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This volume contains the edited proceedings of papers from the twenty seventh International Conference on Software Process Improvement Research, Education and Training, INSPIRE 2022 held remotely, organised by Ulster University, The Institute of Physics, and the e-Learning Specialist Group of the BCS, The Chartered Institute for IT.

The objective of this conference is to promote international co-operation among those concerned with e-learning by creating a greater understanding of e-learning issues, and by sharing current research and case studies through academic and industrial experience.

The conference organisers feel that this objective has been achieved. INSPIRE 2022 has attracted papers from international sources, covering a broad spectrum of practical experience and research. The topic areas include the use of e-Learning for schools, HE and the wider public, AI, social media, programming, security, Sustainability and case studies in use of learning and e-learning in 2022 in various countries, including Bosnia-Herzegovina, Cyprus, Denmark, Finland, France, Germany, Greece, Ghana, Ireland, Italy, Kenya, Luxembourg, Nigeria, Northern Ireland, South Africa, Spain, Turkey, UK, and the USA.

We would like to thank the many people who have brought this twenty seventh international conference into being: the Organising Committee, the International Advisory Committee, particularly for all their hard work in reviewing both the abstracts and the final papers, and the committee members of the BCS's e-Learning Specialist Group.

The organisers would like to thank the Ulster University, The Institute of Physics, and the BCS, The Chartered Institute for IT. for their support.

The Editors

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How the recent past is influencing the future of Higher Education

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Abstract

This paper provides a perspective on the future of Higher Education in the summer of 2022. It is focused on Higher Education in the UK although much of the discussion is applicable more widely. It discusses the difficulties brought about by the recent past, the current context, and identifies the challenges and opportunities for Higher Education institutions going forward.

Keywords: teaching, learning, pandemic, Higher Education.

1.0 Context

Much of the world, including the UK has seen some of the most challenging times in its history for example the Covid-19 pandemic, the war in Ukraine and the climate emergency. For the UK, Brexit has also negatively impacted many sectors including the economy. The implications of these events have been are very challenging for all industries and Higher Education is no exception. At the time of writing further challenges loom, for example the rapidly rising cost of living which is not only impacting staff and students but also increasing costs for UK universities, salaries are not keeping up with inflation, the cost of pensions is rising to untenable levels which have led to strikes in some UK universities, worldwide chip shortages are impacting many industries, and the great resignation [1] is making it harder to recruit and retain staff etc. Whilst all this is happening the 4th Industrial Revolution [2] steadily marches on, as it continues to integrate a range of technologies such as artificial intelligence, the internet of things, augmented and virtual reality, drones, robots, 3D printing etc. blurring boundaries between the biological, physical, and digital worlds.

2.0 Impact on the future of Higher Education

The impact of the changing world is extensive so this short paper will focus on four key areas for Higher Education: mental health, student study, staff and the external environment.

Mental Health: the pandemic has had a substantial impact on many people's mental health. In Higher Education, it has affected both staff and students, and in 2021 36% of university students in Scotland [3] reported moderately severe or severe symptoms of depression. This has put huge pressure on university counselling services who have seen unprecedented demand on their services which are "already plugging the gaps resulting from the lack of NHS resources and funding" [4]. With the rising cost of living – set to get worse in the UK – one in ten students are already having to use food banks and cannot afford basic necessities [5] however in order to succeed in Higher Education, students must have their basic physical and psychosocial needs met before they can focus on learning [6]. The cost of living crisis will inevitably hit the poorest students hardest, and that will almost certainly impact the retention of students as they will likely need to work longer hours to survive, and hence have fewer hours to study. Evidence shows that students from the most disadvantaged backgrounds, often correlated with poverty, are found in higher proportions in modern universities (typically with the fewest financial resources to support these students), than in research intensive universities [7].

Student study: a huge question on everyone's mind as we emerge from the pandemic, is how students will learn and study in future. Student experiences during the pandemic have been vastly different. Learning online has been extremely challenging for many students however it has been transformational for others, for example many students with disabilities or those with caring responsibilities have thrived [8]. All universities are having to decide what their teaching and learning model looks like going forward, which is extremely challenging as one approach does not suit all students. At Abertay University we are trying to find a middle ground whilst investing in technology for the future, with the aim of offering a more personalised approach. We are not reverting to the pre-pandemic model unchanged because like many universities, we have substantial numbers of students who need to work to live, have caring responsibilities etc. and may struggled to attend some classes for good reason. In addition, whilst attendance on campus is core to our teaching and learning model, and the mode of study students expect, taking into account the way students will need to learn over the course of their life, which is predicted to include considerable upskilling and reskilling [9], the ability to learn how to learn online has now become a critical graduate skill. So all programmes incorporate both elements of in-person teaching (largely focused on interactive and social learning) and learning online. The balance between the two is decided at the programme / module level given the diverse nature of the subjects taught at Abertay. Teams are also experimenting with hybrid approaches (teaching on campus and online at the same time), alongside the use of other technologies e.g. telepresence walls, immersive learning experiences, use of artificial intelligence to personalise the student learning experience etc. A secondary consideration / impact of the mode

of delivery going forward will be whether students will come to campus more during the winter if they can't afford to heat their homes during the cost of living crisis, however that has to be offset against the cost of travel and its associated carbon footprint. There are no easy answers.

Staff: The impact on staff has been just as profound as students. All staff are more confident teaching online than they were pre-pandemic, however due to the speed of transition to online, in many cases the pedagogy used was, understandably, not designed specifically for online learning. Nevertheless, staff confidence in the online world has undoubtedly been enhanced and possibly accelerated 10+ years over what might otherwise have happened. Also, in common with students, staff have strong views about attendance on campus. Some staff could not wait to return, and others simply enjoyed working from home, perhaps finding a better work / life balance. However some, unexpectedly, found that they had lost their social confidence in engaging with people face-to-face.

Outside of the core teaching that will take place on campus, most universities are now developing hybrid working policies which can be challenging given that is has been proven that many jobs can be done entirely remotely, yet most feel something is lost from the lack of in-person engagement. There are many factors to consider: team dynamics, staff community, sense of belonging, retention of staff, the carbon footprint of staff travelling to work vs working at home, people's work / life balance, and, given the great resignation, the potential to recruit staff from a worldwide pool as opposed to those within commuter distance or those willing to move, or live away from home during the week.

One challenge that has emerged is that of open plan offices for staff which don't offer the private space for online meetings that continue or, for recording teaching materials for students, both now much more prevalent than pre-pandemic.

External environment: the world economy is currently very challenging for most countries, including the UK, with many having incurred huge debts as a result of the pandemic, squeezing government finances to the limit. This has hit many sectors of the economy including higher education. In the UK, education is devolved to the four nations, but real-term cuts have occurred for years, and these are not set to change as we emerge from the Pandemic. For example, in England, the fees of £9,000 per year, introduced in 2012, now £9250 are worth about 15% less than a decade ago. In Scotland government higher education funding has declined by 14.6% in real terms between 2014/5 and 2022/3, and the gap will increase rapidly in the era of high inflation [10].

As universities try to bridge the gap in funding, the competition for international students both nationally and internationally, through direct recruitment, transnational education, and online delivery etc. has intensified. However, many students who might have been able to afford international study pre-pandemic, may no longer have that option due to their changed financial position.

As universities try to find their “new normal” as we emerge from the pandemic, the fourth industrial revolution continues unabated. In order for universities to thrive and for our graduates to compete in the workplace, we need to ensure we have leading edge technology helping us run our universities, as well as educate our students, and help us to conduct high-quality research. The pressure is therefore on to increase investment in our digital estate alongside continued investment in our physical estate. University digital systems need to support the staff experience with information they need at their fingertips, and the student journey from application to alumni, seamlessly. Our systems need to be intelligent, personalised, and smart, not only integrated internally, but externally, for example with local smart city systems.

3.0 Conclusions and the Future

These are probably the most challenging times in our history to run a university. There are huge pressures, massive competition, new ways of working for staff, new ways of learning for students, new markets and changed markets. We have to meet the expectations of our students, staff, local community, government etc. We have to increase our research, knowledge exchange, and innovation activities, enhance the teaching and learning experience, providing more personalisation, all in the context of ongoing real-term funding cuts. Whilst universities are often talked about as being slow to change, they are fantastic innovators and can be agile when needed, as demonstrated during the pandemic when they switched to online learning and teaching overnight. The sector will inevitably find a way to thrive in this new world however it may not be without casualties.

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Voices from the Pandemic

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Untold stories from the pandemic, how technology affected lockdown life and what we need to take forward into the future

The pandemic fast forwarded our everyday use of technology, and there's no going back, although there are many points that we need to reflect on and consider.

I once heard an engineer described as the magician that turns designers dreams into reality. As knowledge engineers, we have a responsibility to weave that magic into the future for millions of people and need to be much more aware of the impact and affect of our work.

1.0 What was the Lived Experience of Users?

World-wide lockdowns mean that millions of people began using technology in new ways, or ways they hadn't encountered before, and are continuing to do so, but what has been the impact on them, personally?

1.1 The School Child

Eve was 11 when we went into lockdown. As confident with technology she was, surprisingly, one of the most frustrated. She didn't enjoy zooming or FaceTiming her friends, she needed eye contact and easy to read reactions.

Her school offered a wide variety of Zoom lessons but she didn't enjoy them, she never really felt engaged and the text chat made her feel uncomfortably exposed. She also felt a lot of students, though logged on, were not in front of their screens.

Sessions offered without ensuing she understood the relevance to her were difficult to engage with meaningfully.

Eve also found, when returning to school, friendships were hard to reform, covid precautions meant continued uncertainty and disruption and some extra curricular activities never restarted.

She has grown to feel indifferent to a life lead around technology, yearning for physical contact and responses - she wished her computer could have had witty,

interesting conversations with her…..she'll appreciate the developments being mad in AI!

1.2 The "Sandwich" Generation Grandmother, Mother, Daughter and Entrepreneur

Julie, 57 when the UK lockdown was imposed, saw her carefully curated business, Charlie Locks, all but disappear overnight. An Aesthetician, she has created her own brand of skin care products, developed and made in the UK and her dream is to make high end products available to beauticians to improve the standard of care offered to many and often lacking. The products are also sold to the general public, via her website.

Lockdown meant her beautician clients had to close their doors and she knew as self-employed business owners, some without the business longevity to access financial help, many were in peril of losing everything.

She and her husband became expert at trawling government websites for advice and help and passing it on, something that became more difficult in the second lock down when responsibility was passed to local councils.

They used Zoom groups to support their clients and to suggest new business models to help them survive.

Zoom also played an important role in supporting her family, in America and the UK. She could stand outside her mothers balcony and chat and they both had their tablets to allow them to see various family funerals that took place over two years or so.

The biggest frustration she found was the complexity of government and council websites and also suffered financially when someone working from home failed to open an important document which would have enabled them to receive help.

1.3 The broadcast DJ and Event planner

Simon, working for Smooth FM, was amazed to discover he could broadcast easily, and in high quality, from home. A relief as, like so many in our gig economy, he would have had no income at all if he couldn't continue working. His event business ground to a halt but now things are up and running again he finds the ability to do planning work from anywhere (not considered necessary before lockdown) is transformative. His biggest frustration - trying to get help when the problem you face isn't covered by online help and chat bots. Hours are wasted going around in circles and can be a problem even if you are actually able to speak to or correspond with a human!

1.4 The 90 year old retiree

Julie was the happiest person I met in terms of transformative quality of technology during lockdown. A healthy, active, computer literate and inquisitive person, she loved all the on-line offerings that became available. She attended meetings, watched cultural events and rarely wanted to chat because she was "doing" something special! For her, the only drawback seemed to be the lack of a smart

television that would allow her to sit and explore the world, comfortably from her armchair, rather than a desk.

2.0 Who is being left behind?

Before we totally embrace the online world, it is important to realise that many do not have access to, or the skills needed, to cope.

2.1 Those without physical access

The Office for National Statistics estimate that, in the UK, three million people do not have access to the internet. Two million are elderly. Of the remaining million, some cannot afford access and some, neo-luddites or members of some religious communities, chose not to.

Offering public access in easily reached places at convenient times, is imperative. Imagine your only access to a printer, for homework purposes, is the library, several miles away and with limited access time, or your e-learning class are only available on a mobile phone.

2.2 Those without the necessary literary skills

Volunteering at some Covid vaccination sites I was reminded that registering and completing forms requires a fairly high level of literacy. Whilst it was mainly non-English speakers that needed help, several English people were mortified to have to confess they couldn't complete the form I had given them.
In England, literacy is often referred to it term of levels. It is estimated that the 1 in 7 adults have a level at or below entry level 3, the standard expected of 9-11 year olds.
To check the reading level of work you have created you can visit www.readable.com . Microsoft Word offers a tool that analyses your document for you. It's available in the Proofing Tools.

3.0 Are systems robust and sustainable?

In the Spring of 2022, Greater Manchester Hospitals suffered an IT outage lasting several days. There was NO access to any on-line information (bookings, ailments, planned admissions, medications, staffing rotes, etc were unavailable).

Wifi is not universally available and when it is, is not necessity of an adequate strength.

There are concerns about the environmental impacts of hardware and of cloud computing.

4.0 What are the implications of the pandemic experience for future development of e-learning materials, websites and business systems?

As we develop materials it is imperative, we consider:

The diversity of users in terms of literacy and how comfortable they are (or not) with online materials

The diverse ways people access on-line materials

The diverse ways people learn

The need to ensure topics being learnt appear relevant and useful to the student

That people can be desperately frustrated by and resentful of on-line help that doesn't take non standard problems into consideration

Respect and empathy will play key roles in creating successful interactions.

I would never suggest a business should change its businesses practices because technology is forcing it to BUT as many new businesses know that logical systems are essential (anyone creating an "if…then….else" statement around a complex list of criteria of the type used in many Government Departments) it does present an opportunity to consider those systems more carefully, so the computer doesn't always say "no!"

Estonia is one of the countries forging ahead with on-line governmental offerings, but it has needed to reconsider many of its systems as a result.

I sincerely hope that weaving these considerations into the work you do now and in the future will help ensure frustration free and successful outcomes for your users.

Social Media in Education: What do we know so far and what is the future?

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Abstract

Social media are developing into the most important collaborative bottom-up interaction and multi-way communication tools among individuals for discussion, knowledge sharing, comments and ratings, content and information creation and exchange. Social media tools are rapidly changing the landscape of collaboration, communication, knowledge creation, knowledge retention and knowledge sharing. Their emergence has impacted significantly how students learn and the way teachers teach. Students are fascinated by using social media in educational settings as they use them in their everyday lives. The foundation of social media is communication, collaboration and sharing in a bottom-up manner. In order to investigate different aspects of social media adoption and use in Higher Educational learning environments, a longitudinal study starting in 2010 was conducted. This paper presents our findings based on a number of studies using quantitative and qualitative data collection throughout the last decade. The results show that i) when appropriate infrastructure is in place ii) suitable strategies are applied iii) security and privacy are prioritised and iv) teachers are accustomed to using modern technologies, social media can be used as an effective educational tool that improves the overall educational process, academic performance and learning outcomes. The aim of our ongoing longitudinal study has been to enhance teachers' comprehension of social media and its use as an educational tool to create interactive learning environments for students of various disciplines in geographically and culturally distributed environments. The paper concludes with a discussion about the future of social media in educational settings.

Keywords: Social media in education, social networking, using social media in teaching, using social media for learning, bottom-up interaction.

1.0 Introduction

Social media are swiftly and steadily changing the basis and conditions of collaboration. They are developing into the most important bottom-up interaction and multi-way communication tool for collaboration, discussion, knowledge sharing, comments and ratings, content and information creation and exchange (1). As they facilitate users to publicly share their ideas, viewpoints, experiences and knowledge, social media have turned into a tool through which people communicate, interact and evolve in personal, professional and educational communities and environments (2). In today's connected world social media have impacted significantly on the way students learn and teachers teach. Devi et al. (3) define social media as a network that represents the relationships among people.

The term social media refers to web-based tools/applications that facilitate:

i. *social networking:* the use of social media sites to stay connected with friends, family, colleagues, customers, or clients;
ii. *communication:* electronic web-based multi-way communication and interactions in own time - own space - own pace;
iii. *collaboration:* multiple people/groups interact with each other to achieve common goals;
iv. *content creation & sharing:* cooperative bottom-up content formation and disclosure;
v. *evaluation:* posting of comments and ratings.

Many studies regarding the adoption of social media in education propose social media to be used in addition to formal education, and is supported by the following reasons (4, 5):

i. the wide take up of social media by young individuals (digital natives born after 1980), who actively use social media in their free time;
ii. the social and cultural identity of digital natives is created through social media;
iii. participative and collaborative way of creating knowledge;
iv. new pedagogical opportunities;
v. preparation of learners for the 21st century;
vi. affordable at no or low cost, immediately available and easy to use.

The pedagogical potential of using social media in education and learning have been investigated by various scholars (6, 7, 8, 9, 10). They emphasized the potential of the technology to support collaborative knowledge construction, to access specialized just-in-time information, to contribute to the hybridisation of expertise, to support relational and social/civic development and peer/alumni, especially in times of transition and academic help-seeking. Social media also pose challenges to learning as they blur the boundaries of learning, social and leisure spaces (7, 9). It must be stated that when using social media in education and learning, a skilled moderator should facilitate effective learning to occur during the collaborative knowledge creation process (11).

Social media are built upon the foundations of bottom-up communities, knowledge sharing, accessibility and user generated content (1). They are contemporary means through which people communicate, interact, share knowledge and experiences online (2). They allow users to publicly share their opinions and viewpoints in real time and can be used as platforms for self-directed learning and professional activities (12). Social media give rise to amplified volumes of online data, creating thus Big Data (13), which when analysed, can generate important knowledge (14).

There is no doubt that, ever since social networks and social media came into our lives, everything is different. The way we communicate, collaborate, interact, socialize, share and create content are different since a few decades ago. Social media provides free access to online communication and information, free voice and video calls, sharing of documents and links. Papademetriou et al. (15) claim that social media are increasingly used in universities for enhancing teaching and learning, motivating and supporting students, as well as developing community connections.

Social networking is a result of diverse contemporary technological developments that entered our daily lives. It has become an indispensable means because of its cutting-edge technical approaches and egalitarian social potential, by transforming the world into a small cosmic interconnected space. Although the main purpose of establishing these sites is for social communication between individuals, the use of social media has increasingly spread to all areas of daily life and to all cultural, social, political, and economic activities. Social media, motivate the audience to become increasingly involved in most areas of knowledge. Social network tools afford students and institutions with multiple opportunities to improve learning methods. Social media are empowering students, teachers and parents to use new ways of sharing information and building communities.

Bexheti et al. (16), reported four reasons for using social media in the classroom:

i. *Content:* Social Media support teaching and learning since they require Higher Educational Institutions to improve availability of their course content;
ii. *Creation:* Social media provide students with a means to create digital content and publish it online. They increase the amount of user-created content from which learners and teachers can jointly benefit. They encourage more active and proactive approaches to learning;
iii. *Communication:* Social media constitute a network that connects students between them and with teachers, allowing them to communicate with each other and to share their knowledge. Simultaneously they have access to specific and targeted knowledge in a given field of interest.
iv. *Collaboration:* Social media make collaboration feasible between learners and teachers on a given task/project/joint objective, by pooling resources and gathering the expertise of a group of people working towards a common objective.

Despite the fact that students mainly use the social networks for entertaining and connecting to friends, they also use them to promote positive and useful activities, such as finding a course or taking part in international projects. Social media can be useful for achieving improved attendance of students, motivating and engaging them in their learning. Apart from the creation of virtual libraries of previous tasks and secondary data and material related to task, the two-way communication in social media foster collaborative learning and research initiatives. Student have easy access to material, teachers and professionals in a subject. However, this results in non-stop working days for the teachers, which is a challenge that needs to be addressed.

Greenhow and Robelia (17) state that integrating social media in teaching and learning environments may give way for new forms of inquiry, communication, collaboration and work identity that is likely to have mainly positive cognitive, social, and emotional impacts. The question is if social media when used in education can improve academic performance and learning. Using social media in education is found to be effective in improving academic performance and students' learning (15, 18, 19).

In this paper we focus on how social media are changing the way the education system works. Section 2.0 presents related work regarding social media and education. Section 3.0 presents results from our longitudinal study in social media in education since 2010. In section 4.0 we discuss the general findings and the future of social media in education. Section 5.0 completes the paper with conclusion and further work.

2.0 Related work

Students of today, the so-called "Digital Natives" born after 1980, are the first generation that has grown up with social media, and are active users of them in their free time.

They are also called the Net Generation students, as they are digitally literate and they are multitasking. Since the social and cultural identity of Digital Natives is constructed through digital media, it is important that teachers carefully leverage the possibilities of these technologies for collaborative knowledge building in parallel with the benefits of traditional classroom instruction.

With the emergence of Web 2.0, that is characterised by increasing growth of social media, user-generated content, ease of use, interoperability and bottom-up participation the definition of "*knowledge*" nowadays can be understood as a collective agreement about a description that may combine facts with other dimensions of human experience, such as opinions, values, and spiritual beliefs (10).

2.1 Use of Facebook in a social media learning environment

Manca and Ranieri (7) carried out a critical overview of current studies focusing on Facebook used in education. The aim was to investigate the extent to which its pedagogical potential is translated into practice. In total 23 empirical studies were identified and subsequently analysed according to a simplified list of guidelines. The results showed that pedagogical affordances of Facebook have only been partially implemented due to obstacles, such as implicit institutional, teacher and student pedagogies, and cultural issues. However, scholars emphasized its pedagogical affordances, such as widening the context of learning, mixing information, learning resources, and hybridization of expertise.

