is used	3.01	I have participated in e-learning lessons where students act as tutors to each other or peer tutoring is used	2.80	2.89	8.811	1	8.811	3.830	0.051

		I conduct courses, or study modules that require students' and external partners' collective practical work to contribute to the society	2.99	I have participated in courses, or study modules where students' and external partners' collective practical work contributes to the society	3.01	3.00	0.124	1	0.124	0.054	0.816
		There is an assessment approach developed in the institution for collaborative practice based work results	3.21	Collaborative practice is assessed with specific learning outcomes	3.66	3.48	40.809	1	40.809	24.257	0.000
		I have used disruptive technology (AI, VR, robots, chatbots, virtual games etc.) in my classroom already	2.90	I have learned with disruptive technology (AI, VR, robots, chatbots, virtual games etc.) in classroom already	2.75	2.81	4.739	1	4.739	2.093	0.148
		I frequently search and choose new technologies to be tested out in my lessons	3.55	I have suggested new technologies to my lecturers or peer students	3.06	3.26	50.109	1	50.109	26.196	0.000
		My learners come eagerly along with new technologies that I suggest in my lessons	3.77	I come eagerly along with new technologies that lecture suggest in the lessons	3.78	3.78	0.012	1	0.012	0.008	0.928
		I rather prefer using the same technology solutions over again that I am comfortable with	3.45	I rather prefer using during learning the same technology solutions over again that I am comfortable with	3.63	3.56	6.550	1	6.550	5.014	0.025

		My learners prefer using technology solutions over again that they are comfortable with	3.67	My lecturers prefer using technology solutions over again that they are comfortable with	3.97	3.85	17.938	1	17.938	16.542	0.000
		I provide students with timeslots for social engagement within e-learning lessons	3.50	There is enough time provided for social engagement within e-learning lessons	3.26	3.36	11.651	1	11.651	7.030	0.008
I am competent in dynamically modifying online lesson scenarios to meet the students needs	3.57	I am competent in dynamically modifying online lesson scenarios to meet the students needs	3.68	In lessons, where I participate, the lecturer modifies online lesson scenarios to meet the students needs	3.27	3.45	35.526	2	17.763	11.831	0.000
I have access to alumni network as a resource for my lessons	3.89	I have access to alumni network as a resource for my lessons	2.92	In lessons I have been provided access to alumni as a learning resource	2.96	3.03	68.833	2	34.417	18.102	0.000
I promote students' digital co-production with external clients in my lesson scenarios (e.g. design studies, cases or other forms)	3.71	I promote students' digital co-production with external clients in my lesson scenarios (e.g. design studies, cases or other forms)	2.92	In lessons, where I participate, the lecturer promotes students' digital co-production with external clients (e.g. design studies, cases or other forms)	2.99	3.03	43.862	2	21.931	11.750	0.000
I have partners who are experts of disruptive technology usage (VR, AR, AI, robots etc.)	3.59	I have partners who are experts of disruptive technology usage (VR, AR, AI, robots etc.)	2.76	In lessons I have been provided access to the institute's partners in industry and society as a learning resource	3.04	2.99	48.255	2	24.127	12.277	0.000
I attend experience sharing events about digital education	3.58	I attend experience sharing events about digital education	3.14	I have participated in events organised to share experience on digital education	2.84	3.02	46.468	2	23.234	11.282	0.000

