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Technologies for Education: From Gamification to AI-enabled Learning

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ABSTRACT

The landscape of teaching in higher education is dynamic and driven by the interplay among educators, students and curriculum. Educators play the primary role in presenting curriculum for students to absorb and leading classroom discussions. The onus of teaching is on educators who come with different pedagogical beliefs, teaching styles and prior experiences. The effectiveness of teaching is often determined by the teaching quality of individual instructors. This paper presents an overview of technologies which can help with improving teaching effectiveness. The adoption of technologies ensures consistency in delivery of curriculum and delegates some of the educator's role to technology in exchange for greater engagement and involvement from students.

Keywords: teaching, technology, technology for teaching, AI, gamification

Technology plays dual roles as both an enabler and a disruptor in this era of digitalization. It enables classroom learning to be flipped for students to play a more active role in learning, enables personalized learning paths for individualized learning, and promotes collaborative learning to achieve an active learning environment. Disruptive technologies are adopted in some schools of higher education in the form of Virtual Reality (VR) and Augmented Reality (AR) for transformative learning experience.

The adoption of technology into teaching can be traced back to the year 1924 when the first Learning Management System (LMS) called "Teaching Machine" was proposed by Sidney Pressey (S.L., 1927). The technology started with a basic window that can be used to administer questions for students to attempt. In 2002, an open-sourced LMS platform, Moodle (Moodle, 2002), was launched. Moodle became widely acceptable due to its open-sourced nature, and it coincided with the growth of the Internet in 2000. Course sites are set up to establish an online community for learners to access teaching materials and assignments. The development was driven by social constructionist epistemology (Weller, 2021) to achieve reflective inquiry among the web-based community set up by educators.

Experiences and teaching beliefs of educators shape the corresponding pedagogy of the course being delivered. The pedagogy adopted by educators is facilitated by appropriate technology. This paper aims at examining this perspective to inform educators on best practices for promoting a more engaged course delivery. The next section illustrates the main pedagogical approaches which will be mapped to the technology in the following section.

This paper examined the use of game-based platforms from a pedagogical perspective in the delivery of a university's undergraduate module on programming. This paper aims at providing insights on how different teaching technologies can be embedded in tertiary teaching. It contributes to our understanding of teaching technologies from a pedagogical perspective, adding values to how these technologies fare when compared to one other. This paper also discusses how AI-enabled learning can be integrated in teaching to enhance student's learning experience. The paper is organized as follows: second section describes technologies and pedagogies. Thirdsection illustrates how technologies can be adopted in class deliveries. It examines the use of gamification, immersive learning, Artificial Intelligence enabled learning. Finally, the conclusion of this paper is drawn in the last section.

Technologies and Pedagogies

Constructivist

Constructivism pedagogy has its root from psychology's constructivism (Papert, 1980; Piaget & Inhelder, 1967; Vygotsky, 1978). It is rooted in the concept of involving learners in the process of learning for the development of meaning, understanding and slowly moving towards higher level of thinking (Amineh & Asl, 2015; NH & J., 2012). The construction of knowledge is derived from the influence of learners' prior knowledge and learners actively negotiate their understanding from the current learning context. When the prior and current learning are conflicting, their understanding is then slowly shaped by the new learning experience (Amineh & Asl, 2015; Hoover, 1996). Educator's role is in designing the process to allow this sort of conflicting negotiation to take place for new knowledge to stick. A typical constructivist learning process provides opportunities for learners to think, question, reflect and interact with ideas in the construction of meaning (Brooks & Brooks, 1999). The dilemma of constructivism is that the apparent structure for learning may be lacking as learners may not be able to communicate the process of how they arrive at certain answers (Iran-Nejad, 1995; Staver, 1989; Swamy, 1987). The structure of the learning process is crucial for foundation building modules. Novice learners require a more structured learning process starting with remembering prior to proceeding with the higher level of Bloom's Taxonomy (Jonassen, 1991). Constructivism classroom setting involves group exercises for learners to discuss and express their views on the given topics. The other criticism of constructivists is the tendency of learners falling into group think (Brau, 2022; Ruggie, 1998) when involved in group activity during the knowledge negotiation process. A renown model in constructivism is the 5E model (Engage, Explore, Explain, Elaborate and Evaluate) (Ergin, 2012; Paily, 2013) that entails the main learning process in constructivism. This model is later developed into the 7E variant (Engage, Elicit, Explore, Explain, Elaborate, Extend and Evaluate) (Shaheen & Kayani, 2015; Turgut et al., 2016).

