What is the future of digital education in the higher education sector? An overview of trends with example applications at Gdańsk Tech, Poland

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ABSTRACT: Universities worldwide recognise the need to adapt to changes in society, the economy and the way young people prefer to learn. Additionally, the impetus to improve the digital approach in higher education intensifies as educational institutions have to remain competitive with commercial providers of education. Following the latest technological trends and implementing strategies to develop new digital solutions helps to improve the teaching process and the quality of academic teaching. The purpose of this article is to identify, analyse and discuss digital education trends and development directions targeted at the higher education sector. The authors provide a comprehensive overview of the current situation and illustrate practical implementations through examples from Gdańsk University of Technology (Gdańsk Tech), Poland. These include e-learning, micro-credentials, extended reality (XR) technologies, gamification, digital textbooks and generative artificial intelligence (AI). Possible new directions of on-line digital education in the higher education sector development, as well as the benefits and associated risks, are also identified and discussed.

Keywords: Digital education, on-line education, higher education sector

INTRODUCTION

The higher education landscape is constantly evolving, driven by multifaceted factors shaping its trajectory. One of these is the changing dynamics of the labour market. As the needs and demands of the workforce evolve, higher education institutions are responding by adapting their curricula and programmes to meet emerging skill sets, industry needs and narrow the skills gap [1]. Globalisation is increasing competitive pressures, forcing institutions to improve their offerings to remain globally relevant and attractive. Therefore, universities are increasingly being forced to accelerate digitisation to better compete with commercial educational offerings, such as on-line courses and services [2].

The demographics of higher education are undergoing changes marked by shifting patterns of student populations and funding mechanisms. In some areas of the world, the number of university candidates is consequently decreasing. In others, overpopulation is occurring, which can overburden the education system, leading to larger classes, a lack of resources and a deterioration in the quality of teaching [3]. This is driving a growing demand for truly personalised learning experiences and alternative teaching methods. Changes in the demographic area also result in an increased level of internationalisation of many institutions.

The structure of the students is also changing. Older adults, working professionals and people from underrepresented backgrounds are enrolling in higher education, challenging traditional notions of the typical student. At the same time, there is a growing emphasis on providing equal access, with initiatives to reduce financial barriers and promote diversity. Institutions are being forced to adopt inclusive education strategies. This includes expanding financial aid programmes, scholarships and grants to support individuals from diverse socioeconomic backgrounds [4]. In addition, innovative education funding models, such as income-sharing agreements and alternative tuition structures, are emerging to address concerns about student debt and affordability.

At the same time, there is a growing commitment to sustainable development that integrates environmental, social and economic issues. Higher education institutions are investing in interdisciplinary research centres and initiatives focused on sustainability topics, such as renewable energy, sustainable agriculture, climate change mitigation and environmental protection. They are also making changes in various areas of their operations, from infrastructural and administrative aspects to procedural ones, in order to achieve the sustainable development goals set by the United Nations. In some situations, universities are moving to digitise content and on-line teaching for environmental reasons [5][6].

On another note, technological progress is strongly driving the transformation of higher education [7]. The digital education market, also known as the edtech market, is experiencing rapid growth. According to the Grand View Research report, analysts expect it to be valued at USD 77.23 billion by 2028 and to grow at a compound annual growth rate (CAGR) of 30.5% from 2021 to 2028 [8]. There are several reasons why digital education is growing so rapidly in the sector.

As generations change, there is a noticeable decline in the average human attention span, members of Generation Z and Alpha tend to have it shorter than older generations. This calls for adapting the form and content of education to this fact. Research also points to the need to address the preferences of younger students, related to technology-enhanced learning, interactive learning environments and integration of digital solutions into their educational experience [9]. Young university graduates who are digital natives perceive their digital competence and self-efficacy to be high, in particular demonstrating a strong sense of efficacy in using digital tools [10] and this should to be taken into account when designing the learning environment.