				among lecturers and students							
I attend events to meet the industrial, public sector, NGOs or startup sector partners who work with novel technologies	3.62	I attend events to meet the industrial, public sector, NGOs or startup sector partners who work with novel technologies	2.96	I have participated in events where lecturers and students have the opportunity to meet the industrial, public sector, NGOs or startup sector partners who work with novel technologies	2.93	3.01	37.650	2	18.825	8.807	0.000
There is a dedicated time slot in the institution when I share experiences and learn about the new technologies with my colleagues	3.26	There is a dedicated time slot in the institution when I share experiences and learn about the new technologies with my colleagues	2.96	There is a dedicated time slot defined for students to share experiences and learn about the new technologies	2.85	2.93	12.697	2	6.349	3.027	0.049
I have access to the best practices of digital education in my institution	3.55	I have access to the best practices of digital education in my institution	3.18			3.25	9.302	1	9.302	5.176	0.023
I have coworking experiences with the experts of disruptive technologies (VR, AR, AI, robots etc.) in my institution	3.78	I have coworking experiences with the experts of disruptive technologies (VR, AR, AI, robots etc.) in my institution	2.77	I have coworking experiences with the experts of disruptive technologies (VR, AR, AI, robots etc.) in my institution	2.35	2.65	159.557	2	79.778	39.951	0.000
Technical and educational technology support is offered to the lecturers for the development of e-learning courses	3.82	I need technical and educational technology support for developing e-learning courses	3.45			3.53	9.965	1	9.965	6.667	0.010

Technical and educational technology support is offered to the lecturers for developing digital learning resources (e.g. METAVERSE, simulations)	3.35	I need technical and educational technology support for developing more complex digital learning resources (e.g. METAVERSE, simulations)	3.66			3.60	6.803	1	6.803	4.331	0.038
Technical assistant support before the lesson is available for lecturers to set up lessons with technologies	3.66	I need a technical assistant support before the lesson to set up lessons with technologies	2.70	I have opportunity of instruction before the lesson to set up participation in lessons with technologies	3.10	3.00	75.556	2	37.778	20.090	0.000
Technical assistant support during the lessons is available for lecturers and students to manage technologies	3.73	I need a technical assistant support during the lessons to manage technologies	2.64	Technical assistant support during the lessons is available for students to manage technologies	3.18	3.03	109.638	2	54.819	31.047	0.000
There is enough expertise in my institution to provide support for learning with disruptive technologies (VR, AR, AI, robots etc.)	3.53	I need support how to use disruptive technologies (VR, AR, AI, robots etc.) in learning	3.34			3.38	2.587	1	2.587	1.466	0.227
		I must rely on my students' competencies and help when using new technologies in class	3.16	Lecturers rely on students' competencies and help when using new technologies in class	3.73	3.49	67.609	1	67.609	44.829	0.000
I have attended professional training to learn to use innovative technologies	3.67	I have attended professional training to learn to use innovative technologies	3.33	I can learn with innovative technologies at lessons.	3.64	3.53	20.731	2	10.365	5.788	0.003

I conduct pre-service training about using innovative technologies at specific teacher/lecturer study programmes	3.59	I conduct pre-service training about using innovative technologies at specific teacher/lecturer study programmes	3.22			3.29	9.489	1	9.489	4.801	0.029
I conduct in-service training about using innovative technologies for the in-service teachers in vocational education or schools	3.60	I conduct in-service training about using innovative technologies for the in-service teachers in vocational education or schools	2.67			2.86	60.371	1	60.371	30.591	0.000
		I attended a training that is mainly about the principles of how to use technology functionalities.	3.19	Lecturers have trained me how to use technology functionalities before we start practical work	3.42	3.33	10.236	1	10.236	5.526	0.019
		I attended a training where technology is tested from the learner's and lecturers' positions.	3.01			3.01					
		I have learnt about innovative technology when observing or assisting colleagues who use these in classes	3.34	I have learnt about innovative technology when observing or assisting lecturers who use technology in classes	3.31	3.32	0.155	1	0.155	0.086	0.770
		I have learnt about innovative technology at visits to workplaces	3.08	I have learnt about innovative technology at visits to workplaces	3.10	3.09	0.056	1	0.056	0.026	0.873
		I have attended trainings where innovative technology was tested at explorative workshops	2.92	I have learnt about innovative technology at explorative workshops	3.01	2.97	1.417	1	1.417	0.623	0.430