Halverson (9) investigated privacy in using social media in formal education. He proposes private spaces, such as Facebook groups, to overcome eventual concerns of teachers and learners. For successfully introducing social media into formal education their use must be tied to achievement of learning goals. Building on features, such as customizing profiles to see who has expertise in what, may bring additional advantage to learning. Learners have the control of their virtual identity and how they display themselves. In formal education private characteristics, like favourite music, movies, photos etc. may be irrelevant. However, such characteristics may useful for relationship building between learners.

Churcher et al. (20) assert that collaborative social media require a re-thinking of the theoretical framework through which we engage students in a Community of Practice (CoP). The pedagogical advantages and disadvantages of incorporating social media in course curricula through the development of social constructivist-based best practices in Web 2.0 course environments were analysed in the two case studies, a Facebook CoP (a mix of traditional and online components) and a wiki-based exam platform. As a result, they propose a rethinking of Vygotsky's (21) conceptualization of social constructivism within learning communities, which considers that knowledge is constructed through dialogue and interaction with others, and where language is used as a tool to construct meaning. The benefit of using social media, where students spend much of their time, (e.g. Facebook or wikis), is that students easily can connect with these technologies creating virtual CoP for discussion (22, 23, 24).

The goals of the Facebook CoP were to:

i) advance the ownership not only of course content, but also course design and structure;
ii) create a shared learning experience where students were encouraged to learn from one another and about one another;
iii) students together with the teachers, who act as facilitators, collectively create rules to be used on the Facebook page.

The results showed that

i) The students were worried about the evaluation process, as they were unsure about how to obtain an individual grade from collaborative work in a social media environment.
ii) The teachers felt uncertainty in terms of instructing students and providing clear and reassuring guidelines for online activities. Facebook instruction and assignments were found to be most helpful when a specific task or question was posed.
iii) Some students were reluctant for their social and academic lives to cross paths.
iv) Others questioned how the site could benefit their education.

Greenhow and Askari (6) examined how social network sites are perceived and used by teachers and learners in publicly supported school grades prior to college. They investigated impacts of social networks on pedagogy and on students' learning in particular regarding

i) learners' informal learning outside of school;
ii) learners' formal learning in schools and classrooms;
iii) connections between in- and out-of-school learning;
iv) teachers' perceptions and practices regarding distance learning;
v) classroom teachers' perceptions and practices.

The studies were summarised and categorised according to how they

i) establish the effectiveness of technology at improving learning;
ii) investigate implementation strategies;
iii) monitor social impact;
iv) report on common uses to shape the direction of the field.

The findings of Greenhow and Askari (6) reveal that social media use, such as Facebook, for education purposes, mainly is an additional practice in the leisure time of the students. Teachers and learners who were active social media users in their personal lives were among the strongest supporters for using them in education. These teachers reported plans to use them in future teaching practices. However, the workload of teachers and the structured and standardised curriculum were found to be inhibitors to social media adoption. Also, infrastructure, such as learners or teachers lacking computers or internet access at home, were impediments to the use of social media in education and learning. Learners, generally believed in the potential of using social network sites as supports for learning, their actual academic help-seeking, collaborative learning, and other self-directed educational activities outside of school. Finally, they postulate due to the popularity of social media among people and potential of social media use in education and learning, that teacher education initiatives should include opportunities to critically evaluate recent research literature on pedagogy trends regarding social media use in education and conditions for potentially beneficial or harmful social media integration.

Yeo (25) examined the use of social media platforms YouTube and Facebook by tertiary students and lecturers in Singapore for learning and pedagogical purposes.

The results indicated that students preferred using YouTube videos and Facebook for learning beyond the boundaries of the textbook and the classroom at their own pace and place. However, the learning also included distractions in the form of a myriad of games and the various social invitation available on YouTube videos and Facebook. Both students and teachers were positive about using Facebook as a "social" platform for building relationships with one another, outside of school. Both students and lecturers considered that face-to-face class contact is important for communication and for facilitation of academic and formal learning. They proposed a blended approach of traditional teaching and learning with additional feature using social media.

2.2 Use of Twitter in a social media environment

Krutka et al. (26) carried out a survey across three universities. The aims were to better understand the successes and shortcomings of experiences of using the Twitter social media platform for educational purposes. In total 73 students responded to the survey.

The results show that social media successes in educational settings included:

17% positive effects on relationships;
72% social media contributed to understanding course content;
47% increased participation and voice.

Main advantage of using social media in education and learning were:

23% ease of use;
17% the ability to respond quickly;
15% growth of temporal and spatial bounds for communicating.

Shortcomings included:

- defects in course organisation and facilitation;
- mismatches between expectations and use by teachers and learners;
- the small space of 140-character limit for tweets is an obstacle for effective communication;
- lack of frequent communication throughout the course and not only before assignments.

3.0 Our Longitudinal Social Media study

This section presents results of our longitudinal social media study that started in 2010. Since then we have totally published 19 scientific articles presenting the outcomes and results of our study. In this paper we present an overview of all our results.

Table 1. Publications of Social Media in Education in our Longitudinal Study (adapted from Markopoulos et al. (29).

No	INSPIRE Reference	Publication Reference (in reverse chronological order)	Research Population
19	29	Markopoulos et al. (2021a)	GR students: 130
18	28	Lampropoulos et al. (2021b)	274,109 Tweets
17	27	Lampropoulos et al. (2021c)	Longitudinal Study
16	30	Lampropoulos et al. (2020)	GR students: 63
15	1	Makkonen et al. (2019a)	FI students: 43
14	2	Makkonen et al. (2019b)	FI students: 66 GR students: 44
13	31	Kanakaris et al. (2019)	GR students: 178
12	5	Makkonen and Siakas (2019)	FI students: 66 GR students: 44
11	32	Makkonen and Siakas (2018a)	GR students: 40
10	33	Makkonen and Siakas (2018b)	GR students: 40
9	34	Siakas et al. (2017a)	GR students: 42 GR students: 239
8	35	Siakas et al. (2017b)	GR students: 239
7	36	Tsitsekidou and Siakas (2017)	GR students: 42 (MSc level)
6	37	Siakas and Georgiadou (2016)	FI students: 71
5	38	Makkonen et al. (2016a)	GR students: 101 FI students: 71
4	39	Makkonen et al. (2016b)	FI students: 71 FI teachers 32
3	40	Makkonen et al. (2015)	FI students: 71
2	41	Siakas et al. (2014)	GR students: 172 GR teachers: 31 UK students: 15 UK teachers: 10
1	42	Siakas et al. (2013)	GR students: 172

Table 1 shows the outcomes of the longitudinal study. The first column in the table is the sequence of papers starting with the first paper at the bottom. The second column is the reference number according to the INSPIRE requirements. In total 16 papers were published as results of the different studies and summarised in Lampropoulos et al. (29).

Subsequently we carried out a social media data analysis study by using 274,109 Tweets for identifying the effect of the COVID-19 pandemic on online learning (28), and a study aiming to comprehend students' experiences and viewpoints regarding the use of social media in education (28). A sample of 130 Greek Information Systems / Information Technology (IS/IT) students was used for our survey.

In the following section the results from the longitudinal study are summarised according to the 19 publications. The title of the paragraph is the title of the corresponding publication.

3.1 Benefits and Challenges of Social Media in Learning: Learners' Viewpoints

Aims: Investigation of the extent, the best practices, potential benefits and challenges applying social media in learning (42).

Population: 172 Greek students from 23 departments and 5 faculties. The research population was carefully selected covering 1% of the total student population from all the 5 faculties and the 25 different departments of 17200 active students at the time of the study in 2010. The data selected was analysed with the SPSS statistical tool.

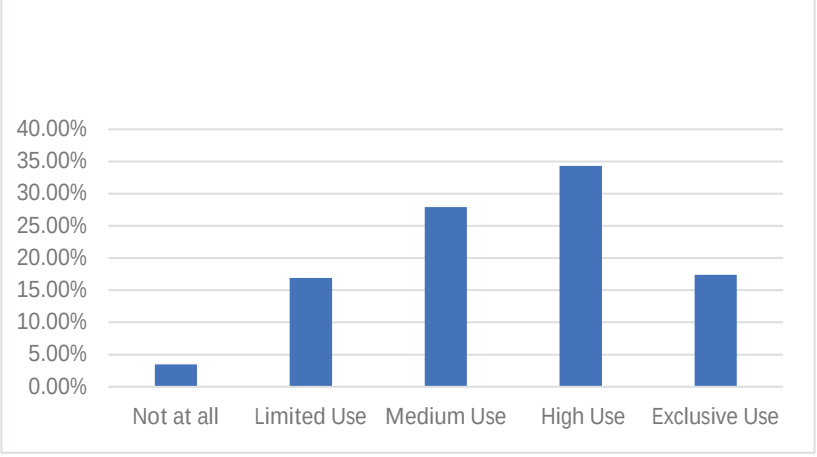

Figure 1: Respondents' Use of Social Media for Learning

Outcomes:

- 51.7% of respondents use social media for learning to a very high degree, despite the fact that no official use of social media is applied.
- Social media used for educational reasons are Facebook, YouTube, Skype, Wikis and Blogs (in descending order).
- The respondents use social media for educational purposes because they are fast (spread of latest information), free (cost-effective) and social.

Benefits gained from the use of social media in Higher Education:

- Social media are communication enablers promoting horizontal knowledge sharing;
- Give a sense of community for its members;
- Promote a feeling of team belonging;
- Provide an opportunity to meet fellow students;
- Improve self-organisation;
- Promote collaboration.

Challenges / Worries / Concerns of using social media in education:

- Group competition;
- Security and safety;
- Compatibility of social media platforms;
- Trust, fake news, quality of content.

Proposed use of social media in education by the students:

- Social media content creation: Wikis and YouTube videos;
- Student conferences: On-line access to student presentations;
- Game-like on-line quizzes and on-line tests;
- Discussion forums.

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3.2 Benefits and Challenges of Social Media in Learning: A Cross-cultural Study

Aims: Investigation regarding the degree to which social media is expected to improve learning (41).

Population: 172 Greek and 15 UK students, 31 Greek and 10 UK teachers (IT).

Outcomes: Teachers are not ready to use social media for educational purposes, as it can be clearly seen in Figure 2. Another important indicator for this is that no teachers from non-IT departments accepted to take part in the survey because '*they were not familiar with social media and thus not able to express any viewpoint'*.

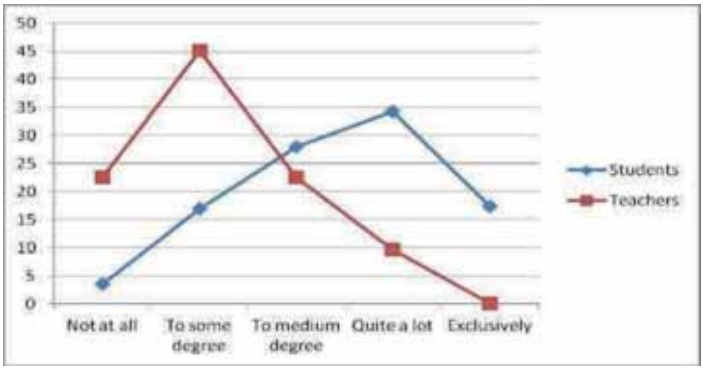

Figure 2. Readiness of using Social Media in Education (41)

Figure 2 shows that students have a much higher readiness than teachers using social media for educational purposes.

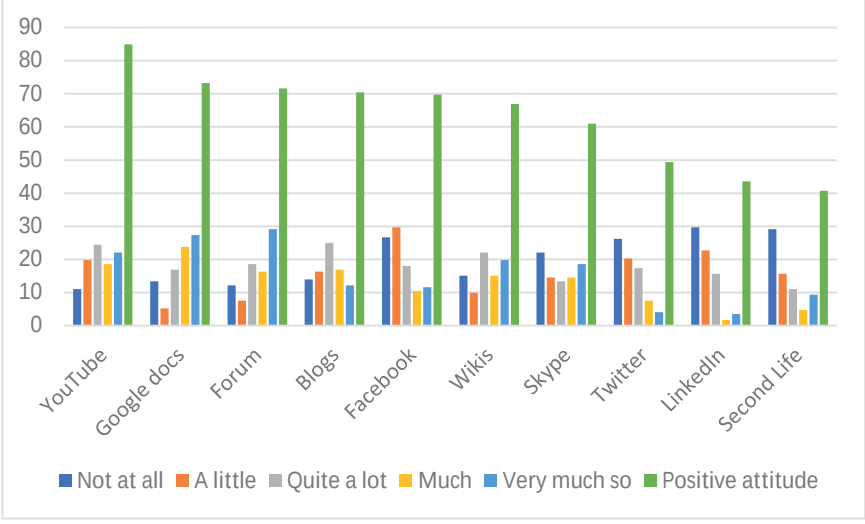

Figure 3. Degree to which social media can be expected to improve learning (student viewpoint).

Figure 3 shows that students have the highest positive attitude regarding YouTube for improving learning. YouTube, Google docs and Forum are very much considered to be suitable social media for improving learning.

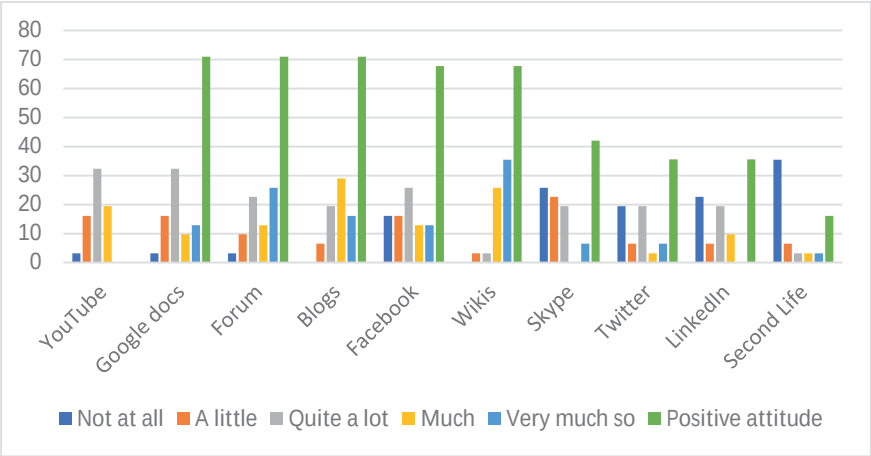

Figure 4. Degree to which social media can be expected to improve learning (teacher viewpoint).

Figure 4 shows that teachers on the contrary do not at all consider that YouTube can improve learning. Instead they have a positive attitude about Google docs, Forum, Blogs, Facebook and Wikis for improving learning. Wikis seem to be very much considered by the teachers to be suitable social media for improving learning.

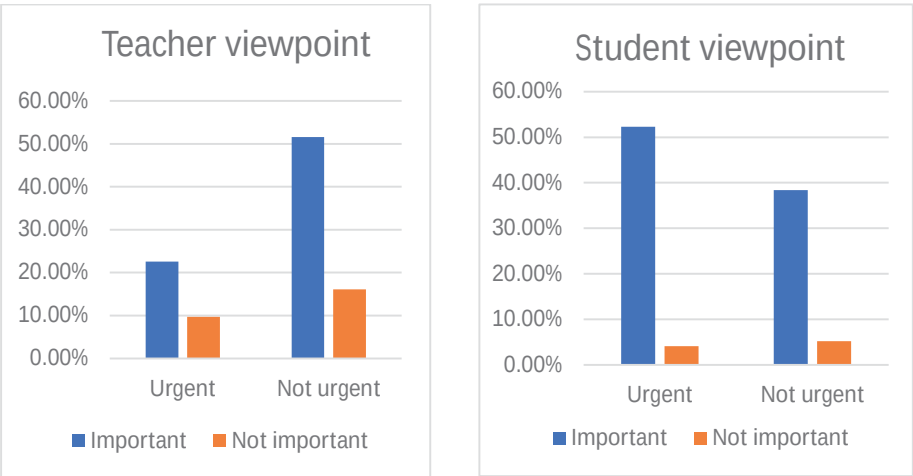

Figure 5: Importance and Urgency of social media in education (41)

Figure 5 shows the importance and urgency of social media use in education. Students consider them much more important than teachers do and also much more urgent than teachers do.

3.3 What promotes the adoption of social media in the teaching of IS/ICT and what constrains it? - Students' perspective

Aims: Investigation of bottlenecks and success factors in the adoption of social media in IS/ICT classes (40).

Population: 71 Finnish IS/IT students.

Background theory: Seaman and Tanti-Kane (43) found that 59% of faculty members consider that social media is likely to improve learning, but also 56% agree that these technologies can be distracting in education.

Outcomes: Considering that social media adoption in education will follow a similar curve as shown in Figure 6, which is a presentation of Roger's innovative technology (infrastructure and applications) diffusion and adoption theory (44).

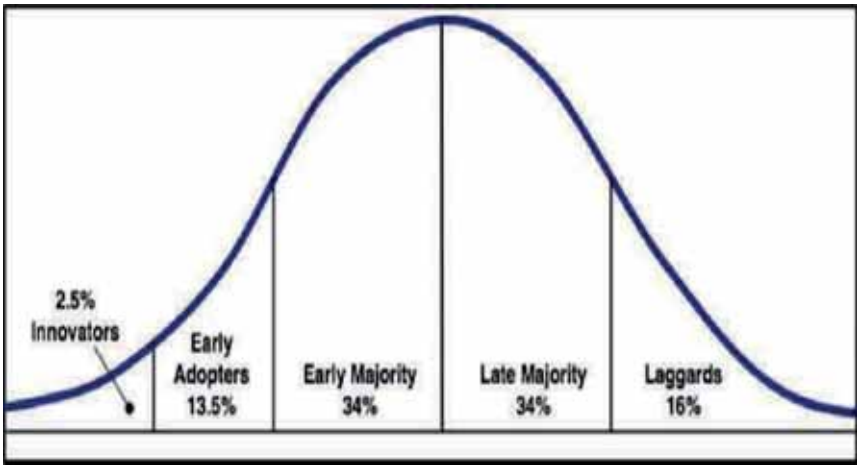

Figure 6. Categories of Innovation Adopters (44)

Figure 6 shows the innovation adoption curve. Early adopters (13,5%) are usually young people who want to try new innovations. The early majority and the late majority count for 68%. In this category the individuals want first to see how the new innovations are performing. They are waiting for the innovations to become accepted by the early adopters and then they may adopt the innovation.

Our study was based on the more detailed Unified Theory of Acceptance and Use of Technology (UTAUT) (45, 46), which also deals with the social aspect; an obvious factor in the emergence of social media use in education.

We need to take into consideration that our sample was mainly based on IS/IT students, who due to the nature of their studies already are familiar with various technologies and hence they are likely to be more interested and willing in adopting diverse contemporary technical innovation

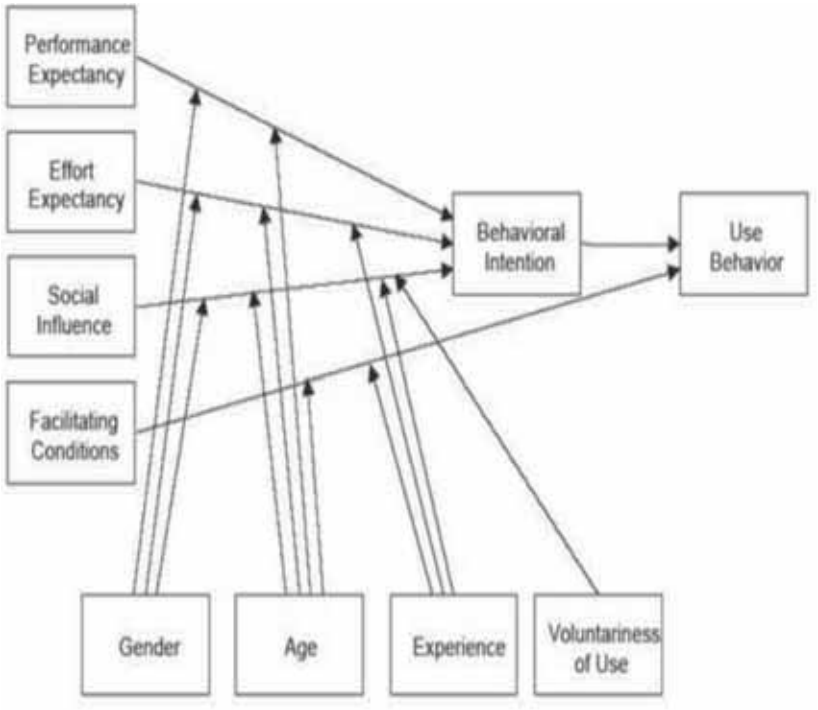

Figure 7. Unified Theory of Acceptance and Use of Technology (UTAUT)(45, 46).

Figure 7 shows the major components of the detailed UTAUT theory and was investigated by using the sample of 40 Finnish students.

The applicability of infrastructure was considered by the students as the most important issue in the planning of learning activities based on social media. The second factor was the ease of use and the third the level of help social media provides towards working or studying. Taking these results into consideration when implementing social media solutions in education the priorities should be:

i. Special attention to ICT infrastructure needs to be paid. Since students' home conditions are not known, the first step should be to analyse the learning conditions of students in their home environments;
ii. Identification and selection of the best platforms regarding usability;
iii. Identification and selection of best teaching methods by involving teachers in selecting suitable teaching methodologies to support students' learning and educational development.

3.4 Adoption and Use of Social Media in Learning and Teaching: Comparing Students with Faculty Members

Aims: Comparison of level of adoption of social media between Finnish IS/IT students and teachers (39).

Population: 71 Finnish IS/IT students and 32 IS/IT teachers.

Outcomes: Similarly, with the students, also the teachers confirmed the importance of the infrastructure as the most significant component when introducing social media in an educational context.

Students quickly use new contemporary social media tools, as early adopters, whilst teachers seem to belong to the late majority. Teachers should experiment with setting up social media activities that may motivate students in the further steps of their studies.

3.5 Adoption and Use of Social Media in Learning and Teaching: A Cross Cultural Case Study

Aims: Investigation of the adoption and use of social media in learning and teaching activities in cross-cultural settings (38).