Digital education also fosters greater engagement with multimedia content, and gamification and on-line collaboration tools facilitate active learning, promoting deeper understanding and memorisation of course materials. The adoption of on-line education was also accelerated by the outbreak of the Covid-19 pandemic. As schools and universities worldwide closed, educational institutions were forced to quickly transition to on-line learning, sparking sudden widespread interest in on-line learning platforms and tools. Due to travel restrictions, people also began seeking alternative forms of education, such as e-learning courses, digital textbooks or webinars.

This article aims is to identify, analyse and discuss digital education trends and development directions targeted at the higher education sector, and also showcases real-world applications with examples drawn from Gdańsk University of Technology (Gdańsk Tech), Poland, providing a holistic understanding of the subject.

E-LEARNING

With the development of the digital education market, the systematic adoption of e-learning in higher education and its integration into various areas of the teaching process is observed. In 2011, a platform called eNauczanie was implemented at Gdańsk Tech, which was built on the open Moodle course management system and tailored to the specific needs of the university. It allows courses to be made available in electronic form via Web browsers and mobile apps and currently provides access to over 18,000 courses for more than 20,000 registered students. The system allows for delivering supplementary or extracurricular materials for students, as well as includes an evaluation tool and a repository of learning content. A survey of 2,375 respondents indicates that 47% of Gdańsk Tech students rate the quality of conducted on-line classes as high and very high, which is also influenced by the appropriate e-learning infrastructure.

The platform is also being used to implement microlearning in the learning process. Due to the challenges of attention span time and the popularisation of social media platforms, young people prefer concise, targeted content on specific topics that can be quickly absorbed to meet their immediate learning requirements [11][12]. Today's students therefore require dynamic and interactive materials, such as videos, animations, presentations, quizzes, podcasts and simulations to demonstrate cognitive engagement. They also have specific preferences for learning resources, which teachers provide accessible in a structured way through the platform.

eNauczanie also allows for implementing a flipped classroom didactic method, which involves reversing the traditional lesson structure [13]. Its main idea is to move the lecture and administrative part out of school time and then use class time for problem solving, discussions and exercises. The goal of this approach is to develop students' practical skills and higher-order thinking skills. Analysis of the survey conducted with 31 Gdańsk Tech students reveals their preferences for the forms of materials and opinions on flipped learning. Preferred resources are descriptive files with screenshots (45%) and instructional videos (42%). E-learning lessons, although disliked by 27% of the respondents, were used by 30% of the students. Moreover, the frequency of use of various forms of materials increases during and after classes. In the context of flipped learning, students expressed their opinions on the advantages and disadvantages of this method. Forty-five percent of the respondents did not indicate any disadvantages. However, the limited time was indicated as one of the barriers to using support materials by 30% of the students.

Higher education institutions, including Gdańsk Tech, are actively developing their e-learning skills and offer. Such activity gives a chance to satisfy market needs, diversify revenues and opens the way to compete with commercial entities. For this reason, the University is establishing its own E-learning Centre and building an educational product portfolio in line with the idea of flexible professional development and lifelong learning.

MICRO-CREDENTIALS

Universities around the world are re-profiling their educational offerings to match the needs of the market and society. One direction is the introduction of smaller forms of education, such as short courses and training, which are increasingly in demand. To standardise the quality and learning outcomes of such forms of education, the idea of micro-qualifications was born. In 2022, the Council of the European Union adopted a recommendation on a European approach to micro-credentials for lifelong learning and employability. The aim is to implement the idea in institutions

and companies in different countries. Due to their easily accessible nature, they also have the potential to counter social inequality. They are, for example, part of the Action Plan for the European Pillar of Social Rights and the Communication on the Creation of a European Education Area by 2025. Over the past few years, government agencies, academic think tanks and international organisations, such as UNESCO and the OECD, have put forward several policy positions on micro-qualifications.

Gdańsk Tech is implementing a micro-credential system based on standards developed by ENHANCE, an alliance founded by seven major research-intensive, science and technology-focused universities, laying the foundation for an innovative European technology university. To ensure consistent and standardised performance, a comprehensive system (named PGEDU+) responsible for the process of granting, managing and validating micro-qualifications is under development. Micro-credentials allow students to tailor their learning experience to their specific interests and career goals. They are often designed to develop specific skills that are in demand in the job market and compared to traditional degree programmes, they are more affordable and accessible. Universities need to go in the direction of recognising and adopting micro-credentials to avoid the threat of being pushed out of by competition from the private training sector.