Collaborative

Collaborative learning is an umbrella term for a variety of educational approaches involving joint intellectual efforts by students or with educators together (Smith & MacGregor, 1992). It was proposed by Dillenbourg (Dillenbourg, 1999a, 1999b) in 1999, it shifted some part of the learning process to evaluate and monitor learners' works on team members. The learning has more emphasis on group work in the class or out of class time for learners to participate in the process of responding to each other's work. Learners collaborate as a group to develop understanding. Each individual contributes to the success of the group work. Collaborative learning enhances higher level critical thinking through collective thinking (Gokhale, 1995). The learning process typically starts with introducing the task and setting aside time for learners to brainstorm and work on the exercise. It then closes the loop with learners presenting the conclusions. Team dynamic is a large variance in this model. To mitigate this large variance, educators can set up house rules, linking peer evaluation to graded outcomes, and assign specific roles for each team member. The benefit of collaborative models is that learners play a highly active role in the learning process. Improved communication and listening skills are often observed as the by-products of this pedagogy model. Practice of collaborative pedagogy includes debate-based learning (Malone & Michael, 2018) and game-based learning (Feigenbaum & Feigenbaum, 2013).

Inquiry-based

Inquiry-based pedagogy is similar to how professional scientists formulate hypotheses and verify them by conducting experiments (Keselman, 2003; Pedaste et al., 2012; Pedaste et al., 2015). The engagement of students arises from development of questions, learners go through the discovery process to connect logical derivation of answers. This pedagogy has well supported literature documenting its effectiveness across different disciplines (Gormally et al., 2009; Magnussen et al., 2000; Preston et al., 2015; Wu & Hsieh, 2006). It is considered as a type of constructivism to fine-tune a learner’s knowledge through refinement of understanding in the search of answers. Lazonder & Ruth (2016) provided a meta-analysis on inquiry-based learning and extent of required guidance from educators. The work synthesizes 72 empirical studies concluding that guidance in inquiry-based learning is pivotal and is independent of the specificity of guidance. The major issue with inquiry-based learning is on assessment or measurements on the quality of inquiry (Quigley et al., 2011) and effective planning for inquiry-based learning. The learning process should incorporate opportunities for learners to interact with each other, formulating the main inquiry related to the topics, peer or self-directed inquiry, and reflection of how the questions have been addressed. Recent discussion on inquiry-based has shifted to online-based inquiry learning (Munzil & Perwira, 2021; Situmorang & Mursid, 2020).

The following section will discuss the technologies and provide the corresponding mapping to types of learning.

Technologies for Deliveries

The acceptance of different technologies takes a longer time for acceptance in education (Salmon, 2019). Education has gone through the phases of Education 1, 2, 3 and currently in the phase of Education 4.0. Education prepares the workforce in industry hence this evolution responds to and taps on industry movement closely. Salmon (2019) presented a historical walkthrough in education and timelines of the relationship between Education movements and Industrial movement. It was highlighted that Industrial revolution 1, 2 and 3 had been driving education and started before Education 1, 2, and 3. The current phase of Education 4 coincides with Industry 4 and is moving in parallel. The first revolution of education started with educator centric pedagogy where learners consume the learning resources passively in the lecture settings. Second education movement saw the shift in paradigm towards ‘blended’ mode of learning and some educators embed social media platforms in course delivery. Education 3 shifted rapidly towards emphasis of online learning; learners take greater charge of their learning to generate knowledge more independently while educators frame the context to enable greater autonomy for learners to look up for the required content.