		I have learnt about innovative technology while sharing experiences with colleagues (in the communities of practice)	3.48	I have learnt about innovative technology while sharing experiences with other students	3.58	3.54	1.793	1	1.793	1.063	0.303
		I have learnt about the technology potential while developing technologies myself	3.52	I have learnt about innovative technology while developing technologies myself	3.22	3.34	17.975	1	17.975	8.596	0.003
		Special training is available for lecturers about disruptive technology usage (VR, AR, AI, robots etc.)	3.09	Special training is available for students about disruptive technology usage (VR, AR, AI, robots etc.)	2.76	2.89	21.087	1	21.087	10.640	0.001

Table 8. General comparison in values, attitudes, experiences and competencies related to disruptive technologies between specialist, educator and student views (ANOVA analysis)

expert	Mean	lecturer	Mean	student	Mean	Total	Sum of Squares	df	Mean Square	F	Sig.
Lecturers have sufficient competences for developing digital learning scenarios with disruptive technologies (VR, AR, AI, robots etc.)	3.34	I have sufficient competences for developing digital learning scenarios with disruptive technologies (VR, AR, AI, robots etc.)	3.06	I have sufficient competences for attending digital learning scenarios with disruptive technologies (VR, AR, AI, robots etc.)	3.19	3.16	7.114	2	3.557	1.870	0.155
Lecturers have sufficient competences for developing digital learning resources with disruptive technologies (VR, AR, AI, robots etc.)	3.47	I have sufficient competences for developing digital learning resources with disruptive technologies (VR, AR, AI, robots etc.)	2.94	I have sufficient competences for developing digital resources with disruptive technologies (VR, AR, AI, robots etc.)	2.94	2.99	21.470	2	10.735	5.540	0.004
Lecturers have sufficient competences for personalization of learning with disruptive technologies (VR, AR, AI, robots etc.)	3.40	I have sufficient competences for personalization of learning with disruptive technologies (VR, AR, AI, robots etc.)	3.02	I have competence to use disruptive technologies (VR, AR, AI, robots etc) to personalize my learning path	3.20	3.15	12.446	2	6.223	3.378	0.035

Lecturers have sufficient competences for adopting e-learning situations with disruptive technologies (VR, AR, AI, robots etc.) for special needs and diversities	3.42	I have sufficient competences for adopting e-learning situations with disruptive technologies (VR, AR, AI, robots etc.) for learners with special needs	2.89	I have sufficient competences for adopting e-learning situations with disruptive technologies (VR, AR, AI, robots etc.) for my special needs	3.15	3.08	24.590	2	12.295	6.870	0.001
Lecturers have sufficient knowledge of the potentials of disruptive technologies (VR, AR, AI, robots etc.) for humans	3.62	I have sufficient knowledge of the potentials of disruptive technologies (VR, AR, AI, robots etc.) for humans	3.19	I have sufficient knowledge of the potentials of disruptive technologies (VR, AR, AI, robots etc.) for humans	3.31	3.30	13.826	2	6.913	4.213	0.015
Lecturers have sufficient knowledge of the learning effects of disruptive technologies (VR, AR, AI, robots etc.)	3.61	I have sufficient knowledge of the learning effects of disruptive technologies (VR, AR, AI, robots etc.)	3.24	I have sufficient knowledge of the learning effects of disruptive technologies (VR, AR, AI, robots etc.)	3.19	3.25	13.447	2	6.723	4.259	0.014
Lecturers have sufficient knowledge of the threats of disruptive technologies (VR, AR, AI, robots etc.)	3.51	I have sufficient knowledge of the threats of disruptive technologies (VR, AR, AI, robots etc.)	3.23	I have sufficient knowledge of the threats of disruptive technologies (VR, AR, AI, robots etc.)	3.40	3.34	8.402	2	4.201	2.621	0.073
Lecturers have sufficient knowledge of the sustainability issues of disruptive technologies (VR, AR, AI, robots etc.)	3.45	I have sufficient knowledge of the sustainability issues of disruptive technologies (VR, AR, AI, robots etc.)	3.22	I have sufficient knowledge of the sustainability issues of disruptive technologies (VR, AR, AI, robots etc.)	3.17	3.22	5.902	2	2.951	1.746	0.175
Students have sufficient competences to participate in practical online courses using disruptive technologies (VR, AR, AI, robots etc.)	3.59	My students have sufficient competences to participate in practical online courses using disruptive technologies (VR, AR, AI, robots etc.)	3.11	I have sufficient competences to participate in practical online courses using disruptive technologies (VR, AR, AI, robots etc.)	3.25	3.23	16.062	2	8.031	4.778	0.009
Students have sufficient knowledge about the pros and cons of using disruptive technologies (VR, AR, AI, robots etc.) in learning to make justified decisions about their learning	3.48	My students have sufficient knowledge about the pros and cons of using disruptive technologies (VR, AR, AI, robots etc.) in learning to decide how to learn digitally	3.09	I have sufficient knowledge about the pros and cons of using disruptive technologies (VR, AR, AI, robots etc.) in learning to decide how to learn	3.33	3.26	16.172	2	8.086	5.070	0.006