XR TECHNOLOGY

To provide an interactive and engaging learning environment that can help students better understand difficult concepts through hands-on experience, as well as better prepare them for the job market, universities are choosing to incorporate extended reality (XR) technologies into the teaching process. According to the recruiters, the future employees lack practical experience [10], the cause of which largely lies in inadequate vocational education. For that reason, Gdańsk Tech decided to launch the Immersive 3D Visualisation Lab (I3DVL) (Figure 1). It provides three levels of immersion in virtual reality, each with different levels of complexity. They provide a kind of production line for applications that are prepared for these levels. The first tests of the application take place in MiniCAVE, the smallest and simplest of the levels, using four 27-inch 3D monitors. The app is then verified in MidiCAVE, a larger and more complex space measuring 2.12 m × 2.12 m × 1.34 m, consisting of four projection screens that form three walls and a floor. The final version of the application is undergoing testing in BigCAVE, the largest and most complex of the levels, which consists of a complete cube with a 3.4-meter edge (with four walls, a ceiling and a floor). It is also used for experiments with finished applications [14].

Figure 1: Gdańsk Tech, Immersive 3D Visualisation Lab (I3DVL) (photograph by Krzysztof Krzempek).

I3DVL offers a versatile array of educational scenarios catering to diverse professionals' interests and needs. One such scenario is virtual prototyping, where participants can independently evaluate the merits and drawbacks of their own or others' projects, such as architecture students examining a virtual rendition of their designs. Virtual training allows simulation-based practice tailored to specific professions, e.g. enabling firefighters to extinguish virtual fires, ship inspectors to scrutinise vessels or assemblers to construct devices. Virtual experiments facilitate hands-on exploration across various fields, such as chemistry, physics and astronomy, enabling activities, such as plotting spatial curves to observe their trajectories. Moreover, virtual escape rooms challenge groups to solve puzzles from disciplines, such as chemistry, computer science, mathematics, and potentially management and economics. Furthermore, the laboratory offers opportunities for VR application development, equipping computer scientists with programming skills and other disciplines with the necessary specifications. The high demand for the laboratory is evident from the over 100 applications developed for utilising the cave systems.

GAMIFICATION

One of the challenges of the higher education system is finding ways to arouse and maintain educational motivation in students. This is especially difficult in the context of a society that generally has difficulty focusing and maintaining attention. Research shows that one way to foster engagement is through the use of gamification [15]. That is why Gdańsk Tech teachers conduct courses in which they apply a professional system of motivation enhancement with

mechanisms used in games. Solutions are developed in co-operation with specialists from the Centre for Modern Education, a unit that supports the development of modern academic didactics at the University. Created gamification is based not only on points, badges, stages, progress, ranks, time windows, exchange of goods, trade, collecting, co-operation and surprises, but also on a specially selected and carefully introduced storyline. For example, students of Finance collect points in the form of banknotes and ration cards to purchase furniture for a small studio flat. In the game titled *Colossus of the Algebron*, students participating in the Linear Algebra subject are trapped in a dungeon, from which they can escape by traversing corridors filled with mathematical challenges. In the gamification named *BEEophysics - Bee happy!* students have completed tasks to earn elements of bee houses to have a chance to build a real one and place it on campus at the end of the semester. Dedicated apps, as well as creative and on-line group work tools allow to carry out gamification in an effective way and minimise the workload of counting points and tracking student progress.

A comparison of students' results in Linear Algebra shows that the pass rate in the course where gamification was used increased by 9.86%. Nearly 70% of the respondents (67 students) answered that the tool used (gamification) raised their motivation to learn. Seventy-seven percent of the respondents felt that they learned more/made more out of the classes thanks to gamification. Eighty-seven percent expressed a desire to gamify the other two mathematics subjects, implemented in the first semester. Eighty-three percent of respondents noted that they worked more systematically during Linear Algebra classes relative to the other subjects (not gamified). In the Physics class, the average percentage of students who passed the exercises on time increased in the class with gamification by as much as 39%. Although gamification is not suitable for all situations, it is an interesting and sometimes very effective tool to support student motivation, especially in subjects that require many demanding, monotonous and tedious exercises.