Education 4.0 garnered a wider range of technologies for course deliveries and demanded greater learners’ interaction throughout the learning process. The key features of Education 4 are the connected technologies, personalized learning journeys, fully digitalized learners’ analytics to prepare them to be future ready. This topic could be discussed with Industry 4.0 and in a wider adaptive system of Globalization 4.0 for a fuller picture (Feldman, 2018; Schwab, 2018). Anealka (Hussin, 2018) presented ideas for teaching and a case for Education 4’s implementation. Vichian (Puncreobutr, 2016) discussed the challenges facing Education 4. Vishal (Jain & Jain, 2021) examined the acceptance of educators in using the technologies with Unified Theory of Acceptance and Use of Technology (UTAUT) model under the Education 4 movement. Monica et. al. (Ciolacu et al., 2017) conducted analysis based on machine learning methods to predict students’ learning outcomes based on learners’ profiles.

The following sections discuss the cornerstone technologies that drive this education revolution.

Gamification

Gamification promotes the engagement of learners by designing learning activities for learners to go through a series of story lines, specifying rules of games, and rewards systems. A study on gamification techniques was presented in (Ab Rahman et al., 2019) in which the game based approaches were evaluated according to the perceived ease of use and perceived usefulness. Almeida and Jorge (Almeida & Simoes, 2019) conducted a qualitative study on the adoption of serious games and gamification in Portuguese higher education institutions and revealed a low take up rate of 20%. Gamification is a generic approach to enhance learners' engagement with vibrant visual colors, audio to boost cognitive thinking. "Serious Games" is a term for designing goal-oriented tasks aimed at improving players' cognitive ability (Shi & Shih, 2015), it requires more planning and implementation and is not straightforward. The design of game goals in Serious Games can be short, mid, or long term (Swartout & van Lent, 2003).

Gamification platforms make use of different game elements to engage learners like badges, leaderboard, challenges, levels, points, online activity, incentives and XP. The most popular game platform used in course delivery is Kahoot!. Melissa (Pilakowski, 2015) published a matrix comparison of different game platforms including Kahoot!, Quizizz, Quizalize, Socrative and Riddle. One key question in the use of gamification is the diminishing effect on student's engagement. Wang (Wang, 2015) studied the diminishing effect of using Kahoot! in a different situation across two groups of students. Students' engagement level is still high despite a longer period of involvement. Both groups find that the use of Kahoot! helped them to be engaged during lessons as it provides a meaningful, interactive, and fun way of learning, besides the determination to get ahead in the game. Thus, it was proven that a longer period of gamification during lessons has no diminished effect on the students' engagement (Ab Rahman et al., 2019).

In Figure 1, the picture on the left depicts the user interface of Kahoot! for instructors to design questions, while the right picture shows the types of questions with time limit and points setting. It adopted shapes and colors to differentiate answers from multiple choice questions. Figure 2 shows the interface of Socrative for quiz creation, it encourages group competition and places it at the landing page under the option of "Space Race". Figure 3 shows another game-based learning platform, Wooclap. Wooclap has richer options for different types of questions, the interface comes with attractive and self-explanatory icons that allows for quick questions creation, making it a good choice for impromptu polling. Figure 4 illustrates Quizizz interface, it has unique features of rating the quality of quiz with quiz quality score. Teleporting questions greatly shorten the preparation time, its bank of questions is accumulated automatically with the creation of new questions.