Population: 101 Greek IT students and 71 Finnish IS/IT students

Outcomes:

- The infrastructure component was more important for Greek students than for Finnish students. This is likely to depend on the fact that infrastructure in Finland is advanced (both at universities and at students' homes), whilst in Greece there is a lack of high-tech infrastructure at schools and universities, as well as at students' homes. This has been particularly evident since the financial crisis which started in 2010.
- The Finnish students valued the role of social influence to a higher degree than the Greek students. For interpreting this result, Hofstede's cultural values were used (47). In collectivistic cultures, such as Greece (35), people appreciate group harmony and consensus, while in individualistic cultures, such as Finland (63) people value freedom, self-reliance and independence. In collectivistic societies, in-groups (family and friends) and out-groups (not close friends) exist. In social media, the in-group can be compared to 'friends in Facebook' with a stronger social influence on individuals than out-group people. In individualistic societies, the social influence appears to be personal achievement which is appreciated. As a result, it is evident that in social media-based learning in countries with high individualistic cultures it is important to identify role models with high performances that can act as motivators for students to improve their learning.

Many automated software tools, such as Usinet6, NodeXL etc. exist for social network analysis, where relationships and knowledge flows between the relationships can be identified and visually mapped in networking graphs. Such tools can be useful for identifying key players, isolated individuals, tie strengths and cohesion of a certain social educational network.

3.6 Adoption of Social Media in Learning: A Student Perspective

Aims: Investigation of two research hypotheses (37).

i) H1: IS/ICT Students are early adopters of social networks;

ii) H2: Male students are earlier adopters of social networks than female students.

Population: 101 Greek IT students (22 females and 79 males, mean age of 23 years).

Outcomes: The results confirmed earlier findings that IT students are early adopters of social networks. They are fascinated by social media and use them in their everyday lives. They are eager to use them as part of their learning. Students prefer to learn by multimedia rather than by reading texts. They are sociable and good at simultaneous interaction, knowledge sharing and self-organisation, hence, they prefer active involvement and group activities.

T-test was used to find differences in gender preferences. The only significant difference was found in the general experience on social media. The male students were more experienced than female students (mean value was 3.80 for males and 3.25 for females, the p value was 0.022).

Social media are considered a 'cool' new fashion and are likely to change the way teachers teach and the way students want to learn. They can enable students and teachers to create their own content and share it within a broad network. Social media provide students and teachers with an unprecedented way to access information, socialise, communicate, speak, publish and co-create.

3.7 A Facebook Group among Postgraduate Students: Evaluation Results towards Learning

Aims: Evaluation of students' engagement within a Facebook group, their motivation, collaborative learning and satisfaction from the overall experience (36).

Population: 42 MSc students in the MSc module in Web Intelligence at the Department of Informatics at ATEI of Thessaloniki in Greece in 2014 and 2015.

Outcomes: The group of 2014 consisted of students aged between 25-40 years, 15 males and 6 females, with most of the students being experienced Facebook users.

The group of 2015 comprised of students aged between 20-45 years, 18 males and 3 females, most with medium Facebook experience.

Four main parameters along with their three sub-parameters were investigated:

- *Students' engagement:* The number of hours spent per week in the Facebook group, the rate of visiting frequency and the type of members' activity.
- *Students' motivation:* The degree of team spirit, communication flexibility and knowledge exchange.
- *Students' collaborative learning:* The degree of effective advising, timely responses and problem solving.
- *Students' satisfaction*: The degree of the group's contribution to the learning process and its emphasis on the students' studies as well as the type of the overall experience when participating in the group.

All four parameters were calculated based on the three sub-parameters rated by the students. The correlations between these parameters were further investigated. The results showed that there is a significant correlation between students' engagement in the Facebook group and students' satisfaction of the overall experience with the Facebook group and subsequently, of the learning achieved via the Facebook group.

Figure 8. Students' Average Scores of Parameter Constructs (36).

The results showed that the contribution of the Facebook group to the students' learning process regarding students' engagement, motivation, collaborative learning and satisfaction, is quite high. Motivation and collaborative learning seem to be the learning factors that are appreciated to the highest degree by the students.

3.8 Using Social Media in Higher Education: An Approach for Active Engagement of Students

Aims: Validation of earlier results (35).

Population: 239 Greek IT students.

Outcomes: The percentage of social media use outside education by the respondents are YouTube (99%), Facebook (93%), Skype (75%), Forums (52%) and Blogs (45%).

The following three social media tools are considered by the students most important for use in education:

i. *YouTube* comes first of Social media tools with 94% of the respondents rating it important for learning;
ii. *Facebook* comes second with 81% of the respondents regarding that it contributes to their learning;
iii. *Blogs* are considered as an important social media tool in learning by 77% of the respondents.

The results showed that YouTube and Facebook are both popular in students' leisure time but are also considered as the social media tools that provide the highest potential learning outcome.

3.9 Social Media Adoption in Higher Education: A Case Study Involving IT/IS Students

Aims: Validation of earlier results (34).

Population: 239 Greek IT students and 42 MSc students.

Outcomes: Based on Table 2, we identify that

- *YouTube* (rated as the most important social media tool for learning), has the highest ranking in the visibility category.
- *Facebook* (rated as the second most important tool for learning) has the highest ranking in meeting peers and the second highest in knowledge sharing and team spirit.
- *Blogs* (rated as the third most important social media tool), have the third ranking in both knowledge sharing and organizational skills.

The Second-life, an online virtual three-dimensional, multi-user environment rated highest for unconscious learning. It has multiple potential uses in education, as users create avatars that represent them in the virtual world.

Table 2. The Three Most Important Social Media Tools according to Learning Aspect (34).

Unconscious Learning	Knowledge Sharing	Organisational Skills	Team Spirit	Meeting Peers	Visibility
Second Life	Forum	Wikis/Google+	Skype	Facebook	YouTube
LinkedIn	Facebook	LinkedIn	Facebook	Skype	Instagram
Instagram	Blogs	Blogs	LinkedIn	Twitter	LinkedIn

YouTube, Facebook and Blogs were considered as the most useful social media tools for education (34). Table 2 shows that the learning aspect of YouTube is visibility. The learning aspects of Facebook are meeting peers, knowledge sharing and team spirit. The learning aspects of Blogs are knowledge sharing and organisational skills.

3.10 Social Media Usability and Functionality in Higher Education: IT/IS Students' Perspective

Aims: Identification of the main factors and problem areas regarding the functionality of social media in Higher Education (33).

Population: 40 Greek IT students.

Outcomes: The Honeycomb model (48) and the theory of external and internal motivation (49) were identified as suitable underlying theories for our study. Figure 9 shows how the Honeycomb can be used in analysing social media use. The left side of the figure shows how the Honeycomb has been adopted for the functionality of social media and the right side of the figure shows the equivalent implications of functionality.

A survey was carried out to identify and examine the perspective of students regarding functionality. In total, 40 students from ATEI of Thessaloniki in Greece, participated in the Webropol online survey. The results showed that sharing content is the most important functionality factor for the Greek students. The students exchange, distribute and receive learning material and sources to a very high degree on social media, such as Google+, Dropbox and Facebook.

Kietzmann et al. (48) recommend the use of content management systems and social graphs for the implications of the sharing functionality. The use of visually mapped graphs has also been recommended for understanding the social influence (38). The results also showed that conversations are not considered significant for the Greek respondents who prefer talking face-to-face instead of through social media.

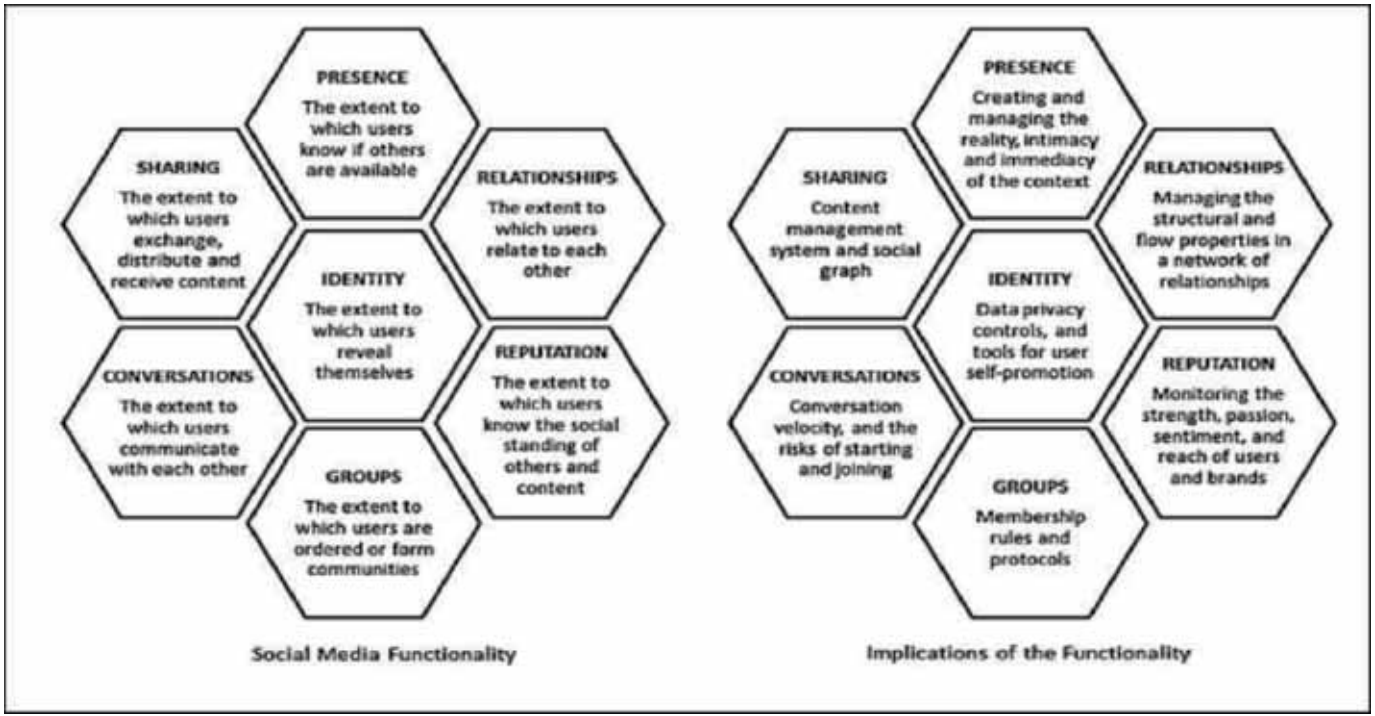

Figure 9. Honeycomb for Analysing Social Media (48).

3.11 Social Media Usability and Functionality in Higher Education: IT/IS Students' Perspective

Aims: Identification of the main factors and problem areas regarding the use of social media in Higher Education (32).

Population: 40 Greek IT students.

Outcomes: The other significant factors found were internal and external motivation. Internal motivation (what we want to do ourselves) is the sum of pre-interest and post-interest. External motivation (what somebody else want us to do) is the sum of pre-benefit and post-benefit (49). Hence, it is important to create strong motivation factors for students to use social media in their learning activities and to demonstrate the benefits. However, no significant difference was noticed between them in our sample.

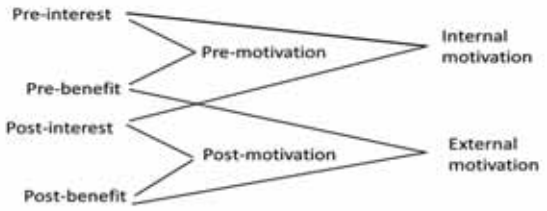

Figure 10. The Theory of external and Internal Motivation (49).

Figure 10 shows how internal and external motivation is created from a combination of interest and perceived benefit.

3.12 Three Quality Attributes - Availability, Performance and Security of Social Media Services used in Higher Education: An Analysis and a Cross-Cultural Study from IS/ICT Students' Perspective

Aims: Investigation of the importance of three quality attributes, namely availability, performance, and security of social media (5).

Population: 66 Finnish IS/IT students and 44 Greek IT students.

Outcomes: The analysis of the collected data indicated that security in both countries is a major issue compared to availability and performance in the design and use of

social media in Higher Education. Malicious software, apps and phishing attacks are the most notable security threats. In regard to the availability attribute, it was identified that errors in the logic of the software and disturbances in planned maintenance were major concerns. Finally, the results of the performance attribute showed that the network performance was the most significant issue. Some cultural differences were found in this survey. For example, the Finnish respondents appreciated far more the availability and performance attributes.

3.13 A Survey and a Case-Study Regarding Social Media Security and Privacy on Greek Future IT Professionals

Aims: Investigation of Greek Higher Education students' awareness of security and privacy issues in social networking when it comes to the acquisition of their sensitive personal data by malicious users through their posts and publications (31).

Population: 178 Greek IT students.

*Outcomes***:** Based on the results of the survey, the respondents were aware of the privacy settings of the social media platforms they use. Additionally, they believed that they should be more careful about sharing personal data and who they add as an online friend. Finally, the students expressed their concern regarding malicious users being able to access their personal data through their online posts and publications on social media platforms.

3.14 Three Quality Attributes - Availability, Performance and Security of Social Media Services used in Higher Education: An Analysis and a Cross-Cultural Study from IS/ICT Students' Perspective

Aims: investigation of the importance of three quality attributes, namely availability, performance, and security in social media (2).

Population: 66 FI IS students and 44 GR IT students

*Outcomes***:** The quality of social media services can be evaluated in many ways according to various attributes. This study focussed on the evaluation of social media services regarding three quality attributes, namely availability, performance and security from a wider perspective.

The same survey instrument was used so as to investigate the significance of these quality attributes in social media and to directly compare the results of the two countries. The analysis of the results indicated that in both countries security was a major issue compared to availability and performance in the design and use of social media in Higher Education. However, some cultural differences were found in this

survey. For example, the Finns respondents appreciated far more availability and performance attributes.

3.15 Security and Privacy Issues and Concerns about the Use of Social Networking Services

Aims: investigation of Higher Education students' major concerns regarding security and privacy issues on social media for supporting and assisting teachers who are eager to design social media-based teaching and learning activities (1).

Population: 43 Finnish IS students.

*Outcomes***:** According to the results, the respondents regarded the potential of their personal information, financial information and intimate secrets being breached as the most notable concern. Furthermore, it was evident that social media improvement regarding security and privacy issues is still considered as necessary. Finally, it was pointed out that teachers should further increase students' awareness of the way they should share content and protect their privacy online properly and more effectively by highlighting the significance of information security and privacy as well as the various online threats.

3.16 A Framework for Introducing Social Media in Education: A Student Perspective Survey

Aims: To pinpoint students' viewpoints concerning the use of social media in teaching and learning activities and to present an educational social media planning and design framework (30).

Population: 63 GR IT students, 11 females, and 52 males, aged from 18 to 20 years old. The majority of the respondents had been using social media for more than 5 years. In total 46% of the respondents used social media for at least an hour per day while 39.7% spent more than three hours.

*Outcomes***:** the majority of the students considered social media as a helpful and indispensable educational tool that can improve learning when applied in a student-centred manner. The mean values of the responses to questions regarding the impact of using social media in education are sorted in descending order in Table 3. Based on the results, it is apparent that they considered social media as a means that can improve learning and that can boost communication, collaboration and knowledge sharing with their fellow students and teachers in an educational context. Finally, they deemed social media as a tool that can promote, enhance and facilitate group work and collaboration and which can positively affect their academic performance.

Table 3. Mean Values (scale 1-4, descending order) of the responses regarding the Use and Impact of Social Media in Education, adapted from (30).

Do you consider that . . .	Mean value
. . . social media can increase knowledge sharing among students?	3.22
. . . social media can improve collaboration among students?	3.10
. . . social media can improve communication among students?	3.10
. . . social media provides a useful platform for academic group work?	3.08
. . . the use of social media to share work with your peers for academic purposes has a positive impact on your studies?	3.02
. . . social media can be used as a means to improve learning in ‘ education?	3.00
. . . social media is indispensable for communicating with both them teachers and fellow students?	2.98
. . . the usage of social media can benefit your academic performance by any means?	2.98
. . . social media is an indispensable educational tool?	2.94

In total, 90.7% of the Greek students (n:172) from multiple disciplines who were involved in the study of the year 2010 considered that the use of social media in education is important and 52.3% of them considered that the use of social media in education is both urgent and important. Half of the students reported that they already use social media for educational purposes (mainly Facebook, YouTube, Skype, Wikis and Blogs) on their own initiative since no official use of social media is applied. The advantages of using social media in learning are that social media facilitates communication, promotes knowledge sharing and creates a sense of community and belonging for its members. The challenges reported were group competition, security and safety, compatibility of social media platforms, trust, fake news and content quality.

When asked which social media tools are most likely to improve learning, both Greek teachers and students considered YouTube, Google Docs, Forum, Blogs and Facebook to be the 5 most important ones. Teachers lag behind and are also reluctant to use social media for educational purposes. In a similar study (34), Greek undergraduate students (n: 239) and master students (n: 42) considered YouTube, Facebook, Skype, Forum and Blogs as the most popular social media tools while they regarded YouTube (visibility), Facebook (meeting peers, knowledge sharing and team spirit) and Blogs (knowledge sharing and organisational skills) as the most

useful platforms for learning. YouTube remained the most popular social media platform for students both for their private life and for educational purposes while Facebook climbed up to second place in the past seven years.

In the study conducted by Lampropoulos et al. (30), a decade after the first study, Greek students (n:63) seemed to be certain about the positive impact that social media may have on education. All mean values based on students' responses (1 = strongly disagree ... 4 = strongly agree) regarding the impact of social media concerning certain factors of education were very high, namely knowledge sharing, collaboration, communication, and academic group work. Additionally, the participants considered social media as an indispensable educational tool that can be used as a means to improve and benefit academic performance.

After having understood students' and teachers' viewpoints regarding the use and potential impact of social media for educational purposes, issues, concerns, potential bottlenecks and success factors in the adoption of social media in educational settings were investigated. The study was based on the Unified Theory of Acceptance and Use of Technology (UTAUT) (45, 46) and the Honeycomb model (48). The main findings of this study revealed worries about infrastructure, security and privacy, network and social media performance as well as availability of broadband and social media services when considered necessary. Moreover, based on the findings of the longitudinal study, we embarked on improving and extending the educational social media planning and designing framework presented in (30). The improved framework is depicted in Figure 11 and it can be used in any educational institution that has a vision to use social media in their teaching and learning activities.

Finally, it is worth noting that there are a lot of factors that should be considered in order to successfully adopt social media-based learning. All the involved stakeholders should take part and collaborate to design appropriate student-centred and technology enhanced learning methods. Therefore, strategies, detailed objectives, action plans and measurement indications should be planned, created and managed as a joint task.

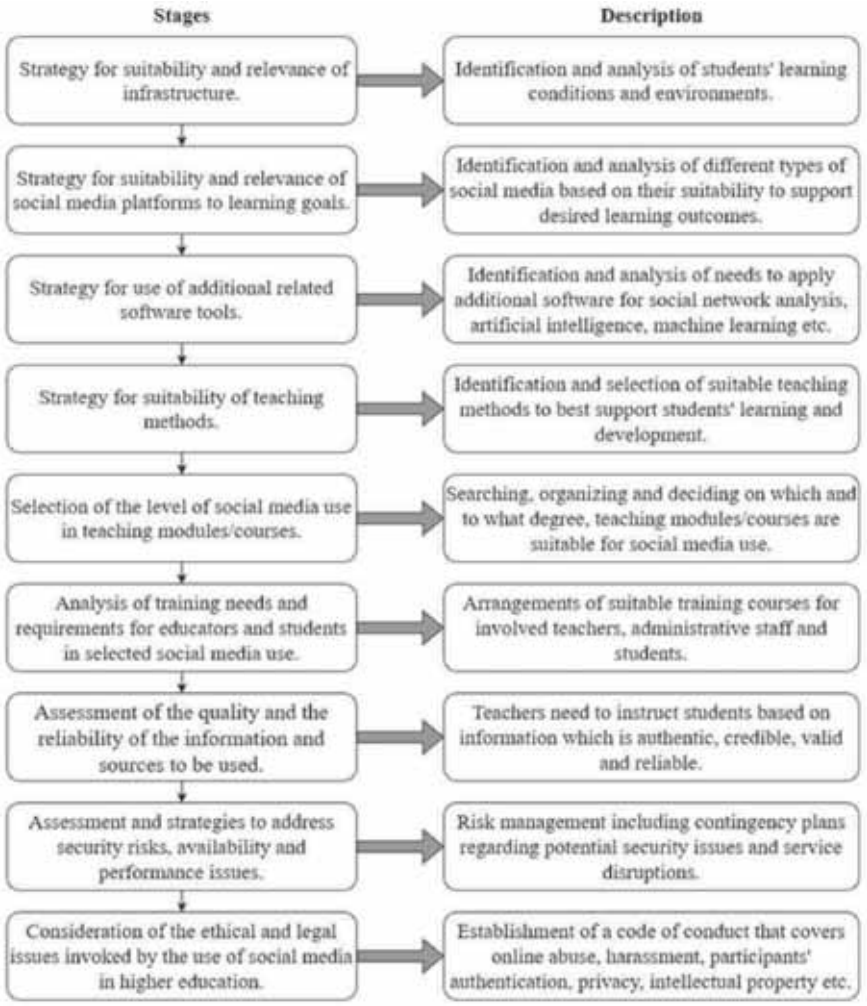

Figure 11. The Educational Social Media Planning and Designing Framework (30)

3.17 A 10-year Longitudinal Study of Social Media Use in Education

Aims: Collection and summarisation of all social media publications so far (29).