choices											
Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much resources (time, money, energy consumption, natural resources etc.)	3.97	Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much resources (time, money, energy consumption, natural resources etc.)	3.68	Using disruptive technologies (VR, AR, AI, robots etc.) for learning requires too much resources (time, money, energy consumption, natural resources etc.)	3.48	3.60	20.027	2	10.013	7.825	0.000
Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much staff training	3.97	Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much re-learning	3.63	Using disruptive technologies (VR, AR, AI, robots etc.) for learning requires too much re-learning	3.01	3.33	113.259	2	56.630	42.406	0.000
Introducing disruptive technologies (VR, AR, AI, robots etc.) in classes requires too much changes in the regulations and norms	3.54	Introducing disruptive technologies (VR, AR, AI, robots etc.) in my classes is hindered by regulations and norms	3.36			3.40	2.263	1	2.263	1.617	0.204
Institutions must evaluate the potential and threats of disruptive technologies (VR, AR, AI, robots etc.)	4.12	I am considering potential and threats of the disruptive technologies' (VR, AR, AI, robots etc.) for humans	3.60	I am concerned of potentials and threats of the disruptive technologies' (VR, AR, AI, robots etc.) for humans	3.36	3.52	47.565	2	23.782	16.198	0.000
Institutions must evaluate the learning potential and threats of disruptive technologies (VR, AR, AI, robots etc.)	4.07	I am considering in my lessons the learning potentials and threats of disruptive technologies (VR, AR, AI, robots etc.)	3.56	I am concerned of the learning potentials and threats of disruptive technologies (VR, AR, AI, robots etc.)	3.26	3.45	56.272	2	28.136	19.339	0.000