Table 1 summarizes the level of support the game-based platforms provide for different pedagogies, reward motivation to learners, and how easy it is to set up for educators. The number of asterisks denotes the level of involvement in the corresponding pedagogy, the rewards and ease of set up. Both Wooclap and Quizizz support a high level of constructivism. Socrative comes with a team-based collaboration feature to support collaborative learning. Rewards system is well incorporated in Kahoot! and Quizizz to encourage learners to collect badges for engaged learning. Quizizz scored the highest in ease of setup. Kahoot! and Socrative score lower and require more set up time .

Constructivist pedagogy promotes the negotiation of new knowledge for retentiveness. Platforms with different question types with collection of learners' answers provided channels for this negotiation to be matched or addressed in the case of mismatches. For example, Quizziz and Kahoot! automatically keep the previously created questions. Different pools of questions are created, and it can be reused by selecting from the public pool of questions (Kohnke 2021 & Lim 2021). Educators can view learners' response to questions and understand the differences to re-align the learning direction. Most of the platforms (Kahoot, Socrative, and Quizizz) provide good support on this, learners can be identified through the platforms for educators to know how learners grasp the relevant topic; the answers can be shown individually or collectively. Collective answers provide insights to the extent of knowledge mismatched to be addressed and the sequence for the instructor to address it can be prioritized accordingly. Socrative shows learners' answers individually.

Collaborative pedagogy emphasizes on group work, peer reviewing learner's work or brainstorming in groups for solution. Socrative emphasizes teamwork through "Space Race" for teams to compete for hitting the finishing line in the shortest time and showing the corresponding group achievements. The group formations need to be populated prior to the launch of team-based racing. Kahoot and Quizizz have some support for collaborative game-based learning, but most of the features are targeted on individualized learning. Wooclap does not provide such support at the point of writing. Different teams can be set up in Kahoot! (Davis 2021) to compete as a team. Similar feature can be found in Quizizz (Rachmawati 2022) for the team to compete together, the total score of the team is computed at the end of the polling.

Inquiry-based pedagogy encourages learner's engagement through the development of different questions and different types of questions for learners to form logical derivation of answers. The corresponding column in Table 1 relates to the variety of questions enabled by the platforms to support inquiry-based learning. Wooclap has the most varied type of questions like multiple choice, polling, rating, open-ended, word cloud, matching answers, prioritization, sorting, fill in the blanks, brainstorming, judgment concordance test etc. Kahoot! supports the commonly used question types, similarly for Quizizz. Socrative keeps its neat and clear user interface and provides questions like multiple choice, true false, and short answers.

The fourth evaluation is on the rewards for learners. Kahoot! has wide adoption in education due to its stimulating music, scoring system, and the creation of a learning-based competition context among learners. The rewards of learners are shown after each question and the leader's board. Quizizz started slightly later and has similar support like Kahoot!. Learners get to redeem their wrong questions or re-practice using flash-cards in Quizizz, there is an accessibility option that can be turned on for more diverse learners. The scoring reward or champion listings in Socrative and Wooclap are less instantaneous and are delayed till the end of the sessions.

The last evaluation provides the rating on ease of setup for educators. Quizizz has the highest rating because of the feature to teleport questions in from question banks. This reduces initial set up time. The question's quality scoring from Quizizz also improves the quality of questions being set up to guide instructors along the way of questions creation. Wooclap's intuitive user interface allows for quick question creation, questions can be re-used and combined easily. Kahoot! platform displays other learning technologies. It has a less clean-cut interface to allow for quick quiz creation. The question bank feature is offered at fees-paying tier. Socrative merges a few functionalities into the same landing page that makes the initial navigation slightly more time consuming due to the similar placement of questions creation and deployment.