Population: 902 Greek BSc IT students, 42 MSc IT students and 31 IT teachers
180 Finnish BSc IS students and 32 IS teachers
15 UK BSc IT students and 10 IT teachers

Outcomes: Our findings undoubtedly have shown throughout the years that a general readiness for using social media in education and learning exists because of i) a pedagogy paradigm shift toward more student-centred collaborative approaches ii) lightweight open and free Web 2.0 applications easy to learn and use iii) digitally literate and multitasking students and iv) contemporary fashion of dynamic collective content creation.

Our results have shown that students are early adopters of social media and are both emotionally and technically ready to use social media for their learning purposes. Teachers, who lag behind in the use of social media for educational purposes, should start experimenting with creating social media activities by actively involving students in the planning and creation of tasks in order to acquaint them with the overall process.

3.18 A Social Media Data Analysis Study Regarding the Effect of the COVID-19 Pandemic on Online Learning

Aims: Sentiment analysis (28) to comprehend the crowd wisdom regarding the effect of COVID-19 on online learning.

Population: 274,109 tweets, retrieved from January 2020 to January 2021

*Outcomes***:** The search query was: *("covid" OR "covid19" OR "coronavirus" OR "lockdown" OR "pandemic" OR "corona virus" OR "covid-19" OR "covid 19" OR "covid_19" OR "corona-virus" OR "quarantine") AND ("remote learning" OR "remote education" OR "online education" OR "remote-learning" OR "distance learning" OR "online learning" OR "distance education" OR "distance-learning" OR "online-learning" OR "distancelearning" OR "onlinelearning" OR "remotelearning").*

Table 4: The top-20 most commonly used words excluding the keywords used.

Word	Count/Percentage	Word	Count/Percentage
school(s)	96,535 (2.21%)	help	15,429 (0.35%)
student(s)	64,544 (1.48%)	time	15,228 (0.35%)
teacher(s)	29,847 (0.68%)	via	14,210 (0.33%)
kid(s)	21,235 (0.49%)	class(es)	13,656 (0.31%)
due	19,494 (0.45%)	week	13,340 (0.31%)
child(ren)	19,178 (0.44%)	support	13,198 (0.3%)
new	19,073 (0.44%)	need	12,383 (0.28%)
Home	17,361 (0.40%)	access	12,336 (0.28%)
parent(s)	16,807 (0.39%)	free	12,169 (0.28%)
Go	16,396 (0.39%)	resource(s)	12,153 (0.28%)

Table 5: The top-20 most commonly used hashtags.

Hashtag	Count/Percentage	Hashtag	Count/Percentage
#COVID19	47,422 (7.03%)	#lockdown	5,870 (0.87%)
#onlinelearning	27,305 (4.05%)	#elearning	5,759 (0.85%)
#remotelearning	2,4661 (3.66%)	#OnlineLearning	5,397 (0.8%)
#distancelearning	19,746 (2.93%)	#Covid_19	4,929 (0.73%)
#coronavirus	17,563 (2.61%)	#pandemic	4,505 (0.67%)
#education	12,692 (1.88%)	#learning	4,380 (0.65%)
#covid19	10,714 (1.59%)	#edchat	4,353 (0.65%)
#RemoteLearning	6,909 (1.02%)	#Covid19	4,179 (0.62%)
#edtech	6,662 (0.99%)	#Coronavirus	3,774 (0.56%)
#DistanceLearning	5,884 (0.87%)	#covid	3,445 (0.51%)

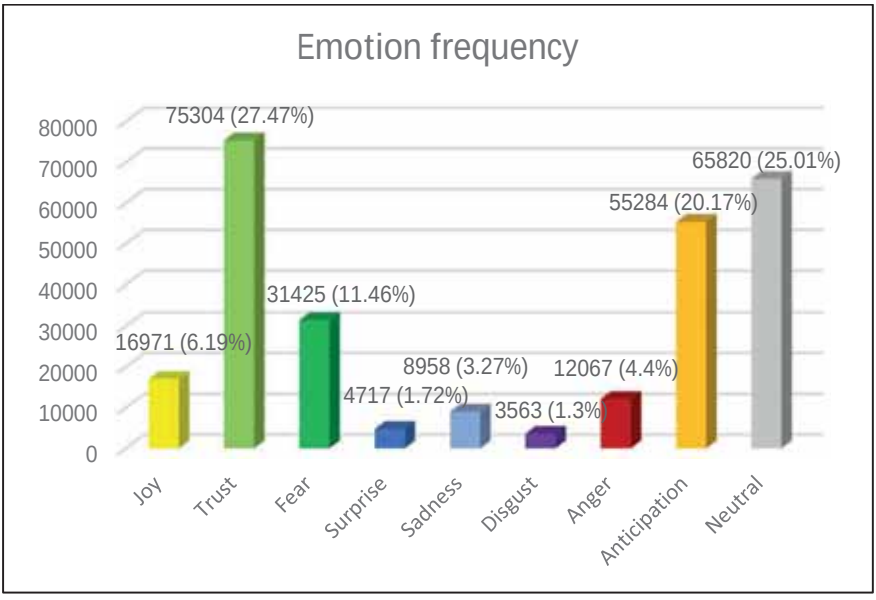

Figure 12: Frequency of emotions

Figure 12 shows that trust is the most frequent emotion concerning the effect of COVID-19 on online learning, followed by neutral and anticipation. Despite the fact that there are various drawbacks in online learning, the results show that the public still considers online learning and teaching method as a positive and viable, to some degree, supplementary method to the traditional one and not as something that could entirely replace traditional face-to-face learning.

3.19 Social Media in Education: A Case Study Regarding Higher Education Students' Viewpoints

Aims: Investigation of student viewpoints about the use of social media in education (29).

Population: 130 GR IT students. Female: 13.1%, male: 86.9%, mean age: 18.31. Totally 87.7% of the students had been using social media for more than five years and 12.3% for about three years. In total 49.9% one hour or even more than three hours (34.6%) on social media daily.

Outcomes: It is worth noting that, 87.7% students have been using social media for more than five years and 12.3% of them for about three years. Additionally, the majority of students, namely 49.9% spent more than one hour and 34.6% more than three hours on social media daily.

*Outcomes***:** the majority of students viewed the integration of social media in education positively and regarded it as a means to promote and enhance communication, group work, collaboration as well as knowledge and ideas sharing with both fellow students and teachers. Moreover, students considered social media to be an invaluable teaching tool that when used in a student-centred manner can increase their productivity, engagement, motivation and academic performance as well as improve the teaching and learning process. Finally, social media was assessed as essential for today's life and as a promising tool that will be more widely used in educational settings in the near future.

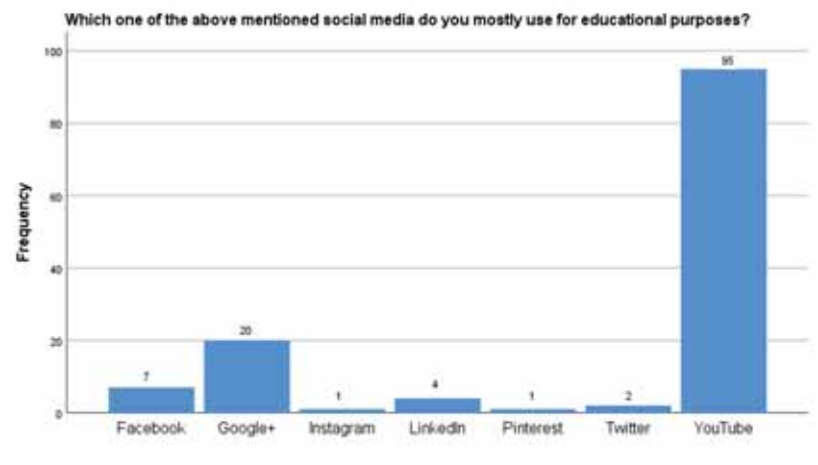

Figure 13. Mostly used social media for educational purposes by students.

Figure 13 shows that YouTube is considered to be useful to a very high degree for educational purposes followed by Google docs. Here we need to remember that there is no official or formal use of social media from the side of the educational institution, but the students use social media for educational purposes on their own initiatives.

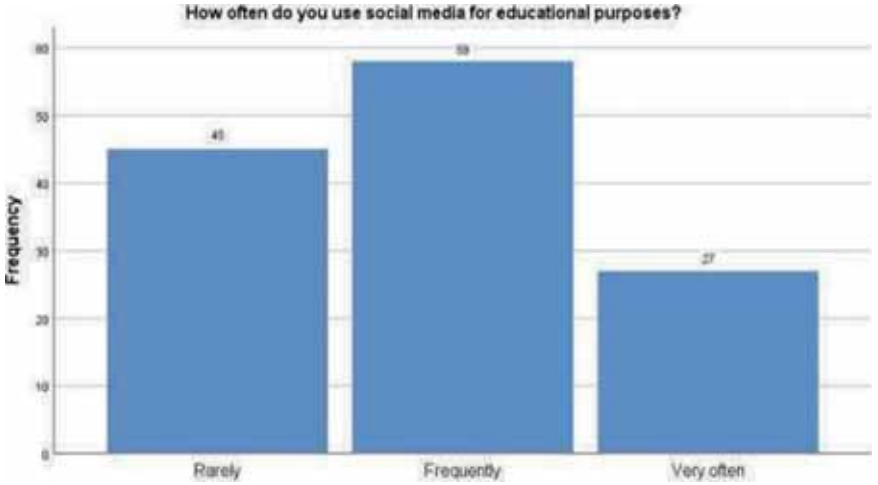

Figure 14: Frequency of using social media for educational purposes

Figure 14 shows that social media is frequently used for educational purposes by the students.

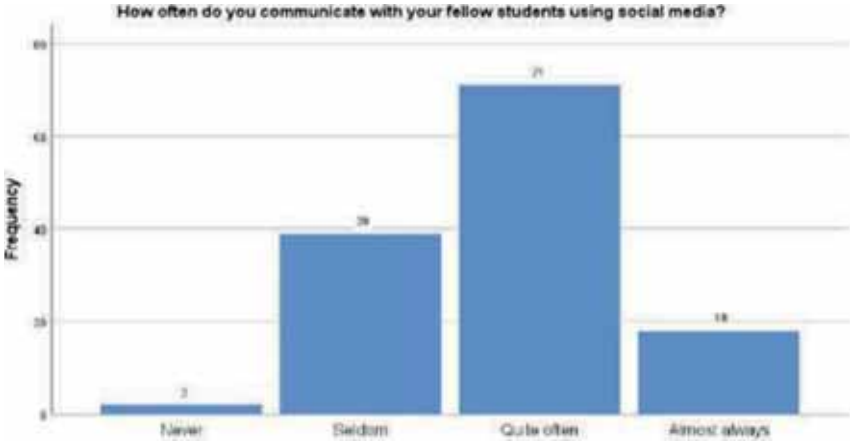

Figure 15. Frequency of communication with fellow students using social media.

Figure 15 shows that social media is used quite often for educational purpose

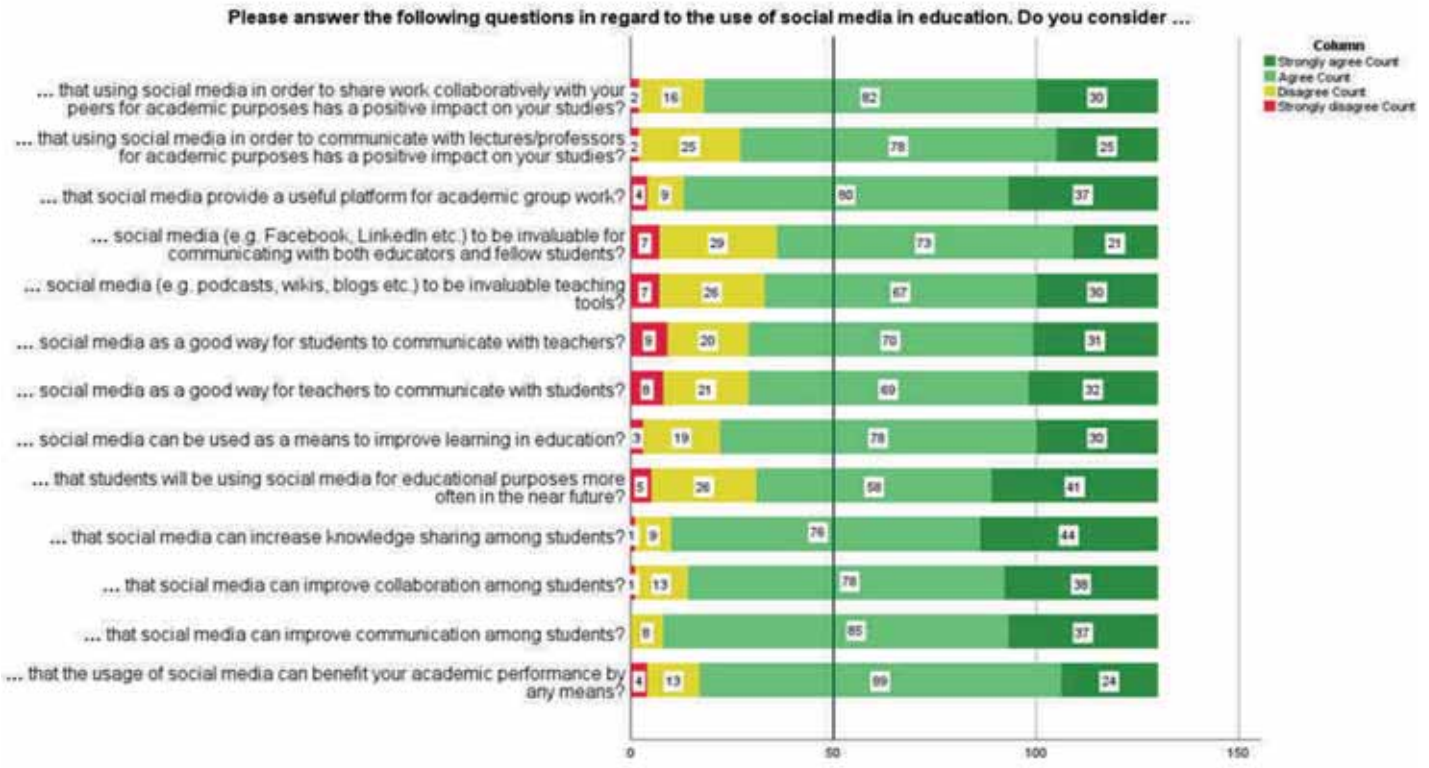

Figure 16. Students' viewpoints regarding the use of social media in education (29).

Figure 16 shows that the 5 most important features in social media use in education are in descending order.

Social media can

- increase knowledge sharing among students;
- improve communication among students;
- provide a useful platform for academic groupwork;
- improve collaboration among students;
- can be used as a means to improve learning in education.

Table 6 shows how the use of social media is viewed by the students.

Table 6. How the use of social media in education is viewed by students (scale 0-3)

Do you believe ...	Mean	Std.
... that social media can increase knowledge sharing among students?	2.25	.614
... that social media can improve communication among students?	2.22	.547
... that social media can improve collaboration among students?	2.18	.628
... that social media provide a useful platform for academic group work?	2.15	.676
... that students will be using social media for educational purposes more often in the near future?	2.04	.820
... social media can be used as a means to improve learning in education?	2.04	.687
... that the usage of social media can benefit your academic performance by any means?	2.02	.641
... that using social media in order to communicate with lectures/professors for academic purposes has a positive impact on your studies?	1.97	.670
... social media as a good way for teachers to communicate with students?	1.96	.811
... social media as a good way for students to communicate with teachers?	1.95	.819
... social media (e.g. podcasts, wikis, blogs etc.) to be invaluable teaching tools?	1.92	.803
... social media (e.g. Facebook, LinkedIn etc.) to be invaluable for communicating with both with students and teachers	1.83	.759

When comparing the results of Table 6 including the results of a survey with 130 Greek IT students published in 2021 (29) with the results of a similar survey with 63 Greek IT students in Table 3 published in 2020 (30) we observe that the first four characteristics of social media considered by the students to be important for using them in education are the same, namely they are considered by the students to increase knowledge sharing, improve communication and collaboration, and are useful platforms for academic groupwork. Also, the fact that social media can be used as a means to improve learning in education receive in both surveys the 6th

place of importance. Also, similar results in the two studies was received for communication between students and teachers, namely not valued to be of particular importance. Similarly, when mentioning particular social media tools, the results received were of lowest importance.

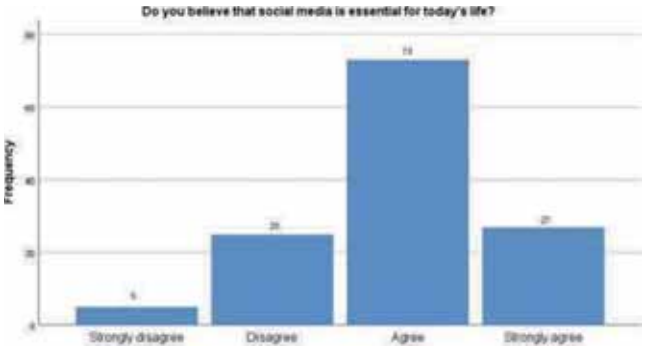

Figure 17. Do you believe that social media is essential in today's life?

Figure 17 shows that the respondents consider to a very high degree that social media are essential in today's life.

4.0 Discussion

After 12 years of researching the use of social media for educational purposes we are convince that the benefits of using Social Media for educational purposes are the following:

Social media are the platforms where students spend much of their free time. Students born after the 80ies have grown up with social media and are native users of social media; hence it can be said that they have a high level of digital literacy skills. Social media can be used in own time, own space and own pace and this gives a flexibility for the students to perform their tasks when suitable for them. A big advantage of using social media for educational purposes is that they are affordable at no or low cost, immediately available and easy to use. As the students in our survey mentioned for preferring them is that they are *'fast, free and social*'. When used in education students are connected to each other and to the global community. This community building provides the opportunity to gain new perspectives and make connections with people different form ourselves from all over the world. Social media facilitate bottom-up communication among students. Communication in general is improved in social media environments. Students learn from one another and build on shared learning experiences. An important social experience take place via collaboration on academic group work. Knowledge is co-created in the social media environment and motivate for knowledge sharing, retention and

understanding. Students, teachers and parents are motivated to receive useful information with regards to the educational process. Social media Analytics and different graphs can be developed regarding behavioural, engagement, personal, attitudinal, and preference data. A key approach to leveraging the power of social media is the use of analytics for investigating the statistics and data regarding what is working and what is not working according to learning goals. Finally, social media are found to improve learning; the ultimate goal of all educational approaches.

However, there are also a lot of challenges of using social media for educational purposes. The challenges include blurred boundaries between social and academic lives. Teachers lag behind in the use of social media. They are likely to increase the workload of teachers and may be difficult to use due to standardized curriculums that are structure to fit in formal education. In order to use social media for educational purposes the infrastructure both at school and at students' homes need to be investigated. Performance, such as network availability and speed need to be taken into consideration as well as availability in the form of potential bugs and maintenance disturbances. Security, safety and privacy are important issues that we need to put a special attention to. The evaluation process is worrying students since work usually is made in a collaborative manner. Compatibility between different social media is another problem. Material is not always easy to transfer from one platform to the other. Time management can also be a serious problem in self-directed learning. In social media students often experience distractions and involve in unproductive behaviour and waste time. The most serious problems, however, those with antisocial behaviour including cyber bullying, excessive use of social media which can lead to anxiety, depression, isolation, Fear of Missing Out (FIMO), etc.

The most interesting thing about social media is how the scene of using social media in education will look like in the future.

Social Media are here to stay. Learners are native users of social media, which embrace the constructivism theory of learning, by involving learning in bottom-up collaborative learning creation. A myriad of new innovative social media applications/tools are daily created. We cannot stop the train, but it is not too late to catch it. Pedagogical potential of using social media in education and learning show that social media afford students and institutions with multiple opportunities to improve learning methods based on the constructivist method, in which learners construct knowledge rather than just passively take in information. Social and cultural identity of digital natives is created through social media. However, using social media in educational settings require re-thinking of the theoretical and pedagogical framework through which we engage student in Communities of Practice (CoP). We also need to give attention to ICT infrastructure both at school and at students' homes. The most suitable platforms regarding usability need to be identified and the best teaching methods for supporting students' learning and educational development. In order to be successful in introducing social media in education teachers need to be trained and learners educated in security, safety,

privacy issues. In particular younger children need to be taught into safe use of social media. For successfully introducing social media into formal education their use must be tied to achievement of learning goals and empowering students to take part in the whole process will be beneficial for its success.

For introducing social media in education, we propose a blended approach including traditional formal teaching and learning approaches together with additional social media collaborative self-directed learning activities.

Most teens believe they know more about social media than their parents or teachers. How can we teach something teens believe they know better? The approach that is most likely to have success is the empowerment and involvement of learners in preparation of social media learning according to learning goals and in management including organisation and facilitation, of learning activities.

Schools need to take a holistic approach to educating learners, parents, and faculty.

5.0 Conclusion and Future work

Based on the findings of our longitudinal study (27) and the results of the continuation of our studies (28, 29), the following reflections for the future were made.

Since social media are powerful influences on if a child feels happy, healthy and successful social media needs to be a priority also in education.

Teacher education should:

i. aim to create learning spaces and experiences that support cognitive growth, affective well-being, and social needs;

ii. offer opportunities for teachers to expand their professional learning networks by using informal social media learning spaces;

iii. look for patterns in the content and categories of social media in order to better understand the needs in the field.

Further work will concentrate on continuation of the longitudinal study with particular emphasis on practical approaches.

6.0 Acknowledgements

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Papers

Accomplishing the Vision and Mission of Higher Education Using E-Learning: The Catholic Institute of Business and Technology

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Abstract

For more than three decades e-learning has come to be recognised as a key for success at all levels of education (primary, secondary and tertiary) and for training and acquisition of industry specific skills in businesses around the world.