DIGITAL TEXTBOOKS

As technology becomes more integrated into education, the adoption of digital textbooks is likely to increase. This trend is driven by cost-effectiveness, accessibility, and the growing familiarity with digital tools among students and educators. Universities in Poland are slowly implementing digital textbooks in various approaches, some of them, for instance, the AGH University of Science and Technology in Kraków, Poland, are developing open license able to be displayed on various devices solutions. The textbooks they have developed can be viewed on their Web site, in a mobile app or downloaded to a disk for off-line use. Their advantage is easy access and full responsiveness.

Gdańsk Tech focuses more on multimedia that adds extra educational value to traditional textbooks. For example, the University in collaboration with partners: Politecnica delle Marche in Ancona, Italy, Joanneum Gesellschaft MBH in Graz, Austria, and with the support of the Academic E-Learning Association SEA, developed a multimedia-rich digital textbook named *The Big Book of Online Education*. The authors of the publication are international experts in didactics, modern education and e-learning. The digital book consists of practical advice, inspiration, tools, usage scenarios, as well as examples of innovative teaching methods applied in academic practice. It stands as the most comprehensive on-line education guide at the higher education level, and contains an extensive database of videos, animations, presentation simulations, links to external sources and other multimedia content.

Gdańsk Tech has also developed prototypes of other alternative educational materials that could replace or supplement traditional books and scripts, and is still exploring new approaches. The future of academic textbooks is unknown, it is clear, however, that universities require the development of new generation interactive content that can better present concepts, but also satisfy the educational needs of young people.

GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

The rapid development of technology is leading to the adoption of advanced solutions by society. Higher education is forced to follow these changes, so it is inevitable to introduce AI solutions into everyday educational practice. At Gdańsk Tech, active efforts are being made to popularise and implement them. The situations of its use are noted in various areas, such as natural language processing, image recognition, document processing, generating new variants of solutions, improving the evaluation process, and providing methodological support and adaptation to the needs of people with disabilities.

A study conducted in the Faculty of Architecture revealed that students who utilised AI tools generated notably more innovative designs than those employing traditional methods alone. The study identified three distinct approaches to incorporating AI tools: semi-traditional, hybrid, and hybrid-interactive. Each approach varies in the degree to which AI-generated images influence students' design processes. The findings underscore the considerable potential of artificial intelligence to redefine architectural design methodologies, offering promising avenues for exploration and creativity within the field [16].

Another example is the use of artificial intelligence in a research group project on management concepts at the Faculty of Management and Economics. In academic activities focused on solving managerial problems in both real and hypothetical organisational contexts, the integration of AI tools has played a significant role. During each session, randomly assigned groups use artificial intelligence tools, while others rely solely on human ingenuity. Reflecting on the solutions generated by artificial intelligence, participants collectively share insights to improve future use of the tools. It has been observed that

while AI solutions demonstrate technical proficiency, they often lack the human spark that can be seen in the originality of ideas. It was observed that students prefer ideas rooted in personal experiences and empathetic insights.

In order to promote the use of AI tools in the service of science and education, the Faculty of Electrical Engineering and Telecommunications and Computer Science organised a competition within the subject of Research Projects, which is compulsory for all students in the Master's programme. There were 80 projects, and the best seven were awarded and honoured. Among the works submitted were: Detection of mental disorders based on speech; Study of machine learning algorithms in application to speech recognition of medical personnel; Cleaning the world with the support of a mobile artificial intelligence platform; and Analysis of the relationship between the sound of the voice and the colour assigned to the voice sample of the speaker/singer. There are more and more examples of the application of artificial intelligence in the teaching process at Gdańsk Tech and this trend is expected to continue in the future.