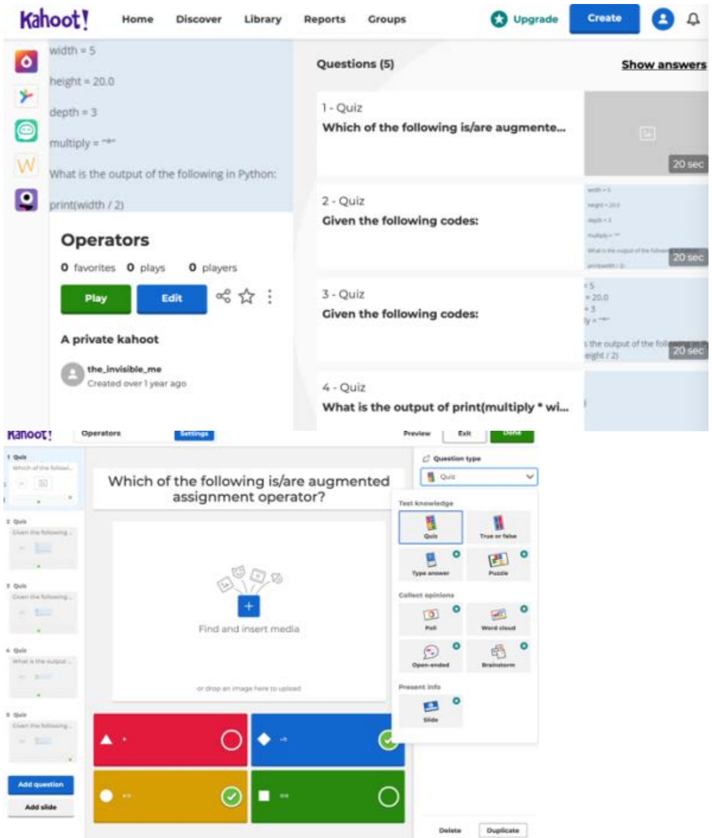

Figure 1. Kahoot interface

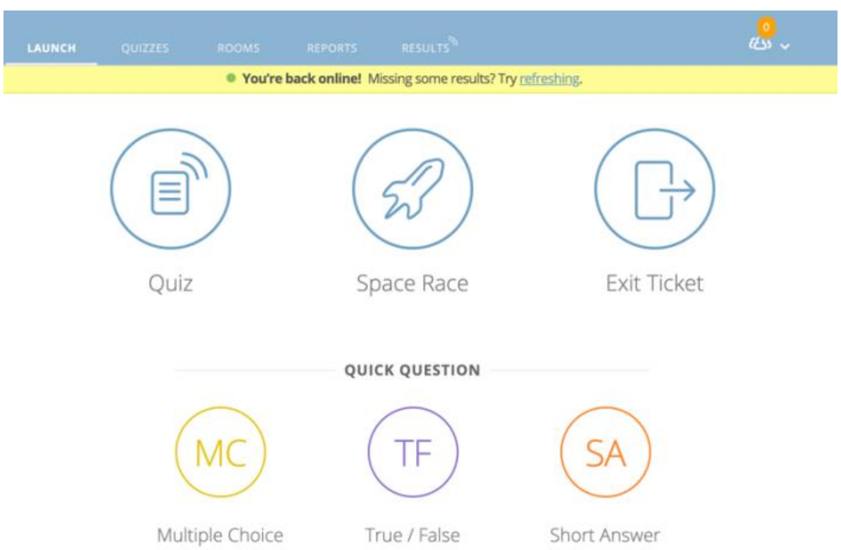

Figure 2 Socrative interface

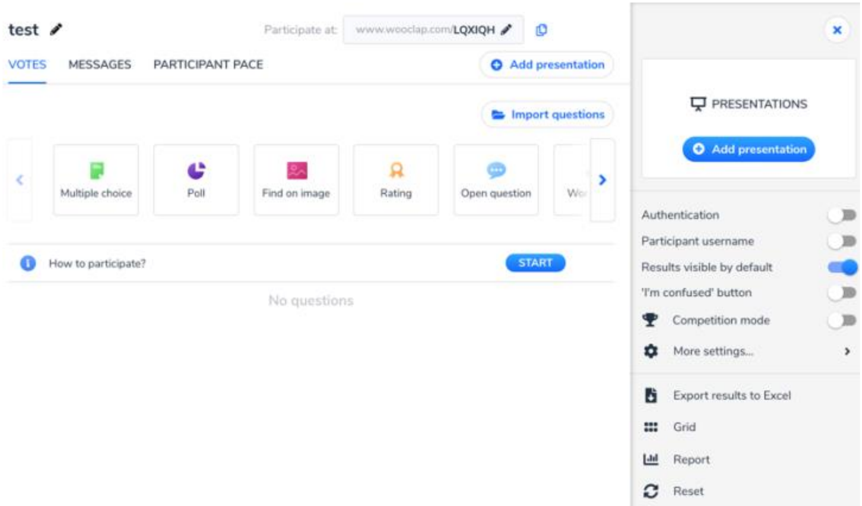

Figure 3 Wooclap interface

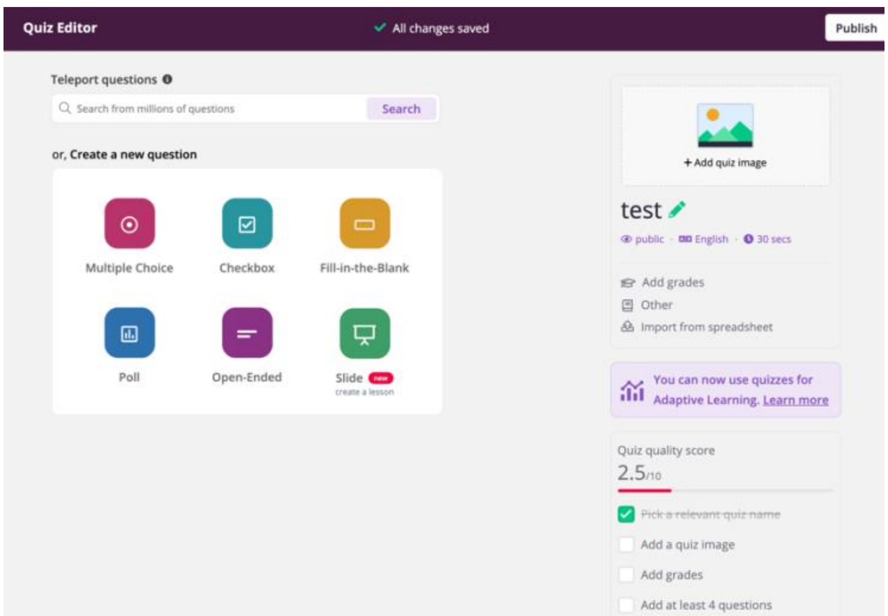

Figure 4 Quizizz interface

Table 1 Game based Platforms Comparison Table

	Constructivist	Collaborative	Inquiry-based	Rewards	Ease of Setup
Kahoot	*****	****	****	*****	***

Socrative	***	*****	**	***	***
Wooclap	*****	nil	*****	***	****
Quizizz	*****	****	***	*****	*****

Immersive Learning (Augmented Reality & Virtual Reality)

Augmented reality (AR) was pioneered by Boeing researcher Thomas Caudell and David Mizell to support an industrial process on providing wiring instructions in 1992 (Thomas & David, 1992). This sets off the use of augmented reality in industrial settings. AR immerses one into an "augmented" environment, overlays computer generated images on real-world environments. Real, existing environment or object is used to overlay it with augmented imagery. It can be accomplished by using a smartphone, taking a picture of yourself and modifying the environment you are in (Snapchat lenses). Pokémon Go makes use of AR technology to entice players to traverse the physical world following an "augmented" map in search for Pokémon characters. Virtual reality (VR) attempts to create an entirely virtual environment, replacing the reality to provide a totally immersive experience. The immersive environment of VR can take users to any imaginable settings. It generally requires a head-mounted display (HMD) or headset to be worn by the user to experience the immersion through a series of computer simulations. VR has a longer history than AR, the first HMD called Telesphere Mask was patented in 1960 by Heilig (Heilig, 1960). It subsequently flourished in the entertainment industry, business, medical and military training.