While rapid technological advancement coupled with the 4th Industrial Revolution has led to a growing interest in e-learning in recent years, the COVID-19 pandemic has accelerated and consolidated it. Employing a case study approach, this paper examines the important role e-learning can play in improving access and quality of not only higher education (HE) but also technical and vocational education and training (TVET) in Africa. In this regard, the Catholic Institute of Business and Technology (CIBT), a nascent University College in Accra, Ghana has tremendous but latent potential to make a significant impact in Ghana, Africa and beyond in this era of rapid global technological progress if the appropriate e-learning measures are put in place. Thus, through a case study approach and documentary analysis, this paper explores how e-learning as a tool can assist in attaining SDG4, which represents a critical enabler of a sustainable and robust revival from the COVID-

19 pandemic and the progress on all the SDGs (https://sdgs.un.org/events/driving-collective-action-sdgs-role-further-education-building-sustainable-and-resilient). According to United Nations Department of Economic and Social Affairs, COVID-19 has wiped out 20 years of education gains. The Sustainable Development Goals Report 2021 contends that the deployment of e-learning as a tool to remedy the situation is crucial for society, the education of its youth and its manpower development as well as job creation. Consequently, it examines and establishes how pivotal e-learning is to the progress of the CIBT vision and mission.

Keywords: (Higher Education, E-Learning, Business Technology, CIBT-Africa, Digital Divide)

1.0 Introduction

From the standpoint of higher education provision, it is important to put in context the available resources and consider the processes for delivery. E-Learning from the from the very beginning has and continues to playout as a solution for efficient and effective education delivery at all levels and in all communities. This is done by via enabling access and promotion of l=flexible and independent learning online.

e-Learning as defined in the UNESCO International Bureau of Education Glossary of Curriculum Terminology include ““[a]ll forms of electronically supported teaching and learning, especially the web-based and computer-based acquisition of, and engagement with, knowledge and skills. It may take place in or out of the classroom. It is often an essential component of distant education and may involve virtual learning environments” [1].

Additionally, e-learning is increasingly being perceived as a weapon to combat the challenges plaguing education. Particularly, in Africa, it is seen as a tool to decolonise the curriculum and implement relevant education, reported by Uhomoibhi [2] and Blignaut et al,[3].

Therefore, the authors present, argue and report that CIBT with its newly focussed plan, revived vision and mission, once implemented, is poised to deliver strong positive impact by widening educational access and enhancing the quality of not only HE but also TVET through e-learning; subsequently, contributing to the attainment of the fourth Sustainable Development Goal (SDG4) and its targets. E-learning is pivotal to enabling CIBT to assist in achieving SDG4 by ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all; and its targets (4.3 and 4.4) of ensuring equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university; and substantially increasing the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship by 2030 [4, 5, 6]

Approaches to education, teaching and learning have been revolutionised due to the COVID-19 pandemic disruptions. Consequently, the pandemic has altered HE's and TVET's existing strategies of teaching and learning, as well as their capacity to reach and engage students while simultaneously foregrounding the problems and inequities of those that lack resources for swift digital change and virtual learning. Doubtless, e-learning is central to the transformation of HE and TVET post COVID.

Furthermore, integrating the SDGs into HE (and possibly TVET) by mainstreaming and interweaving them into programmes, curricula and strategies of higher education institutions (HEIs) including e-learning strategies, will have the most significant effect on their implementation since HEIs serve as innovative hubs of critical thinking that nurture leaders, policy makers, educators, entrepreneurs, scientists, researchers and many more.

2.0 Background and Problem

2.1 History

CIBT is a university college established under the auspices of the Catholic Archdiocese of Accra in 2007 with the motto "For God and Country" (Pro Deo, Pro Patria). CIBT is accredited by the National Accreditation Board (now the Ghana Tertiary Education Commission [GTEC]) and affiliated to the University of Ghana (UG) and the Kwame Nkrumah University of Science and Technology (KNUST). As a tertiary institution, its first batch of students graduated at the end of the 2011/2012 academic year. While its vision is to become a leading tertiary institution, a place of excellence, devoted to providing an intellectual, moral and social environment that responds to the needs of a rapidly changing society; its mission is to create a unique institution in which the core education values of excellence and integral human formation are effectively functioning, and professional education provides access to various fields of human endeavour such as business, technology, arts, social and natural sciences. It aims to offer opportunities for students to broaden their horizons by transcending their academic disciplines, and specialised fields; and cultivate the spirit of entrepreneurship, innovation and critical thinking.

The CIBT, first located at Tantra Hills in Accra, later moved to its current campus located in the heart of the City of Accra. Currently, CIBT runs a number of undergraduate degree programmes including Bachelor's degrees in Business Administration, Public Administration, Procurement and Supply Chain Management, Information Technology and Religion. Significantly, the institution's main goal presently is to charter and assume autonomy in the next couple of years. Consequently, it aims to meet the requirement of establishing two or more faculties. Thus, it is set to soon introduce several degree and non-degree programmes which will include Law, Agribusiness, Computer Science + Technology and Education courses as well as professional workshops for adult students and new Certificate and Diploma programmes. Its plans also include collaborations with the Commission for Technical, Vocational and Training (CTVET) to facilitate the running of TVET courses.

The primary goal of CIBT is to prepare individuals for successful professions in business, government, and non-government organisations. The overall objectives of the Institute are to provide its graduates with skills needed to meet the challenges of the everchanging environment in which organisations operate and to equip them for advanced studies.

2.2 Current Challenges

Presently, aside its natural resources, the youth constitute Africa's unlimited resource. Its youth population is rapidly rising and expected to grow to over 830 million by 2050. Despite the economic potential of this population, many youths in Africa do not benefit from robust human resource development and economic prospects. Currently, a third of the nearly 420 million youth aged 15-35 are jobless and marginalised, another third is underemployed and only one in six is in paid employment.

Confounding the extreme levels of joblessness and underemployment, Africa's youth encounter various setbacks varying from mixed growth economies, lacking in job creation capacity for its fast-growing populations, to the global financial crisis. Africa is the only region where the youth swell will grow in the imminent future. This provides either the opportunity to exploit the demographic dividend or the risk of an ominous catastrophe jeopardising social cohesion caused by the absence of appropriate policies to harness this dividend fused with substantial migration in search of greener pastures.

Bearing in mind the dire economic situation and insecurity throughout the continent, it is urgent to explore and deliver options and viable solutions to improve employment conditions. This brings the higher education environment into focus. Universities are producing graduates with deficient skills, who must be re-tooled to meet industry exigencies. While more employable graduates are needed, universities must not only focus on producing job seekers but also job creators. Thus, universities are embracing entrepreneurship and innovation as empirical solutions to the youth employability problem.

Compounding this problem is the challenge of the general poor access to quality education in Africa, reported by Takyi-Amoako [7]. While globally, Africa's population is the most vibrant and youthful, its education sector paints a bleak picture and threatens to leave this tremendous human resource potential untapped if deliberate bold steps are not taken. As far as (formal) education is concerned, Africa lags every other region or continent in this world, and yet in 2020, 3 out of 5 Africans were under the age of 25, which will be 1 out of 2 Africans in this age group by 2050 (according to Takyi-Amoako forthcoming; UNICEF/AUC 2021 [8].

Going beyond their traditional roles, universities must function as change agents and catalysts of economic progress within their diverse settings. In the process, they ought to consider the higher education objectives of the Continental Education Strategy for Africa (CESA 16-25), which are in line with the African Union

Commission Agenda 2063 and the Common African Position (CAP) on the Post-2015 Development Agenda and the United Nations Sustainable Development Goals (SDGs).

The CIBT is very much interested in the future of the African continent and the sacred and secular progress of its rising youth population. The spiritual, moral and material formation of the individual is critical. Therefore, the aim of the CIBT is to morally form the character of its students while intellectually developing them and training them to be entrepreneurial and innovative to respond to the dire challenges of Ghana, Africa and the world. The CIBT's purpose is to develop the whole person for the progress of society.

Now that the flagship project of the African Union's Agenda 2063, the African Continental Free Trade Area (AFCFTA), which creates a market of 1.2 billion people with a combined GDP of $3 trillion has been launched in Accra (just a short distance from the CIBT), the CIBT must leverage this opportunity to contribute to the acceleration of economic integration on the Continent through its teaching and learning, knowledge creation and consultancy services (Africa Renewal Magazine 2020). Indeed, the CIBT, which is strategically and geographically positioned and surrounded by reputable tech companies, top financial and consulting firms can assist effectively in implementing this AFCTA vision.

3.0 Study Approach and Methodology

According to studies, scenarios are employed as a scholarly methodology that enables the researcher to explore, iterate and revise. They help to challenge existing assumptions, identify novel lines of inquiry, and create opportunities for new research to emerge, —thus, unlocking a research approach that equips engrossed researchers to understand and tackle complex and uncertain contexts and generate interesting results. Fundamentally, scenarios as a research methodology supplements conventional research methodologies by generating opposing ontologies about the future. The scenarios methodology exposes assumptions, ensures that they can be discussed, and establishes if the concepts employed in framing knowledge can credibly be substituted with alternative concepts to stimulate alternative knowledge and action as reported by Ramireza, Mukherjeeb, Vezzolic, Kramerd [9]. It is considered a research strategy that is categorised as creating knowledge by means of action to explore a subject according to Morgan [10]. It involves a "social-reasoning process which utilises dialogue and conversation to share participants' perceptions of the environment and to facilitate . . . interactions . . . in a process of sense-making through theory building and storytelling" as reported by Wright and Goodwin [11]. While it is regarded by some as "an appropriate mode of theorizing" according to Chermack [12] (2007: 7), and therefore empirically, "statements about futures are neither true nor false" according to Dufva and Ahlqvist [13], and thus, cannot be considered 'objective' according to Lloyd and Schweizer [14], others observe that scenarios methodology offers a useful means of generating novel ideas reported by MacKay & McKiernan [15], and foregrounds 'what-if' questions in research during

challenging times [16]. Ravetz [16] indicates that "with 'what-if?' as the leading question, our whole conception of the scientific enterprise could evolve in a fruitful way" (p. 536) "…indeed, it is when we are accustomed to asking 'what-if?' (that we) expect... the unexpected (and) fully appreciate how no single perspective can completely capture any real situation. This is what genuine complexity . . . is all about." (p. 537).

Thus, the e-learning scenarios will explore: 'what' levels of improved access to and quality HE and TVET would be attained 'if' e-learning models are adopted at CIBT; what models of e-learning are appropriate and effective if CIBT aims to help address the problems of low access and quality in HE?

Scenario as a methodology enabled 'what if' questioning to complement more traditional 'what' and 'how' questions such as whether e-learning increases or decreases access to and quality of education in HEIs. Scenarios as methodology constitute what Morgan [[10] termed "an approach to research that is substantially rational", which implies that its experts cultivate observation and questioning abilities that scrutinise their own decisions and oblige them to select smart options regarding the procedures they implement and their purpose and significance. It is also to keenly study the choices that promote the several possible forms of knowledge awaiting to be deployed, with dynamic expectation of the outcomes of such deployment. This resonates with the view that central to future studies are not only multidisciplinarirty and transdisciplinarity, but also undisciplinarity, which imply the deliberate rejection of the position and nature of discipline while enacting a well-developed and ordered research methodology (Sardar 2010). Nevertheless, scenarios as a mode of critical inquiry are taxing in regards to resources, time and effort in grasping the relevant thinking, techniques, tools in a manner that ensures accessibility to all stakeholders. In any case, it is envisaged that novel technologies will enhance its accessibility according to Ramireza, Mukherjeeb, Vezzolic, Kramerd [9].

4.0 Barriers to Education Innovation and Sustainable Development

In higher education context there is a link between innovation and sustainability. The fundamental barriers include a lack of willingness of leaders, policy makers and decision makers to envisage a sustainable future inside universities and lack of support of senior management for bottom-up sustainable initiatives.

The use of e-learning in education has been innovative. At CIBT, following frecent developments and COVID-19 pandemic this has been considered an important area of focus for all stakeholders including staff and students.

The link between education development and sustainable development are related and on convergence often result in long-term impact and benefits [17] We

distinguish between two types of innovation in relation to sustainability. They include structural and operational innovation. Structural innovation involves changes in structures, hierarchies and governance in an organization. Operational innovation is used to describe the introduction of tools which may enhance and maximize the operations of the institution. Then arises the question of how can innovation and sustainability be integrated in order to maximize their advantages for universities? In order to answer this we have recourse to the four main principles which guide innovation in the field of sustainable development. They include the principles of ingenuity, simple implementation, environmental efficiency and economic viability. The principle of Ingenuity is for instance where innovation is often the implementation of a simple idea put towards a greater use. In the case of simple implementation, the best types of innovation in the field of sustainable development are those that are simple and easy to implement. For Environmental efficiency, it is, that some types of innovation can lead to real impacts in areas such as energy consumption and reductions in CO2 emissions and the fourth principle of Economic viability, is where innovation in the field of sustainable development can also help to reduce costs and minimize the loss of financial resources. Well defined areas of application and clear process of integration are key ingredients for achieving sustainability.

The obstacles to education innovation and sustainable development are identified to include (i) Lack of specific working groups, committees and sustainability offices comprising formal groups and dedicated offices to offer guidance. These groups must be multidisciplinary and hierarchically multi-layered. (ii) Cultural and behavioural change - sustainability is a broad issue that requires cooperation at multiple hierarchical levels, isolated efforts may therefore be limited in terms of their impact [18]. Recent study suggests that cultural changes are the best way to pursue sustainability [19]. (iii) Lack of financial resources, which prevents growth and development, crippling most of the systems and progress. (iv) Lack of engagement between municipalities, companies and universities - In general, the engagement of municipalities and the private sector within universities consists of activities regarding capacity building, community outreach and problem-based research [20, 21]. Very often initiated by staff or student bodies, engagement activities which targets the provision of solution to an existing specific problem within the local communities or the private sector. These academic research activities do result in engagements in less organizationally embedded but highly autonomously individually driven projects. In communities where there abounds the necessary facilitation, community learning and continual efforts directed at building capacities, Higher Education institutions have the potential to enable the development of more sustainable ways of living. (v) Lack of reporting and accountability mechanisms - The United Nations and other various other education for SD declarations lack discussion on a requirement for reporting or accountability mechanisms [22, 23]. This makes it difficult for universities to track their specific in-house achievements or inadequacies so as to support policies and learn from the experiences of others.

5.0 Conclusion

Over the years, e-learning has remained a solution to the many challenges faced by tutors, learners and administrators in educational institutions and in the very recent times in society at large. Educational institutions have the potential to play a significant role in fostering sustainable development through the provision and use of a framework based on the integration of the economic, social, and environmental dimensions. This would involve the adoption of an interdisciplinary approach; teacher training, comprising pre- and in-service); implementation of curricula based on the three pillars of sustainable development comprising social and environmental justice, meaningful political participation and respect for local and indigenous cultures. In the context of current developments especially as our current study shows, cultural diversity presents the opportunity to strive for development while reconciling the economic, social, and environmental concerns. There is the need to integrate traditional knowledge with new technology.

The current study shows that many higher education institutions are yet to advance in a number of areas that are required for the full implementation of sustainable development principles. For most of the cases adjustments are required in campus operations, supported by best practices leading to improvements in performance and fostering good relationships with principal actors both inside and outside the institution.

In the face of the present situation specifically in Ghana and generally in Africa, the use of e-learning is seen as core in the delivery of the right type of education for the population (especially the youth), creation of employment and the development of manpower. We conclude that investments in e-learning in important, strongly facilitating institutions like CIBT to accomplish its mission and vision as a provider of higher education in the Ghana and in Africa.

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Bios

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James Uhomoibhi, is an academic of strong international standing in Physics, Computing and Engineering. He has a first degree in Physics from Nigeria, a BPhil degree from Italy, MSc in Optoelectronics and Optical Information Processing and a PhD in Laser Physics from UK. Following his initial appointment as lecturer in Queen's University Belfast he completed a PGCHET in Higher Education. Today he is at University of Ulster where he was Faculty e-learning coordinator (2004-2015) and now lectures in Engineering whilst researching in computer science and education. He is a visiting Professor of Physics, Computer Science and IT in two Nigerian Universities. He is also a visiting Professor of Science, Technology and Environmental Studies at the Open University in Tanzania. James is a Chartered

Physicist and a member of the Institute of Physics; He is a Chartered IT Professional and a Fellow of BCS and also a Fellow of the UK Higher Education Academy. James Uhomoibhi is the African Laser Centre Representative in Europe and has served as Head of SEFI Task Force on European Cooperation with Africa. SEFI is the European Society for Engineering Education. He also sits on the Board of the International Network for Engineering Education and Research (iNEER). He is a member of Council of SEFI and of the BCS, the Chartered Institute for IT. James Uhomoibhi is a member of the Diversity and Inclusion Committee (DIC) and the International of the Institute of Physics (IoP). He is the founder and current Chair of the BCS e-Learning Specialist Group. In 2011 James Uhomoibhi was appointed a LEADS Scholar by the Nigerian National Universities Commission (NUC), charged with the responsibility of linking experts and academics in the Diaspora to the country. He is a recipient several academic and community awards including amongst others, the iNEER Global Achievement Award in Engineering Education (2011), Belfast Ambassadors Award (2012), BCS Long Service Award and the Distinguished Service Award of the Powerlist All Ireland African Leadership Excellence Award Programme, which he received in 2012. James Uhomoibhi very recently received the Sentinus Ambassador of the Year 2016 Award for outstanding works and contributions to STEM Education and Research Development and Implementation in Northern Ireland, UK.

E-Learning Strategy in Higher Education Institutions in Developing Countries: The Role of Organizational Resources

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Abstract

Many higher learning institutions have adopted e-learning in order to solve learning and performance issues as well as to gain competitive edge. E-learning has reshaped delivery modes in higher educational institutions. Several factors have been identified which influence the development and implementation of e-learning. Organizational resources is one of the factors that influence effective implementation of e-learning. This paper examined e-learning strategy in higher education institutions in developing countries with specific focus on the role of organizational resources. The paper answered the question what is the role of organizational resources on effective implementation of e-learning in higher education institutions? The paper was anchored on Resource Based Theory of the firm and utilized archival data. The study concluded that organizational resources play a significant role in the implementation of e learning in higher education institutions in developing countries. Recommendations that may be adopted have been articulated in order to revitalize e-learning strategy by utilizing various organizational resources. The findings will help in the management of the e-learning system and will provide insights which may aid stakeholders to develop e learning policies.

Keywords: E-learning, Higher Education Institution, Organizational Resources

1.0 Introduction

According to Gallagher and La-Brie[1] online education has entered the mainstream and become a growing market in the 21st century as it has enhanced accessibility to learning for more people. According to Selim, [2] and Eke [3] , e learning is the delivery of course content via electronic media. The desire for expanding and increasing accessibility to higher education has resulted to introduction of information and communication technologies in many countries in the form of (e-learning). Most Of the developed and developing countries today, regard higher education as a critical agenda issue since economic development depends on the availability of a workforce that is educated and skilled as well as on technological improvements that increase the productivity level[4] .

In order to continue being competitive, universities have engaged in the practice of delivering courses via online technologies [5]. E-learning has become popular amongst the institutions of Higher Education due to increase in demand for education and even the rapid internet technology expansion [6]. This trend has made it necessary for universities to consider the new opportunities that have been offered by the distance education technologies.

E-lcaming is actually a revolutionary way of empowering learners with skills and knowledge they require which is convenient in terms of time and space. According to Wannemacher, [7] Leaming Management Systems (LMS) have slowly been introduced in universities in Kenya so as to improve learning, instruction and also to obtain competitive advantage. E-Learning has been recognized as being critical as it enhances performance in the education sector [8]. Studies have confirmed that e learning is user-friendly since it is flexible in terms of accessibility and usability [9, 10, 11]. It allows students to study on their own without direct control and supervision [12, 13, 14]. Many Institutions of higher learning have ventured into e-learning since it results to cost reduction and efficiency, its transparent, scalable, flexible, accessible, consistent and it improved performance of students [15, 16, 8]. Furthermore, it improves learning outcomes in the university since students tend to have more interactions in e learning environments [17, 18, 19, 20]. E-Learning has thus become an indispensable educational technology tool [21] and a realistic strategy to increase participation in education by increasing accessibility.

Resources are a vital source of organizational performance [22]. Firm resources can bolster performance if well used, managed and even controlled [23]. Firm resources are assets or production inputs that are owned, controlled or accessed by an organization [24, 25]. According to Lee and Whitford [26] resources are assets that may be used by an organization to enable it achieve the set goals. There are various types of firm resources such as physical, reputational, intellectual, technological human, and financial [27, 28].

This study focuses on financial, human and technological resources. Financial resources are critical as they affect a firm's ability to execute the given tasks.

Finances are required by higher learning institutions to effectively develop and implement e learning. Financial implications have a direct influence on e-learning implementation in any institution. Finances are a necessity for acquiring the required technology, for developing courses and support [29]. A number of studies support the need for adequate financial resources in implementing e-learning [30, 31, 32].

Human Resource is important asset in any organization. They can be casual, temporary or even permanent [33]. Human resource entails the knowledge, ability, experience and skills rooted amongst staff. Higher learning institutions should have staff that are well equipped with knowledge and skills on e-learning for smooth adoption.). Studies have acknowledged that trained and technically competent faculty had the skill and also experience in eLearning and encouraged the use e-learning by students [34]. Lack of adequate ICT skills has hampered effective implementation of e learning [35, 36, 32,37]. Lack of training can actually prevent the effective utilization and the possible benefits that could be enjoyed by using the system. E learning success requires large infrastructural investment. Lack of technological resources limits effective implementation of e learning [35, 37,38, 39,32].

According to Govindasamy [40] many Higher Education institutions as well as Institutes of Corporate Training have resorted to e-Learning so as to solve learning and performance issues and also so that they are not left behind. Higher Education is undergoing considerable change in response to multiple factors for instance the development of information and communication technologies, globalization, internationalization and regionalization, an advancing network society and knowledge society, socio-cultural trends, demographical trends and the marketization in higher education, including the changing roles of governments.