Institutions must evaluate the sustainability issues of disruptive technologies (VR, AR, AI, robots etc.)	4.06	I am considering in my lessons the sustainability issues of disruptive technology (VR, AR, AI, robots etc.)	3.46	I am concerned of the sustainability issues of disruptive technologies (VR, AR, AI, robots etc.)	3.39	3.48	32.942	2	16.471	10.699	0.000
Institutions must evaluate the health and wellbeing aspects of disruptive technologies (VR, AR, AI, robots etc.)	3.92	I am considering in my lessons the health and wellbeing aspects of the disruptive technology (VR, AR, AI, robots etc.)	3.54	I am concerned of the health and wellbeing aspects of the disruptive technologies (VR, AR, AI, robots etc.)	3.39	3.50	22.442	2	11.221	7.493	0.001
Disruptive technologies (VR, AR, AI, robots etc.) should be used in learning only if they brings additional value to the learning process	4.06	Disruptive technologies (VR, AR, AI, robots etc.) should be used in learning only if they brings additional value to the learning process	3.81	Disruptive technologies (VR, AR, AI, robots etc.) should be used in learning only if they brings additional value to the learning process	3.79	3.82	5.492	2	2.746	1.989	0.137
Using disruptive technologies (VR, AR, AI, robots etc.) in learning develops students' competences for digitised jobs	3.97	Using disruptive technologies (VR, AR, AI, robots etc.) in learning develops students' competences for digitised jobs	3.79	Using disruptive technologies (VR, AR, AI, robots etc.) in learning develops students' competences for digitised jobs	3.94	3.89	5.371	2	2.686	2.355	0.096
Using disruptive technologies (VR, AR, AI, robots etc.) in learning provides resilience for the education sector	3.67	Using disruptive technologies (VR, AR, AI, robots etc.) in learning provides resilience for the education sector	3.74	Using disruptive technologies (VR, AR, AI, robots etc.) in learning provides resilience for the education sector	3.61	3.66	3.034	2	1.517	1.270	0.281
Using disruptive technologies (VR, AR, AI, robots etc.) in learning promotes ecosystem sustainability	3.68	Using disruptive technologies (VR, AR, AI, robots etc.) in learning promotes ecosystem sustainability	3.54	Using disruptive technologies (VR, AR, AI, robots etc.) in learning promotes ecosystem sustainability	3.49	3.53	2.941	2	1.470	1.199	0.302
Using disruptive technologies (VR, AR, AI, robots etc.) in learning does not threaten the diversity of learning practices	3.85	Using disruptive technologies (VR, AR, AI, robots etc.) in learning does not threaten the diversity of learning practices	3.67	Using disruptive technologies (VR, AR, AI, robots etc.) in learning does not threaten the diversity of learning practices	3.51	3.61	10.573	2	5.287	3.984	0.019

Using disruptive technologies (VR, AR, AI, robots etc.) in learning does not threaten the ecosystem sustainability	3.88	Using disruptive technologies (VR, AR, AI, robots etc.) in learning does not threaten the ecosystem sustainability	3.63	Using disruptive technologies (VR, AR, AI, robots etc.) in learning does not threaten the ecosystem sustainability	3.34	3.51	29.318	2	14.659	12.224	0.000
Using disruptive technologies (VR, AR, AI, robots etc.) in learning brings additional value to the learning process	3.91	Using disruptive technologies (VR, AR, AI, robots etc.) in learning brings additional value to the learning process	3.99	Using disruptive technologies (VR, AR, AI, robots etc.) in learning brings additional value to the learning process	3.86	3.92	3.312	2	1.656	1.597	0.203
Using disruptive technologies (VR, AR, AI, robots etc.) in learning advances human abilities	3.83	Using disruptive technologies (VR, AR, AI, robots etc.) in learning advances human abilities	3.78	Using disruptive technologies (VR, AR, AI, robots etc.) in learning advances human abilities	3.73	3.76	1.046	2	0.523	0.436	0.647
Using disruptive technologies (VR, AR, AI, robots etc.) in learning advances social and collaborative dimension of learning	3.93	Using disruptive technologies (VR, AR, AI, robots etc.) in learning advances social and collaborative dimension of learning	3.66	Using disruptive technologies (VR, AR, AI, robots etc.) in learning advances social and collaborative dimension of learning	3.64	3.68	6.682	2	3.341	2.593	0.075
Using disruptive technologies (VR, AR, AI, robots etc.) in learning promotes students' learning results	3.87	Using disruptive technologies (VR, AR, AI, robots etc.) in learning promotes students' learning results	3.64	Using disruptive technologies (VR, AR, AI, robots etc.) in learning promotes students' learning results	3.67	3.68	3.598	2	1.799	1.461	0.232
Using disruptive technologies (VR, AR, AI, robots etc.) in learning is more cost effective than face-to face learning	3.49	Using disruptive technologies (VR, AR, AI, robots etc.) in learning is more cost effective than face-to face learning	3.26	Using disruptive technologies (VR, AR, AI, robots etc.) in learning is more cost effective than face-to face learning	3.22	3.26	5.662	2	2.831	1.963	0.141

e-DIPLOMA

Funded by
the European Union