In the education setting, the use of AR and VR is common in medical and healthcare education (Herron, 2016; Hsieh & Lee, 2018; Hsieh & Lin, 2017; Pottle, 2019). Trainees learn through surgical simulation to simulate actual operation prior to actual operation. This greatly reduces the chances of making mistakes during surgery where certain mistakes can cost human lives. Other cases include autism treatment, limb pain treatment, anatomy teaching, virtual anatomy and other nursing or medical education (Hsieh & Lee, 2018).

Hadi and Esmaell (Ardiny & Khanmirza, 2018) reviewed the use of AR and VR for teaching. The different types of HMDs were reviewed from both the hardware and software perspectives. The challenges to implement it for teaching includes high cost, lack of realism in simulation setting, health and physical impacts on students as well as hardware limitations. The work in Horváth (2018) designed an experiment that exposed learners to 3 different learning modes with the same content and explored the use of 3D presentation for teaching. It concluded that the use of 3D presentation as a kind of virtual reality reduces some load (40% lesser user operation, 72% lesser machine operation) as compared to the typical 2D exposures that typical learning platform provides. Maria et. al (Puggioni et al., 2020) proposed a ScoolAR framework for content creation for immersive learning experience. Jorge et.al. (Martín-Gutiérrez et al., 2017) compiled the series of technologies involved in AR and VR. The different scenarios of immersive experience for web conferences, AR and VR projects for education were included. Riva et.al. (Riva, 2006) classifies the virtual experience brought by virtual technology to different categories: cabin simulators, projected reality, augmented reality, telepresence, desktop virtual reality, and visually coupled systems.

The implementation of VR lessons requires hardware and software for viewing and lesson creation. It is suitable for domains involving objects, arts, linking objects, geography, science, or engineering. The hardware is one part of the cost, Google has provided a low-cost solution using Cardboard. The other main challenge in VR is the creation of 3D lessons. Table 2 consolidates a number of VR solutions suitable for deployment in higher education. For some works that have attempted to implement it, students' general feedback and how the lessons are integrated across the relevant technologies are listed. Nearpod comes with free and paid VR and AR lesson plans. EON Reality supports a variety of devices for users to enjoy the immersive, experiential experience. ClassVR offers a VR platform for lessons with hardware. Google Expedition for immersive virtual journeys allowing students to follow the pace of educators during the immersive experience.

Table 2 Platforms for VR

	Works	Course	Students Feedback	Integration
Nearpod	(Hakami, 2020) deployed Nearpod in Najran University, Saudi Arabia	School Administration	Increased engagement. Promote active learning. Questionnaires showed positive learning experience.	Integrate with students' device and video-conference learning system
EON Reality	(Al-Allaq et al., 2021) incorporated EON to construct VR of 6-axes robotic as a prototype for future engineering learning tool.	Engineering Course	No self-reporting from students' perspective. The work provided detailed writings on implementation	Involves EON studio, SDK, Dynamic Load, and Raptor. Connect to Vicon tracking system and CAD system.
ClassVR	(Kurniawati et al., 2019) deployed ClassVR to Special Needs Students (age from 6-20 years old). The lesson is designed for students to follow instructions on picking objects in the classroom.	Tasks-based learning.	No self-reporting on engagement. Students were observed to look happy and focused during the learning.	Integrate with the use of Google Cardboard and Unity 3D.
Google Expedition	(Brown & Green, 2016) explored the use of Google Expedition for a Greek language course.	A pre-course for Nursing course.	Students reported learning sticks better and increased curiosity in the domain.	VR Cardboard, Android phones with Google Expeditions installed.