1.1 Statement of the Problem

Increasingly, a number of universities worldwide including those in Africa are attempting to implement e-leaming strategies so as to enhance quality, equity, share the instruction using technological resources, to compete globally and meet the ever increasing demand for tertiary education. It is thus indisputable that e-learning is a critical tool in education technology [21]. Despite its benefits, its successful implementation is yet to achieve fruition [41].

Nchunge, Sakwa and Mwangi, [36] reiterated that studies had shown that in the developing world, the ICT adoption levels amongst HEIs in comparison with the developed world was unfavourable. On the same vein Sargent, Hyland and Sawang [42] posited that there was a low level of adoption rate for technology. Further according to Buabeng-Andoh [35] available literature depicted that in developing countries universities had experienced a lot of challenges while implementing e-learning for teaching, learning including research and that there was limited investment in ICT. Moreover, studies have established that in the developing countries which practice asynchronous e-learning, quality issues have been

experienced. The key issues highlighted include poor ICT infrastructure, lack of ICT skills, low internet, inadequate financial support, poor administrative support, having ambiguous policies, lack of training, demotivated instructors, lack of full utilization of LMSs [43, 44, 45, 46, 47]. Additionally, in developing countries, the absence and also inadequacy of infrastructure has been identified as being a barrier to accessibility amongst students [16]. This paper therefore intended to examine e-learning strategy in higher education institutions in developing countries with specific focus on the role of organizational resources.

1.2 Research Objective

This paper examined e-learning strategy in higher education institutions in developing countries with specific focus on the role of organizational resources.

1.3 Research Question

What is the role of organizational resources on effective implementation of e-learning strategy in higher education institutions?

2.0 Literature Review

2.1 Theoretical Framework

This study's conceptualization is anchored on Resource Based Theory (RBT) [22]. The RBT postulates that an organization's resources are its source of performance and also competitive advantage. Thus a firm's different resources can actually have a significant influence on its performance. The resources in this study are the financial, human and technological resources.

2.2 Empirical Literature Review

Several studies have been conducted on the implementation of e-learning in developing countries. Wamae [31] established that poor connectivity, unreliable power supply, inadequate financial resources, inadequate infrastructure as factors that hindered effective implementation of e learning in Kenyan higher education institutions and recommended for training of staff and improvement of infrastructure and technology.

Munguatosha *et al*. [30] contended that in developing countries, factors such as self-efficacy, a reliable technical including administrative support, infrastructure, system interactivity, adequacy of budget, accountability and a flexible institutional structure affected the implementation of e-learning in institutions of higher learning.

Nyerere, Gravenir and Mse [48] and Mpofu et al. [49] found that a large number of the academic staff who facilitated ODeL lacked special training on content delivery

and were ill equipped in handling e-learning pedagogy. Mutisya and Makokha [50] conducted a study on challenges affecting e learning adoption and found that staff lacked adequate capacity for handling e-learning and this resulted to its low adoption. Blinco, Mason, McLean and Wilson [51] articulated that for e-learning to be successful the instructors and students should have adequate technical skills to enable them use e-learning tools.

Institutions that provide e-learning must ensure there is adequate technological infrastructure, which includes network connections, computers as well as technical support for students and staff. [52]. Having regards to technological aspects that should be considered Sanders and Nagelhout [53] noted reliability, quality including medium richness. For online courses Universities should have modern supportive quality technology with an appropriate in transfer knowledge [18, 54, 55, 56]. According to selim [19] the IT infrastructure in the university should be rich, reliable and have the capability to provide the courses with required tools to ensure the delivery process is smooth. A study by Al-Ghaith, Sanzogni and Sandhu [57] established that Internet quality was an important factor that influenced the adoption as well as usage of e-services in Saudi Arabia. Tarus [58] found that inadequate ICT and e-learning infrastructure were amongst the key barriers to e learning adoption in Kenyan public universities.

In a related study, Kasse and Balunywa [37] assessed e learning implementation in Ugandan higher learning institutions. Their study revealed infrastructural challenges faced by the institutions included lack of electricity and unavailability of Internet connectivity and also technical incompetence. Further in a study done in Tanzanian higher learning institutions also confirmed that power outages and inadequate ICT infrastructure were key challenges for e-learning adoption. [38].

According to Ridley-Duff [59].every business enterprise requires adequate finances for growth and development. Finances determine organization's growth and survival [60]. According to Arafeh, [61], Perraton [62] and Trucano, [63] few rigorous studies in relation to costs on technology applications in higher education in developing countries exist.

For an online learning course to be implemented it will require adequate budgetary allocation [64]. Online learning systems budget involve high investment costs as well as long-term sustainability[65,66]. Schmidt and Keil [67] held that an organization's budget and allocation for resources should be reinforced by a strategic plan to ensure a smooth and consistent implementation.

Wallet [68] found that ICT expansion in education sector in Sub Saharan Africa was slow because of corruption, absence of efficient policies, lack of basic infrastructure such as classrooms, electricity supply, computer labs, internet connection, inadequate financial resources and lack of qualified teachers, with the challenges being experienced more in rural areas. In their study on preconditions for successful implementation of e learning Tarus and Gichoya [69] confirmed that majority of the

respondents considered financial allocation as being a key component for e-learning activities such as installing and maintaining the e-learning platform, training instructors, developing e-content and e-learning infrastructure development.

Aung and Khaing [70] identified major challenges faced by developing countries in regards to e-learning systems implementation and found that there was a poor network infrastructure, lack of knowledge in ICT, weakness in content development, language incompetency etc. Similarly Babiker [71] found that in Arab countries experienced challenges such as ICT Infrastructure, copyright issues, local content and culture while implementing e-learning. A study by Odero and Abdillahi [72] in regards to students perspective on challenges in adopting online learning in a developing country highlighted some challenges which included lack of computers/laptops, lack of adequately equipped computer laboratories, limited access to internet, slow internet connectivity, Inadequate ICT skills, unreliable electricity supply amongst others. Similar sentiments have been echoed by a study by Odero [73] on effectiveness and challenges of online learning in Kenyan public universities.

3.0 Research Methodology

This paper examined e-learning strategy in higher education institutions in developing countries with specific focus on the role of organizational resources. The study used archival data obtained from analysis and synthesis of empirical studies secured from articles in peer reviewed Journals, Thesis and conference proceedings.

4.0 Findings

The findings of the studies reviewed demonstrate that in the absence of organizational resources such as financial, human and technological resources, the implementation of e learning in higher education institutions remain elusive. Studies done in developing countries have highlighted key issues that hamper adoption of e learning such as poor ICT infrastructure, absence of ICT skills required for use of e-learning, low internet, insufficient financial support, poor administrative support, ambiguous policies, lack of training, demotivated instructors, lack of full utilization of LMSs [70, 43,45,71,44,46, 72,73, 47,68]. The challenges highlighted revolve around organizational resources. Thus, organizational resources have the potential to improve activities linked to e-learning implementation so as to fully support educational activities in higher education institutions.

5.0 Conclusions and Implications of the study

The study concludes that organizational resources play a significant role in the implementation of e learning in higher education institutions. E-learning strategy can enhance an institutions competitiveness due to the benefits derived from it. The

results of this study provide useful information to the managers of Higher education institutions in developing countries on the role of organizational resources during the process of implementing e learning. The resources identified as financial, human and technological can assist the institutions to increase the efficiency as well as effectiveness of the adoption and implementation process. The findings may provide insights which may aid in the development of e learning policies.

6.0 Recommendations

Regarding financial resources the study recommends that the management of higher education institutions should provide special budgets to facilitate E-Learning, should provide finances which can be used to purchase new equipment or even upgrade the existing ones, to hire competent technical staff, train staff, develop e content and can also be used to install and maintain the e-learning platform. The funds should be disbursed on time. Further the institutions should engage in public-private partnerships so as to mobilize resources to support e-learning initiatives.

On human resource the study recommends that higher education institutions should hire competent and adequate staff who can handle e learning issues. Both students and staff should receive proper training on the e learning system so that they may gain learning as well as teaching skills. Further, professional training can improve the instructors' capabilities in accessing virtual class facilities as the instructor will be empowered on how to manage various technical applications such as assignments and tests, course messages, the discussion board, and also grading for effective and efficient course management. Management should promote development of e-learning resources by organizing workshops and conferences for the instructors.

On technological resources the study recommends that higher education institutions should install an enhanced high-speed internet bandwidth for the e-learning system, there should be a reliable power supply, institutions should frequently upgrade their software, provide adequate laboratories that have a high computer inventory with an uninterrupted network amenities as this may motivate both the students and instructors. The management should improve on the existing e learning infrastructure and technology and ensure that it is user friendly and reliable. Management should ensure there's frequent monitoring and evaluation to ensure the resources provided are able to enhance implementation of e-learning so that if there are any stumbling blocks corrective action may be undertaken.

7.0 Suggestions for Further Research

Obviously, many more studies should be done on the implications of human, financial and technological resources on the adoption and implementation of e learning. Further studies may be done on other factors that may influence implementation of e learning such as instructor attitude, demographic factors and ethical dimensions.

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Digital Learning: Approaches to Teaching in Developing Countries

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Abstract

In Kenya, the growing levels of informality in employment as livelihood options and the impact of the COVID-19 pandemic calls for the prioritisation of eLearning as it is key to achieving educational goals. Education plays a significant role in realising a better quality of life, SDGs and general economic growth.

As was the case globally, schools in Kenya were closed to contain the virus, which meant moving to online learning for learning continuity. The pandemic created the space for fast-tracking eLearning. It exposed the limitations of implementing eLearning goals due to resource scarcity in impoverished developing countries, reflected in uneven ICT development in the case of Kenya.

This paper argues that the underlying reasons are two-pronged, with poor policy design and implementation playing a role alongside a lack of resources, including ICT infrastructure. Given systemic weaknesses in delivering equitable education for developing countries like Kenya, this paper outlines the challenges and explores the gaps in delivering eLearning. It aims to contribute to discussing the changes and enhancement of teacher roles within eLearning and in situations of resource scarcity.

This study utilises desktop studies of secondary data from journals and policy documents. The global SDGs offer a framework for emphasising the importance of a holistic body of goals and indicators highlighting education's prominent role in development. It argues that

eLearning is necessary for education as both means and ends due to technology's promise and trajectory.

Keywords: E-Learning, Development, Education Policy, Teacher training, Pedagogy

1.0 Introduction

The challenge of implementing eLearning is reflected not only in resources to deliver eLearning but a lack of engagement from teacher training institutions to equip teachers with tools and pedagogical skills [1]. The impact of the global COVID-19 pandemic propelled institutions, including academic institutions, into embracing computer led solutions [2, 3]. Like most countries, Kenya included an ICT policy, albeit with uneven penetration mirroring the prevailing poverty, gender and inequality challenges [4, 5, 6]. In addition, the growth of informal livelihoods is a factor where over three-quarters of the population are informally employed and live in informal housing and slums [7, 8, 9]. These have implications for eLearning as a consequence of the pandemic [9]. And digital inequalities, both gendered and income-related [10], impact ICT distribution and access. This, in turn, affects the population's ability to access digital services [3].

Together with the national policies on IT, integration in education necessary for eLearning are global imperatives [11, 12, 13, 14]. For example, UNESCO's planning for Information and Communication Technology (ICT) in teacher education cites three key principles for effective ICT development in teacher education include infusing technology in all aspects of teacher education programme; Introducing technology in context; and the encouragement of students should experience innovative technology-supported learning environment in their teacher education programmes [1]. This is the move from teacher-centred lecture-based learning to learner centred interactive learning environment. In Africa, there are gaps in teaching skills, especially digital skills necessary to develop learners and labour in the emerging digital world [15, 16, 17].

Technological developments are shifting teacher-centred, lecture-based instruction to student-centred, interactive learning environments [18]. However, meaningful technology integration requires pedagogy to integrate technology in their planning and effective classroom instructional delivery [19]. And in addition, technology possesses the quality of enhancing communication [20]. The specific teaching and learning needs demand particular technology use that matches technology to teach in innovative ways. This not only enables teaching better but can also serve to enforce parent-teacher collaboration in curriculum development, creating a continuum from the institution right down to local support [21].

Challenges facing the integration is technology in teaching are rooted in teachers themselves lacking access and knowledge about the technology. Some research has

gone into integrating ICT into the curriculum In Kenya [22, 23]. Among the reported challenges impeding integration are resistance of teachers to embrace innovation; lack of infrastructure for ICT integration; negative attitudes of teachers towards integrating ICT; and school management related problems.

2.0 Resistance to Change

In the last decades, many developing countries, even those with robust ICT integration in other sectors such as trade and general communication, have lagged in teacher training programmes [24]. The older generation of teachers is likely to resist ICT integration due to a lack of exposure. In comparison, the younger generation of teachers is more likely to embrace change as they are exposed to ICT penetration in other sectors [1]. As much as the younger preservice population are amenable to ICT integration, they are faced with teacher educators who, due to long experinc3es with traditional modes of learning, now find it challenging to integrate ICT for education training the younger teacher students. The development of partnerships with other higher education institutions that facilitate technology-rich content would be a way to engage, but this is also an avenue that embedded teacher trainers are wary of [1].

3.0 Lack of infrastructure for ICT integration and School management related problems

Various technological resources are necessary for pedagogical ICT integration. In ICT terms, all integration strategies require hardware, equipment, and software, including the relevant programmes. Hardware includes computer laboratories, workstations, laptops, desktops, mobile phones, radios, calculators, projectors and video recorders [25]. The software needed for content knowledge is divided into three to support pedagogical aims: (1) instructional programmes designed to teach skills or information by demonstrating examples, explanations or problem-solving. (2) productivity programmes which help teachers and students to plan, develop materials and keep progress records and (3) Administrative programmes utilised by school administrators at school, county, and nationally providing data that facilitate an exchange of information among various stakeholders [1].

These challenges beg several questions: What is missing in the teacher education and training curriculum? Is there skill training and maintenance for teachers? Do the teacher training institutions have the necessary infrastructure for ICT integration? This paper reports on the findings of a study that attempted to respond to these questions.

4.0 Education Policy Design

On the Issue of resourcing e-learning, there is the need to consider education policy design. The design and implementation of a successful ICT enabled teacher education programme is key to the fundamentals of education reforms the government has put forward as necessary to realising Vision 2030 [12]. The onus is on teacher education institutions to adopt and engage in the transformation of education or risk being left behind due to rapid technological change [26]. Both the pre and learning teacher trainees should be designed for and benefit from new models of pedagogical tools for learning [26].

SDGs realisation and ICT development and education are evolving discourses with common aims [27]. Scholars, including Heeks and Ospina, among others, have documented ICT's widespread impact and solutions for developing countries, covering, among other themes, technology and knowledge transfer, processes and socially embedded nature of actions, and transformative intervention [28, 29]. Included in these is democratising education, one of ICTs' primary uses often as an overlapping concept with blended learning, eLearning, online courses, and online or distance education [30]. Kenya's strategic plan, Vision 2030, cites technology establishment as one of its key aims. However, ICT integration has been sporadic and uneven [31, 32, 33, 34]. Kenya boasts one of Africa's fastest-growing mobile and ICT growth trajectories [12]. However, the growing inequality both globally and in Kenya [35], reflecting educational outcomes and access to digital resources, contributes to the ever-increasing digital divide [36, 37, 38, 39]. The digital divide is the gap between the digitally literate and those unexposed or illiterate, sporadic users and non-users [40]. The statistics are damning. Only an estimated 22% of Kenyans in public primary schools have access to digital learning [40, 38]. Considerations of private schools shift the numbers to 48%, demonstrating evidence of the digital divide.

Curriculum change has characterised the Kenyan education system. Since independence, there have been several curriculum changes characterised by long implementation periods and failing to evolve to meet national and global requirements. Teachers' resistance to shift from one curriculum to the next, as well as incompetence and lack of sensitisation and training prior to the introduction of a new curriculum, are cited as the reason for slow uptake by teachers [19, 38, 40]. Teacher understanding of the new curriculum, ownership of it and implementation of it depend on how much knowledge they have on the curriculum change meaning characteristics of the innovation, context and content.

These goals can only be achieved through the close coordination and collaboration between teacher education institutions and stakeholders in the educational system, which means working closely and effectively with administrators, national or state educational agencies, teacher unions, business and community organisations, politicians and other important stakeholders [12, 41].

Despite growth in the number of institutions offering teacher training, Access to resources is a crucial challenge. Many do not have the learning resources, and some even lack basic libraries [25]. The capacity of these institutions to link theory to practice is evident, and many graduating teachers fail to master education media practical units to enable their capacity to integrate ICT in their future classes [19, 1, 20]. The inevitable outcome is technologically incompetent teachers, whose lack of interaction with technology training culminates in their resistance to technology but will also fail to contribute to the country's education policies and broad plan to realise Vision 2030.

A good curriculum, especially one that challenges to integrate ICT meaning change, requires good teachers. Therefore, there is a need for continuous professional development in pre-teacher training and within-teacher training as well as with practising teachers. This can be a path to retrain teachers who failed to engage with ICT in their training and update existing competencies in a world experiencing rapid technological evolution. The Kenya Institute of Curriculum Development would have achieved its aim of transforming the curriculum to meet the needs of Vision 2030.

Waning teacher enthusiasm and morale and a lack of incentives as it is established that teachers are reluctant to change teaching styles and habits(ref). Due to poor remuneration, among other factors, and minimal time spent preparing to make time for other priorities, top of which is economic subsidy projects, there is scarcely any motivation or time left to train. Incentives that could successfully motivate teachers to participate in professional development of ICT workshops, including certification of training by the Ministry of Education, public recognition and time allocation by supervisors, which reduces isolation and increases professional satisfaction and, in turn, results in enhanced productivity and opportunities to become a Trainer of Trainers.

6.0 Changing Teacher Roles

The changes necessary in pedagogical practices are possible under certain conditions [1]. They include: (1) Attitude led to changes, including a shared vision of technology integration. This involves all the stakeholders in the continuum of entities necessary for effective integration from institutions to the home [20]. (2) The standards and requirements for curriculum support, including content and technology, should be complementary, reflecting the appropriate teaching [25]. (3) Policies that ensure the appropriate use, including equitable access and security, should be put forward. (4) Skilled personnel and opportunities for professional development coupled with access to technical assistance for students and teachers (5) Community-wide engagement, including partnerships and collaborations [19].

The rapidly evolving technologically led global environment requires that, given the deficit present in Kenya, an assessment of the actual state and magnitude of the

deficit is established [25]. The set of standards for teaching skills and knowledge in the use of technology produced by International Society for Technology in Education (www.iste.org) offers a starting point as a useful diagnostic tool to determine competency levels and basic content of teacher professional development programs. There is no single set of standards that "fits all" as different socio-economic, cultural, educational, and technological existences require different approaches. However, minimum guidelines and suggestions for the content of teacher professional development in the use of technology are necessary(ref). The requirement for training is a non-negotiable imperative(ref). In addition, creating teaching content links curriculum objectives to technology-led and technology-based activities. This includes developing lesson plans and evaluation strategies s that incorporate technology. The construction and use of education websites, the dissemination of information on ethics, and the use of ICTs are some of the competencies that teachers experiment with and explore as they evolve in ever-increasing advanced applications.

7.0 Conclusion

Digital learning has a lot to offer the tutor and learner, creating opportunities that have hitherto not been fully recognised nor explored in detail. It has also exposed challenges posed for learners, researchers, teachers and institutions in the provision, delivery and sustenance of education in society. Collaboration is made possible where team can act as single-source author involving subject matter experts and peers thereby allowing the giving of real time feedback. The ability to reuse and personalise content allows for the achievement of a close-to-true flexible and independent learning. This also minimises costs on the long run potential increasing access to education. The big challenge posed by digital divide and weaknesses in policy for digital learning is exposed especially in developing countries, as highlighted in this paper using Kenya. Drawing on data from diverse sources whilst considering the sustainable development goals (SDGs) and the prominence and significance attached to education, we highlight the need to intervene to address and bridge the gap created by digital divide at all levels in to make way for the creation of appropriate space, tools and skills for digital learning, taking into consideration, both the content and context.

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Impacts of COVID-19 on Distance Education in Higher Education: A Descriptive Analysis

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Abstract

Covid-19 has profoundly affected human life and seems to continue to affect it. Many sectors had to make important changes in the way of doing business. One of these sectors is the education sector. In the period of pandemic, besides its deficiencies, advantages of distance education were better noticed and important experiences on distance education were gained. On the other hand, there is a possibility that pandemic may continue or new pandemics will occur. Considering these situations, it is evaluated that distance education will maintain its popularity in the future. The aim of this study is to examine the academic studies on the effect of Covid-19 on distance education in higher education and to determine the direction of the trends, in terms of the resulting conditions. For this purpose, 51 articles from the databases provided by TUBITAK ULAKBIM EKUAL (EKUAL) were examined. According to the study review form, developed using the literature to assess related publications on distance education, academic studies were subjected to descriptive analysis. The results displayed the general scope of research articles related to the effect of Covid-19 on distance education in higher education. It is considered that this study will provide an infrastructure to the future studies.

Keywords: Coronavirus, e-learning, distance education, remote learning, university education

1.0 Introduction

In parallel with the developments in technology, distance education, first started in 1840 with letters, began to be carried out more effectively with information and communication technologies (ICTs) in the 1980s [1]. Until the start of the Covid-19 epidemic at the end of 2019, distance education has tended to fill the shortcomings of formal education due to physical and economic disadvantages and has continued its development and expansion in parallel with the speed of digital transformation in the world.