DISCUSSION

Faced with a rapidly changing landscape, higher education around the world must adapt to new needs and challenges. It is worth noting that this transformation is not homogeneous - different institutions are taking different approaches in response to these changes. Many universities are trying to adapt to the digital revolution by incorporating modern technology into the teaching and learning process. However, as noted, progress in this area is often slow. Limited funding and the long adaptation of research and teaching staff are the main obstacles encountered in the process of implementing change. Not all trends are equally effective.

While some innovations are enthusiastically embraced, they can often be only superficial changes that do not lead to deeper, systemic transformations. In addition, over-reliance on technological solutions can bring negative consequences, such as digital exclusion or deterioration of teaching quality. Faced with this challenge, universities are looking for different ways to develop education and didactics. There is a need to strike a balance between using new technologies and preserving existing educational values. There is also a need to provide adequate financial support and training for academic staff to enable them to implement changes effectively.

In the future of digital education in higher education institutions are expected to embrace hybrid learning models, blending traditional face-to-face teaching with on-line components to offer students greater flexibility and accessibility. This shift will be accompanied by a focus on personalised learning experiences, leveraging technology to tailor educational content and activities to individual student needs. To remain competitive in this evolving landscape, institutions will prioritise international and interdisciplinary collaboration.

Revenue diversification will also become a priority, driving institutions to explore new sources of funding and innovative business models, including the development of a commercial offer of training and e-learning courses connected with the development of a standardised micro-qualification system. As artificial intelligence continues to advance, educators will grapple with harnessing its potential to enhance teaching and learning, while addressing ethical and social implications. Amidst these changes, building a seamless and engaging digital experience will be paramount, requiring careful integration of various educational technologies and platforms to support student success and engagement.

CONCLUSIONS

Universities around the world are adapting to changing socio-economic realities and student preferences, integrating the latest trends, including boldly entering the digital education market. Technological advances, the globalisation process and the growing demand for personalised educational experiences are driving this phenomenon. As the labour market evolves, there is a growing demand for short-term, specialised skill certifications. Digital learning platforms can facilitate access to micro-credentials, allowing learners to quickly acquire and validate competencies in specific areas. However, digital transformation faces challenges, such as financial constraints, the need for staff training and the need to balance technological advances with educational values.

Gdańsk Tech explores these trends, investigating a variety of initiatives, such as e-learning, micro-credentials, XR technologies, gamification, digital textbooks and generative artificial intelligence, supported by practical examples. These address the challenges of engaging students, meeting diverse needs and enhancing the quality of teaching. Digital education has the potential to create new level of engaging learning experiences. All evidence suggests that the future of higher education envisions mixed learning models (face-to-face and on-line), personalised learning experiences, international collaboration and the ethical integration of artificial intelligence. Potential new directions require further and in-depth research.

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BIOGRAPHIES

Alina Guzik (PhD candidate) is a digital and innovative education expert, senior product manager, certified e-learning designer, teacher, chief specialist for innovation and creator of more than a dozen award-winning digital educational products implemented in international markets. She is the author of innovations with a grant from the National Centre for Research and Development (NCBiR), Poland, and co-author of a dozen international projects. She is a co-author of many publications, including The Book of Trends in Education and The Big Book of On-line Education, the largest on-line education guide for academic teachers. She is the designer of e-learning courses, mobile apps, educational platforms, interactive textbooks and books for children and young adults. She conducts scientific research in the area of digital education, e-learning, modern didactics methods, innovations and new product development.

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Małgorzata Gawrycka (PhD, university professor). From 2012 to 2020, she was Vice Dean for teaching in the Faculty of Management and Economics at Gdańsk University of Technology, Poland. Currently, she is Dean of the Faculty. Her scientific interests are focused on issues related to the macroeconomic policy of the state. In particular, she is interested in the problems of the situation on the labour market, demographic changes, qualifications and professional competence of employees and graduates, substitution of labour by capital and the implementation of selected goals of sustainable development related to the national economy. She is the author (or co-author) of numerous scientific papers, and the manager and participant in national and international projects, including *MayDay*, Education for Entrepreneurship, Use of Flexible Forms of Employment by Entrepreneurs in the Pomeranian and Greater Poland Voivodships.