Artificial Intelligence enabled learning

Popenici and Kerr (Popenici & Kerr, 2017) explored the phenomena of using AI in teaching in higher education, the challenges and the future directions. It was highlighted that universities should rethink their function and pedagogical models with a focus on imagination, creativity, and innovation. The team from University of Edinburgh (Bayne, 2015) developed the 'Teacherbot' for co-teaching for a large cohort with around 90,000 signed-ups from diverse backgrounds. The 'Teacherbot' was programmed by the teaching team to deploy an agent to roam Twitter accounts. From there bots are trained to understand queries from students. The response of bots was tweeted to students. Students were more open to interacting with the bots with formal and informal exchanges of texts.

Fahimirad et. al. (Fahimirad & Kotamjani, 2018) presented a conceptual review paper that investigated the emergence of using artificial intelligence in teaching and learning in education. It examined the educational consequences of emergent technologies on how institutions teach, and the way students learn. It (Fahimirad & Kotamjani, 2018) highlighted the following areas where AI can be embedded in educational context:

- Grading automation
- AI tutors as supplementary support for students
- Feedback for instructors and learners with AI tracking and monitoring.
- AI as facilitator to coach weak students
- The separation of roles (AI and education) provides a judgment-free environment for students to trial-and-error.

One earlier scholarship that bridges AI and teaching is illustrated in (Balacheff, 1993). It was posited that machines must be able to handle and produce relevant didactical information about the teaching process, in order to be able to interact and collaborate with the teacher. This remains an open problem for both researchers in mathematics education and computer scientists, but it is one of the conditions for tomorrow's cohabitation of artificial intelligence and real teaching. Kumar and Meeden (Kumar & Meeden, 1998) described a project that used AI robots to teach AI courses to strengthen the role AI plays in computer science curriculum. A Robot laboratory was built to teach AI concepts and hands-on behavior-based programming to build the robot from scratch for navigation tasks and sensor readings. Another educational project was described in (Burgsteiner et al., 2016) to teach AI at high school level. The content was adapted and structured with respect to pupils' prior knowledge and educational background. The objective is to foster "AI Literacy" with the course.

Tuomi (Tuomi, 2018) published a report on the impact of AI on Learning, Teaching, and Education. AI was referred to as "the next electricity". The impacts on education settings have been relatively modest, but it will change rapidly in coming years. The report provided coverage on recent developments in learning, teaching and education with AI. It was depicted that AI was deployed for test generation and assessment to reduce teaching loads. Developments of AI for diagnosing students' attention, emotion and conversation are on-going. The major bottleneck is obtaining sufficiently large datasets for higher cognitive tasks like course development and management. Monica et. al (Ciolacu et al., 2018) deployed an AI assisted Higher Education Process with smart sensors and wearable devices for self-regulated learning. An Early Recognition System linked up students' earlier data for the prediction of final examination's scores. Students at-risk were identified at an early stage and provided support to the identified students. The failure rate in examinations was reduced by half.

Conclusion

Technology for education started from using technology as a platform for students to attempt questions. This work reviewed several technologies to support education from the perspective of gamification, immersive learning to Artificial Intelligence. From a gamification perspective, we reviewed a few gamification platforms based on the major pedagogies. There is a lack of ready tools that can gamify the longer term of course content to provide structural engagement. Commonly used gamification platforms were reviewed based on their relevance to different pedagogies, rewards and ease of setup. Immersive learning immerses learners into an "augmented" environment for a different learning experience. It has been commonly practiced in medical and healthcare education. The set up cost and complexity are higher as it involves both hardware and software. A few recent works on immersive learning were reviewed. The last section reviewed AI-enabled learning which outlines the possible integration of AI into grading, tutoring, tracking and monitoring students' performance. The adoption of technology in education does require higher set up costs in terms of resources and time. The benefits of consistent delivery, shorter subsequent set up time and contextualized learning experience for learners deserve the initial investment.

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