However, due to the fact that the epidemic could not be brought under control in a short time and the concern that transmission would increase more in classroom environments, it was decided to interrupt face-to-face education in many countries of the world and switch to distance education. This decision has seriously accelerated the development and dissemination process of distance education. In this process, schools with distance education units continued to carry out education and training activities using their own infrastructure, schools that did not have such infrastructure either received support from schools with distance education infrastructure or used software with license or no license fee in order to provide distance education services to their students [2]. This process, which started in a compulsory way, seems to cause the development of distance education more rapidly, as well as the transition of universities to a distance education-centered education system. As a matter of fact, while the Covid-19 outbreak cannot be fully controlled in the world yet, the authorities make statements that the world should be prepared for such epidemics in the following periods. Under these circumstances, distance education has become a more important subject for researchers as well as for practitioners today compared to previous years.

While studies on distance education by researchers for many years have been included in the literature, studies that tend to analyze these studies are frequently encountered as well. It is seen that these analysis studies shed light on issues such as in which direction the studies regarding distance education have evolved and in which areas there is a gap. Studies in which the Covid-19 epidemic affects distance education, how distance education has evolved after the epidemic, what are the gaps in this area, and where the areas to be developed and studied in order to implement the most effective distance education in the epidemic environment are rarely encountered in the literature.

Based on these highlighted issues, the research questions of this study, which aims to examine the academic studies on the effect of coronavirus on distance education in the context of higher education and to determine the direction of trends in terms of emerging conditions, were determined as follows:

1.What are the most frequent/ly used research designs, research methods, data collection tools, sampling selection methods, sample size, target populations, environments, data analysis methods, specificised tools used in education?

2.What are distributions of numbers of publication database, keywords, publication month, male and female author, page, reference and country?

3.What are speficied aims, research topics and future works in articles?

In the following sections of the study, first of all, distance education and the effect of Covid-19 on education will be explained. Afterwards, studies related to literature analysis on distance education will be described briefly and limited number of published studies on the effect of Covid-19 on education and distance education will be mentioned. Then, the methodology of the study will be presented and the findings of the study will be revealed and the study will be concluded with the conclusion section that includes the evaluation and future studies.

2.0 The Literature Review

Covid-19 pandemic situation has become a turning point in higher education and shaped the educational landscape globally. In order to ensure the physical distance and protect the health of public, significant steps were taken in the educational field. As part of securitization policies, higher education institution started to take precautions and adapt their programs to the pandemic situation and lessen the personal contact. They took initiatives to change their educational programs and methods. The educational environment which was mostly based upon face-to-face interaction evolved into distance learning and remote learning. Many countries in the world suspended in-person instruction and temporarily moved to the remote model. UNESCO reports indicated that by the end of April, 2020 many educational institutions were closed in 186 countries. In some countries such as China and South Korea, in-person and physical programs were shut down in January [3]. Leaving the traditional educational environment, universities started to use video-conferencing tools such as Zoom and Moodle system.

Rapid transformation into distance education became a necessity for higher education institution. The remote learning process is called as distance education or distance learning. These are similar terms. In literature, distance learning is defined as a kind of educational process in which interaction with the lecturer and student is provided through online environment from different location [4]; while distance education means the separation of teacher and student [5]. Also, the term of distance learning is widely used literature to refer to the blended learning which both combines online learning and face-to-face programs [6]. It represents approaches that focus on open access to education and training, freeing learners from the

constraints of time and place [7]. The concepts “e-learning”, “online learning” and “distance learning” “distance education”, “distance learning”, “online education”, “online learning”, “remote learning”, “remote education”, “e-learning”, “electronic learning”, “open learning”, “open education” and “mobile learning” are interchangeably used. As for the concept of online education, it is a flexible instructional delivery system that encompasses any kind of learning that takes place via the Internet [8]; whereas e-learning is the delivery of a learning, training or education program by electronic means [9]. Besides this concept, online learning is described as the type of instruction mediated via the Internet, which might be synchronous or asynchronous [10]. In parallel with distance learning, remote learning gives learners who are not in a physical location for in-person education, access to online training materials [11].

It provides the learner with freedom of space. Supported with computer-based communication, learners can study whenever convenient, which might eliminate the time constraints and limitation [12] Students can participate in the courses through video conferencing tools and e-email options. Distance learning environment offers asynchronous network [13]’ Even though distance education has various benefits, it has also brought together many challenges for both students and lecturers. These challenges can be listed as login problem, audial problems, lack of interaction, socialization [14], and access to Internet. To combat with the problems, global cooperation in higher education level is required. Education experts are fostering the lecturers, instructors to share their distance learning experiences, applicable strategies and take tangible actions to support the educational process.

There are various studies on distant education and online courses. Some examined the perceptions and views of students on distance education and online courses [15,15,17,18,19,20,21]. Besides the studies focusing on the perspectives and views of students, some researchers and academics dealt with the perception of the faculty staff, who were offering online courses and analyzed the opinions of the instructors [22]. Some studies compared the effectiveness of classroom and online learning [23,24,25,26,27,28]. Besides these studies and researches, there are other studies in the field. For instance, Croft, et al.[6] dealt with overcoming isolation in distance learning. The concept of distance education is in use for many years; however with the sudden outbreak of Covid-19, the concept came to the fore as a great necessity to fight with the educational crisis which emerged in 2020. In literature, there are some studies related to the distance education experiences of universities during Covid 19 period. For example, Istanbul METU Alumni Association made an assessment of Covid 19 Process Distance Education. The research revealed the distance education problems. These were categorized as communication problems, lack of Internet infrastructure, unsatisfying attitudes of instructors, lack of sufficient

feedback, lack of interaction among students, lack of cultural and social facilities, limited technical opportunities such as computer, according to the Istanbul METU Alumni Association, [29]. Higher Education Council of Turkey made an analysis of distance education in universities in Turkey during Covid 19. According to the analysis results, many of the universities in Turkey had a fast transition process to the distance education. Almost all of the universities provided distance education for theoretical courses. Distance education is mostly applied in the discipline of Social Sciences.

Many worldwide initiatives were taken to minimize the negative effects of Covid-19 on educational processes and support the quality, efficiency of the educational programs in higher education. According to the report of International Association of Universities in 2020 on the impact of Covid-19 on higher education worldwide, different organizations and countries are leading significant roles to support the quality of education in higher education during pandemic process. UNESCO established a portal on Covid-19 Educational Disruption and Response with the purpose of decreasing educational disruption and enabling the continuity of education. Besides this, UNESCO has opened national distance education platforms to support the curriculum-based study for higher education students. It also published recommendation paper to plan distance learning solutions. The American Council on Education recorded and organized webinars on Covid-19. Association of African Universities have prepared a resource page to support higher education institutions. Association of Indian Universities has formed a platform for Indian Universities to share e-content, approaches and strategies. Moreover, CHEA (Council for Higher Education Accreditation) has published Covid-19 resources for institutions and accreditors. The Higher Education Commission of Pakistan established a system of online-courses. Inter-American Organization for Higher Education shares online educational resources with their members. World Digital Library took an initiative to support higher education institutions and opened access to collections over 19,000.

In literature, there are various researches handling the topic of distance education during Covid-19 pandemic process. Murphy [30] discussed the consequences of the securitization of higher education for post-pandemic pedagogy and discussed whether distance education would be a threat to face-to-face schooling and stated that securitization theory will be an important tool for educators in terms of both understanding, observing emergency eLearning and advocating the desecuritization of schooling in post-pandemic process. Dhawan [14] analyzed the online learning during Covid-19 in terms of its strong and weak points, opportunities and challenges. He asserted that online education has challenges for both instructors and students. In terms of instructors, adaptation to the new methodologies and keeping the continual

engagement of the student is challenging. Students may find the distance learning boring and they have difficulty in focusing on the course. What is more, governments do not have sufficient standards to ensure quality control for e-resources and e-content delivery. Despite this, he stated that distance education offers good opportunities, such as flexible learning environment and it gives the instructor to try different methods. It develops the problem-solving skills of students. Favale et al. [31] analyzed the internet traffic of Torino Polytechnic University campus network which established a virtual classroom system based upon BigBlueButton Framework and found out that students download on-demand lectures teaching material. Adnan and Anwar [32] analyzed the perspectives of Pakistani higher education students related to distance learning. As a result of the study, students reported monetary , technical problems, lack of interaction with the instructor and on-campus interaction which negatively influenced the team work and projects. Alawamleh, Al-Twait and Al-Saht [33] conducted a research to analyze the effect of online learning on communication between instructors and students during Covid-19 pandemic and found out students prefer in-classroom learning. Ali [34] carried out a meta-analysis study on online and remote learning in higher education institutes and found out that besides the resources; staff readiness, student accessibility and motivation play significant role in online learning and faculty staff should use technological learning tools to enhance the learning experience of students. Koçoğlu and Tekdal [35] conducted a research to observe and analyze educational activities implemented in Turkey during the Covid-19 pandemic. As a consequence of the study, the study showed that the teachers participated in the study had different remote teaching activities as required for different disciplines. Korkmaz and Toraman(2020) [36] aimed to analyze difficulties and problems that teachers have experienced in online learning activities during the Covid-19 pandemic by collecting the data from teachers at any level. They also analyzed expected changes in educational pratictices. The study showed that most of the teachers had difficulties in online learning and they have expectations about the change of the educational processes. Wotto [37] analyzed distance learning implementations and adaptations of France, the United States and Canada during the Covid-19 pandemic. He revealed that these countries had developments about the distance learning before the pandemic in terms of organizational effectiveness, so troubles transitioning to distance education was not experienced for these countries. As a result of the study, he pointed out that MOOC-based programs implementations which are used in distance education earlier made easy the adaptation in these countries. In this study, articles related to Covid-19 and distance education in databases provided by TUBITAK ULAKBIM EKUAL were examined.

3.0 Method

3.1. Research Design

In the study, articles related to Covid-19 and distance education in databases provided by TUBITAK ULAKBIM EKUAL were examined. A study review form has been created by compiling and reviewing descriptive analysis related to education for evaluation of these articles. Publication database, publication month, research methods, research designs, , data collection tools, sampling selection methods, sample sizes, sample groups and environment, data analysis methods, specificised tools used in education, distribution of male and female authors, frequently used keywords, number of keywords, page and reference count, distribution of countries, research topics aims and future work of the study are included in the study review form. According to these specified categories, 51 academic studies which were decided to examine, were subjected to descriptive analysis.

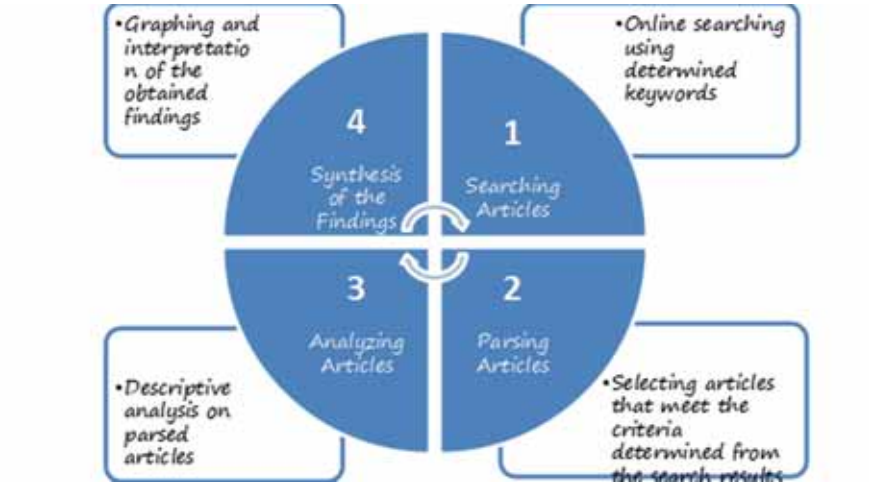

Figure 1: Process of the study

In the study, descriptive research design was used and content analysis was preferred for the data analysis. Descriptive research design is used to depict facts and characteristics of a researched area of interest in a systematic and proper way according to Dulock [38]. The content analysis can be defined as a systematic coding and categorizing approach used to describe the characteristics of a document's content according to Vaismoradi, Turunen & Bondas, [39]. Since the content analysis was used, research method of the study is mixed method which includes quantitative and qualitative approaches. The four stages followed to conduct the

study are indicated in Figure 1. In the Searching Article Stage, by using determined keywords, online search was conducted in the databases provided by EKUAL. In the Parsing Article Stage, articles which are appropriate to the criterias determined and rest of them are eliminated. In the Analyzing Articles Stage, selected articles were subjected to descriptive analysis. In the Synthesis of the Findings Stage, all findings in the analyzed articles were tried to be interpreted and graphed.

3.2 Data Collection and Analysis

In the study, computerized searches were conducted to collect articles related to the effect of Covid-19 process on distance education in databases provided by TUBITAK ULAKBIM EKUAL(02.09.2020). While conducting the computerized search, specific search terms (and derivatives) were used as boolean/phrase: Covid-19 or coronavirus or 2019-ncov AND “Distance education” or “Distance learning” or “Online education” or “Online learning” or “Remote learning” or “Remote education” or “e-learning” or “electronic learning” or “open learning” or “open education” or “mobile learning” or “m-learning” AND “higher education” or university or universities. The limiters and expanders used to filter search results are as follows:

- Expanders: Apply equivalent subjects
- Limiters: Peer-reviewed, English
- Document types: Academic journals

The articles obtained after completing the computerized search were subjected to a preliminary evaluation. The preliminary evaluation process has been made to determine whether the articles are suitable for the study and consists of four stages as evaluation of titles, checking of abstracts, checking whether the article has methodology and full text scanning. Inclusion criteria included: Published in a peer-reviewed journal, publication in 2020(Covid-19 process), content related to distance education and Covid-19 and, having a methodology section. Exclusion criteria included: Content unrelated to distance education and Covid-19, lack of methodology, not written in English.

By applying content analysis on the articles suitable for review, the study review form previously created in Excel was filled. The data in this study review form, which includes the categories were mentioned in the “Research Design” section, are graphed to clarify the findings.

3.3. Sample

205 articles were found as a result of computerized search with certain search terms. After these articles were subjected to the preliminary evaluation stage based on the inclusion/exclusion criteria, 51 articles from 10 databases which are provided by EKUAL were decided to be suitable for study and to be examined using content analysis. The number of articles included in the study from the databases provided by EKUAL and excluded from the study are given in Table 1.

Table 1. Reviewed publication databases for the study

Database	Included	Excluded
Academic Search Ultimate	9	29
ScienceDirect	5	16
Scopus	12	15
MEDLINE(Pubmed)	8	23
Directory of Open Access Journals	5	29
Springer Nature Journals	2	4
The Belt and Road Initiative Reference	1	11
IEEE Xplore Digital Library	1	1
Supplemental Index	1	5
Complementary Index	7	21
TOTAL	51	154

3.4 The Scale

The findings were separated into main headings, relevant information was put under these headings and they were cross-checked by the authors of the study. The misinformation which was found out during cross-checks were revised and they were also checked by another researcher. These efforts helped to enable the validity and reliability of the research. Since concrete data was collected during the research, frequent repetition in controlling the collected data provided reliable research data. It was also found out that there was compliance between different independent researchers controlling the findings.

4. Findings

4.1. Publication Databases and Publication Months

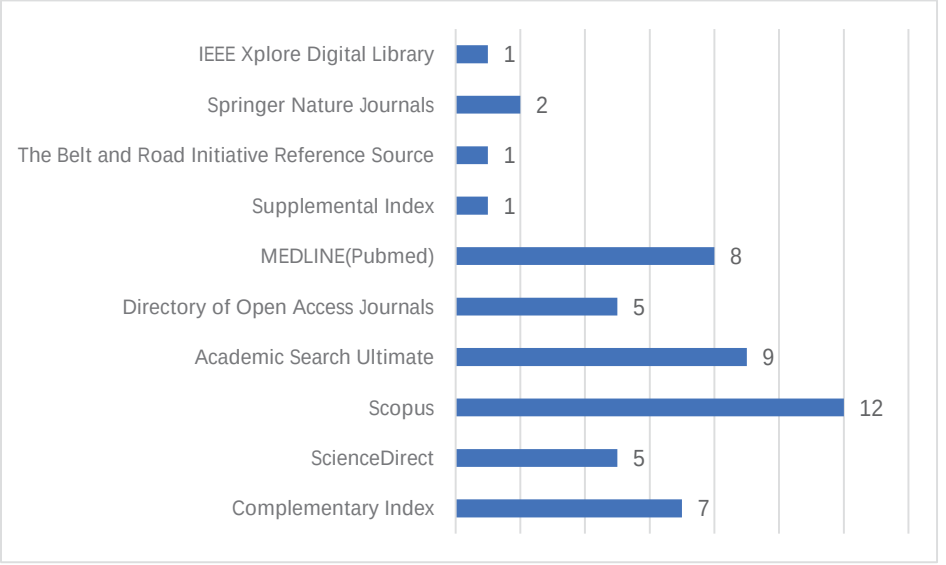

Chart 1. Publication databases and number of articles reviewed

The publication databases containing the articles included in the study are shown in Chart 1 together with the number of articles they have. Scopus has been the most published publication database of articles about Covid-19's impact on distance education. Academic Search Ultimate that is a multi-disciplinary database took the second place in terms of number of articles. The fact that articles written about the effect of Covid-19 on distance learning combine two disciplines such as education and health disciplines, and that Academic Search Ultimate is a multidisciplinary database may be a binding finding at this point. In addition, the third database with the most articles is Pubmed, a biomedical database. Most of the articles reviewed were found in the Scopus database, which is stated to contain more publications in every area by Falagas et.al [40].

It was observed that almost half of the 51 articles examined were published in May. There is an increase in academic studies from March to June. Regarding the excessive number of studies in May, it is thought that researchers can access more concrete data to investigate the effect of Covid-19 on distance education as the

distance education process has overtaken the transition period. The evaluations in the publishing processes of the journals and the publishing time can also affect this process. The publication months of the articles are presented in Chart 2 below.

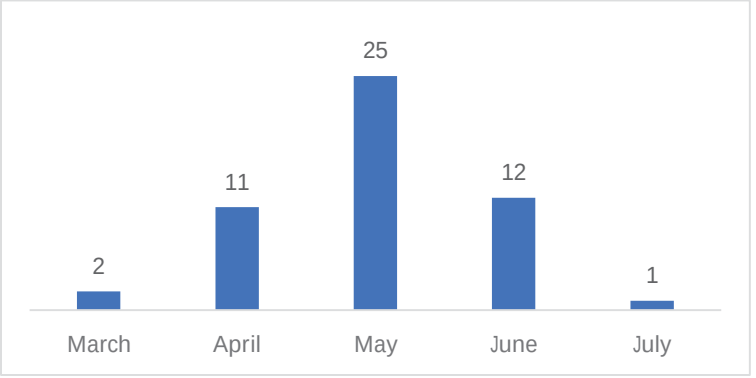

Chart 2. Distribution of publication months of articles

4.2. Research Methods and Research Designs

Research methods are divided into three parts as quantitative, qualitative and mixed. According to Nakkeeran [41[, the qualitative research method is referred to as the methods used to collect and analyze non-numerical data. According to Park et al. [42], quantitative research method is seen as a method used in the research and analysis of mathematical, technical and numerical results. On the other hand, according to Livingood et al.[43], mixed research method is known as the use of quantitative and qualitative methods together in data collection and analysis. The research methods and research designs used in 51 articles on Covid-19's impact on distance education were examined. It was observed that quantitative methods were used in 47%, qualitative methods in 31% and mixed methods in 22%. The percentages and numbers of the research methods used by the researchers in these articles are presented in Chart 3.

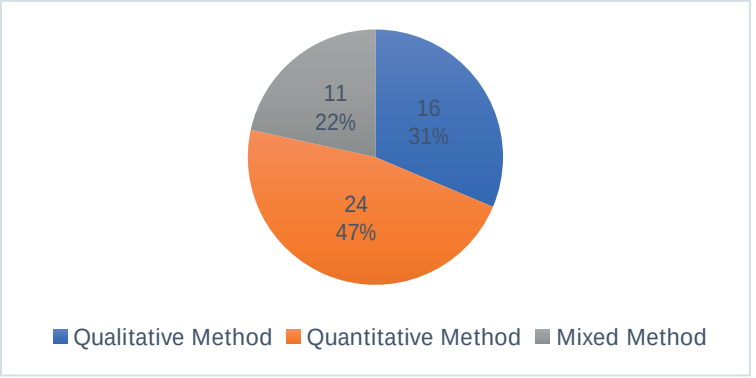

Chart 3. Distribution of research methods of articles

It has been observed that the studies conducted with the quantitative research method are more than the studies conducted with the other methods. In the study conducted by Yıldız et.al.[44], which included meta-analysis of academic articles in the field of education between 2015 and 2020, it was observed that quantitative methods were mostly used in the articles. Researchers stated that mixed methods are also frequently preferred and stated that qualitative methods are used less frequently in researches. When the frequency of research methods used in articles published on Covid-19's effect on distance education in 2020 and the frequency of research methods used in education-related articles between 2015 and 2020 were compared, the preference of quantitative methods remained the same, while a change in the frequency of preference of qualitative and mixed methods was observed.

The distribution of research designs used in 51 articles examined are presented in Chart 4.

In the articles reviewed, it was observed that 45% cross-sectional, 15% quasi-experimental, 12% experimental, 6% meta-synthesis, 6% action research, 4% grounded theory, 4% case study, 4% correlational, 2% design-based research and 2% content analysis research designs were determined.

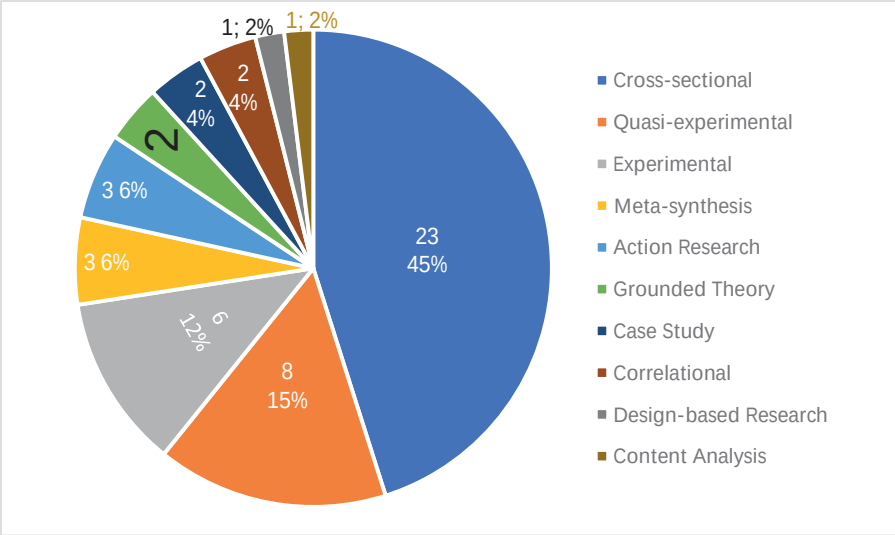

Chart 4. Distribution of research designs of articles

Cross-sectional study was the most preferred research design with 45% preference rate in 51 articles examined in this study. According to Thappa and Gupta [45], cross-sectional study is a view of a population at a certain time. In the content analysis study on 861 articles related to distance education published between 2009-2013 by Bozkurt et al. [46], the most preferred research design was case studies with 66%. In addition, in the content analysis study of 890 articles published on distance education from 1990 to 1999 by Berge and Mrozowski [47], it was observed that descriptive research and case study research designs are frequently preferred. According to the findings obtained from 51 articles examined, there was a shift towards cross-sectional study in the choice of research designs. The preferences of researchers to use cross-sectional research design have increased recently. The large number of cross-sectional studies can be explained by evaluating the impact of the Covid-19 process-a specific time period- on distance education in the articles examined.

4.3. Data Collection Tools

The data collection tools preferred by the researchers for use in the research were obtained by examining the abstract and methodology sections of the articles. Data collection tools were taken as the researchers stated in the articles and no changes were made. Preferred data collection tools in the reviewed articles are given in Chart 5 below.

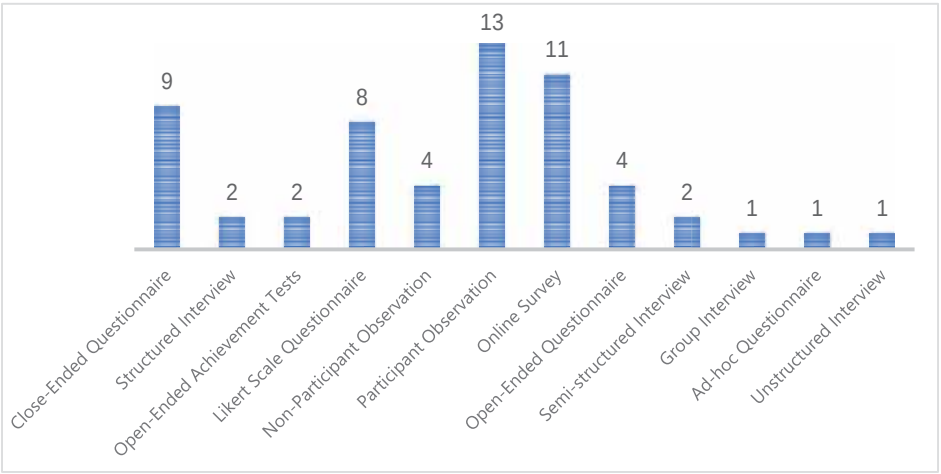

Chart 5. Distribution of data collection tools used in articles

In the study in which 58 articles were examined by Altınpulluk [48] in order to determine the tendency to use augmented reality in education between 2006-2016, it was observed that the most used method as a data collection tool was the questionnaire. In the study conducted by Bozkurt et al. [46], the most used data collection tool in articles examined was survey. In these two studies, the concepts of survey and questionnaire were seen as peers. Looking at the most used data collection tools in 51 articles examined in this study, the most used method when looking at the total of their types was questionnaire. Since the most preferred data collection tool is questionnaire, it was observed that the data collection tool preferences in the articles examined in this study were similar to the data collection tool preferences in the articles examined by Altınpulluk [48]. In addition, questionnaires including closed-ended, open-ended, likert scale and ad-hoc were used in 22 academic studies in total. Non-participant and participant observations were used in 17 academic studies in total. Interviews, including group, structured, unstructured and semi-structured interviews, were used in a total of 6 academic studies. There was an increase in the preference of observation as a data collection tool.

4.4. Sampling Selection Methods

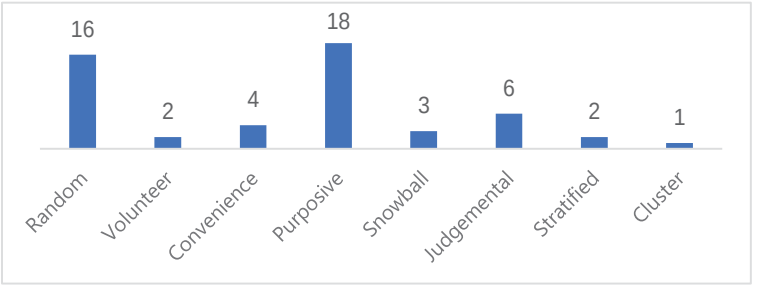

Chart 6. Distribution of sampling selection methods used in articles

The content of 51 articles was analyzed and the frequency of the sample selection methods used in the articles was obtained. The findings obtained are presented in Chart 6. In 51 articles examined, it was observed that the most used sampling selection method is purposive. According to Collingridge and Gantt [49], purposeful sampling is used to select participants suitable for the purpose of the study. The frequency of use of random sampling method by the researchers also seems to be close to the purposeful sample selection method. In the study conducted by Gökmen et.al. [50] regarding the methodological trends of articles published on distance education between 2005-2014, it was observed that the most used sampling selection method was purposive. For the study(ibid), it seems that random sampling method is one of the most used methods in the articles. These findings of the study(ibid) comply with findings that obtained from 51 articles examined in this study, it is observed that sampling selection method preferences are similar to those in articles between 2005-2014.

4.5. Sample Size

Sample sizes of 51 articles were examined. In order to categorize the sampling sizes, some ranges have been determined. The distribution of sample sizes is presented in Chart 7 below.

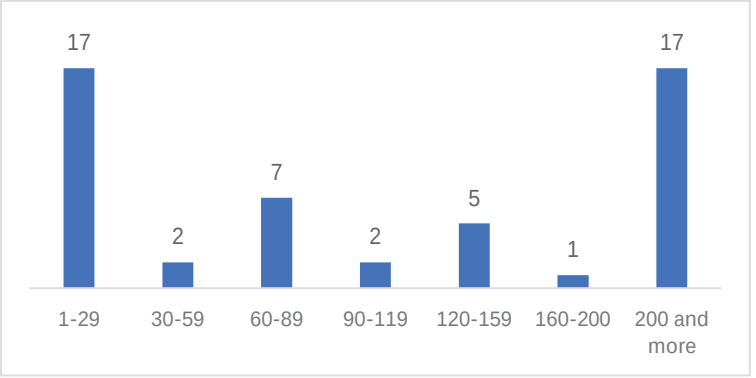

Chart 7. Distribution of sample size in articles

The most used sample size ranges in articles examined were observed as “1-29” and “200 and more” with 17 frequencies. In the study which included meta-analysis of academic articles in the field of education between 2015 and 2020, conducted by Yıldız et.al. [44], “1-29” and “200 and more” sample size ranges were observed to be the most preferred ranges by the researchers. It seems that the findings of the study(ibid) comply with findings of 51 articles examined in this study. In the articles examined, it is observed that mostly small sample sizes or large sample sizes are used. It can be thought that researchers had to conduct research with small sample sizes due to isolation measures. Large sample sizes, on the other hand, can be shown as a success of the researchers, which are carried out in cooperation with institutions and supported online. Also, used techniques in the stage of data collection during the research can affect the sample size.

4.6. Sample Groups and Environments

The sample groups and the researched environments in the articles were examined and their frequencies were graphed. It was observed that among the 51 articles examined, 12 different sample groups were used. The frequency distributions of the sample groups are given in Chart 8 below.

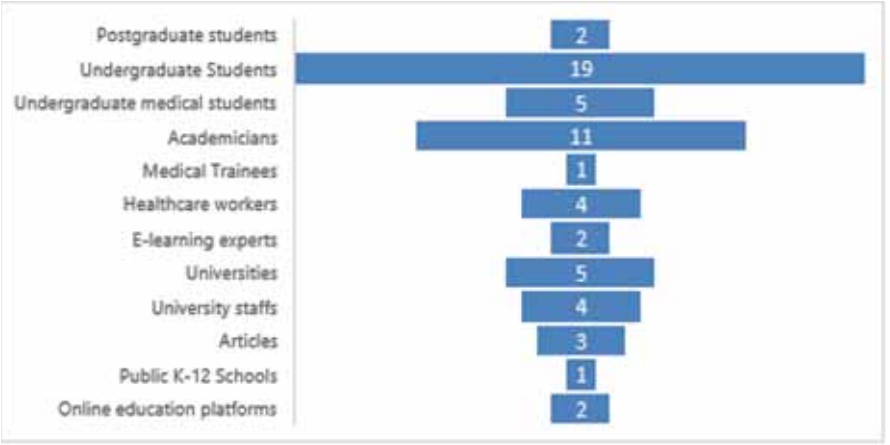

Chart 8. Distribution of sample groups

According to the findings obtained, undergraduate students selected as a sample group in 19 articles were the most preferred sample group of researchers. After the undergraduate students, the most second preferred sample group was academicians with used in 11 articles as sample group. The preference of sampling groups that include undergraduate students and academicians in studies can be interpreted as the effect of Covid-19 on distance education is evaluated more in higher education institutions. In addition, it seems that medical undergraduate students, healthcare workers and medical trainees have a significant frequency among the sample groups. This finding shows that studies for distance education will increase in the field of health. In the study conducted by Bozkurt et al. [46], the most preferred sample group in the articles examined was bachelor students (undergraduate students). In another study conducted by Yıldız et al. [44], the most preferred sample group in the articles examined was again undergraduate students. The findings regarding the sample groups used in 51 articles examined support these two studies by showing similar results with these two studies. The fact that the sample groups are mostly undergraduate students is thought to be because they are the most accessible environment within the framework of academic studies. The frequency distributions of the researched environments in the articles are given in Chart 9 below.

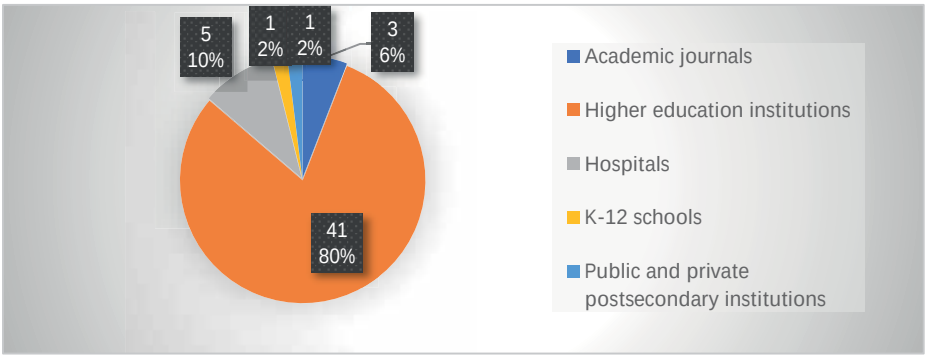

Chart 9. Distribution of environment used in articles

It is observed that 80% of the researches in the articles take place around higher education institutions. The fact that the researchers frequently prefer undergraduate students and academicians as the sample group can be interpreted that the effect of Covid-19 on distance education in higher education institutions has more opportunities for research. The number of studies conducted around the hospital seems to be considerable. Gökmen et al. [50], who examined published articles on distance education from 2005 to 2014 in their study, observed the environment in which the studies related to distance education were carried out the most were higher education institutions with undergraduate students. This observation in the mentioned study is confirmed by the findings which obtained from 51 articles in this study. For the study(ibid), Studies conducted in the hospital setting were not taken into consideration and not mentioned. Our findings contribute to the existing work by examining distance education studies conducted on hospital settings. In addition, the transformation of medical education of medical trainees, healthcare workers and medical undergraduate students, which were previously mentioned as sampling groups, to distance education due to isolation measures, has enabled researchers to conduct research on distance education in hospital settings.

4.7. Data Analysis Methods

The data analysis methods used in the articles were examined. As a result of the examination, the data analysis methods used in the articles were observed as inferential statistics, descriptive analysis, descriptive statistics, content analysis and thematic analysis. According to Perez-Vicente and Ruiz [51], inferential statistics are used to draw conclusions about the population by manipulating sample data. According to Ninness et al. [52] , descriptive analysis is a method used to determine the relationships between behavior and environmental events in an environment.

According to Halfpenny [53], descriptive statistics is used to measure and enumerate the characteristics of a population. According to Walters [54], thematic analysis is the process of analyzing data according to common aspects, relationships and differences in a dataset. The frequency of these data analysis methods in articles was graphed. The frequency of using the data analysis methods obtained is shown in Chart 10 below.

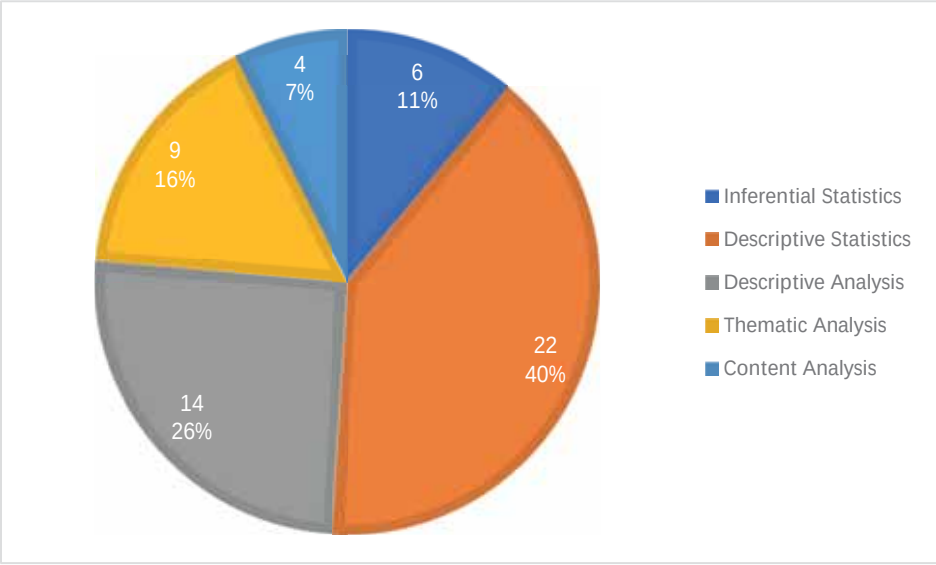

Chart 10. Distribution of data analysis methods used in articles

According to the findings, the most used data analysis method was the descriptive statistics with 40%. It is not surprising that the preference of descriptive statistics as the data analysis method is excessive, since the most used research method in the articles examined is the quantitative research method. The frequency of descriptive statistics preference of the researchers was followed by descriptive analysis with 26%. In the study conducted by Bozkurt et al. [46], descriptive statistics were the most used data analysis method in the articles. In the study conducted by Yıldız et al. [44], while the most preferred data analysis method in the articles was inferential statistics, content analysis and descriptive analysis followed inferential statistics. In the study conducted by Gökmen et al.[50], they observed that inferential statistics is the most used data analysis method in the articles examined. The fact that descriptive statistics is the most preferred method in accordance to obtained from 51 articles supports the findings of Bozkurt et al [46]. Comparing findings obtained from 51

articles examined with findings of the other two studies, the data analysis method preferences of researchers shifted from inferential statistics to descriptive statistics regarding to research about the effect of Covid-19 on distance education. In addition, it has been observed that researchers tend to descriptive analysis instead of inferential statistics. Furthermore, content analysis studies are thought to increase as the number of articles on the effect of Covid-19 on distance education increases.

4.8.Tools Used in Distance Education

Among 51 articles investigating the effect of Covid-19 on distance education, the tools specified for using distance education were examined and frequency distributions were created. Frequency distributions of the tools specified for distance education are presented in Chart 11 below. In some of the studies, it was seen that more than one tool was used for distance education.

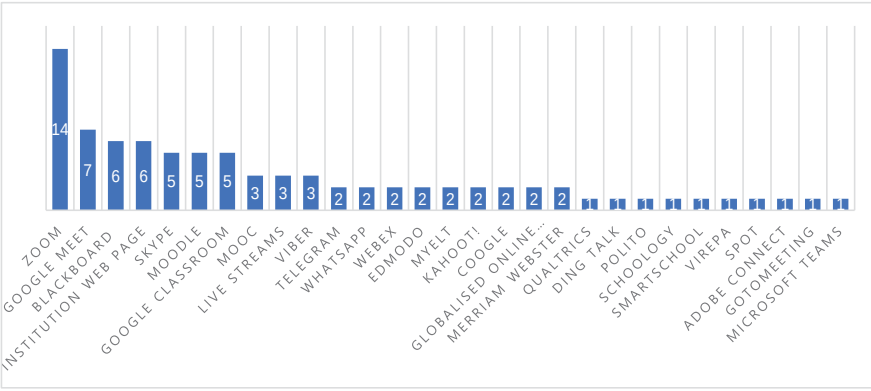

Chart 11. Distribution of tools used for education in articles

Due to Covid-19 isolation measures, there has been a transition to distance education. Many online tools and platforms have been used to provide distance education. According to the findings obtained in the articles examined, the most used tool in distance education was Zoom, a video conference tool. Video conferencing tools like Zoom, such as Google Meet and Skype, have also been found to be used frequently to perform distance learning activities during the Covid-19 era. It seems that learning management system platforms such as Blackboard are also frequently used in distance education. It has been observed that lifelong learning and e-learning

platforms such as Google Classroom, MOOC (Massive Open Online Courses) and Moodle are also preferred by instructors. In addition, the preference of social media platforms such as Whatsapp, Telegram and Viber in distance education is also a positive finding for distance education. In a study by Telli and Altun [55], it was stated that online video conferencing applications such as Zoom, Google Meet and derivatives are used in distance education. In another study conducted by Basilaia and Kvavadze [56], it was observed that subjects related to the tools used for distance education in the Covid-19 period were discussed and findings related to the use of similar applications in distance education were found. It was observed that the findings obtained from 51 articles match these two studies.

4.9. Distribution of Authors

The number of male and female authors in the articles reviewed was examined and their frequency distribution was created. Female and male author distributions are given in Chart 12.

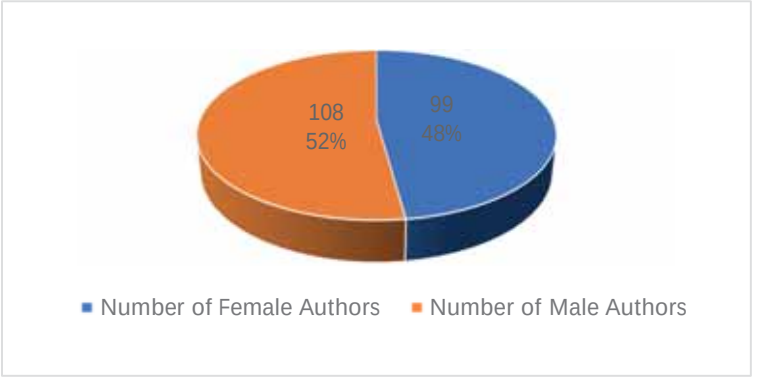

Chart 12. Distribution of female/male authors in articles

For 51 articles examined, the total number of authors contributing to the articles is 207. Male authors constitute 52% of the total number of authors, while female authors constitute 48%. According to the findings, the gender distributions of the authors who conducted research on the effect of Covid-19 on distance education are close to each other. At this point, it can be said that the effectiveness of female authors at the academy has started to increase. In two studies by Bond et al. [57] and Lin et al. [58], the number of authors in the article were examined. In addition, in the study of Lin et al. [58], it was stated that there is limited space in the article to

analyze the gender of the authors. In this respect, the findings obtained will make a concrete contribution to the literature.

4.10. Frequently Used Keywords

The keywords used in 51 articles examined about the effect of Covid-19 on distance education were subjected to descriptive analysis. In the first stage of the analysis, a total of 267 keywords (122 field related and 145 research related) were found for the articles examined in the study. Frequency distributions of keywords were created for each article. The frequency distributions of the keywords used for each article are shown in Chart 13.

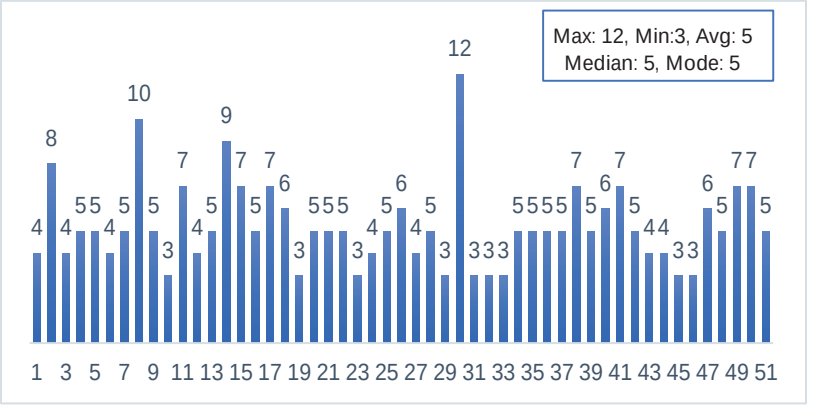

Chart 13. Number of keywords used in articles

It was observed that the number of keywords used in the articles was generally close to each other. In the second stage of the analysis, the keywords related to the research are separated from the field specific keywords because the frequency of the research related keywords is very low and the research related keywords are not considered to provide meaningful findings for this study. Field specific keywords used in the articles and their frequency distributions are presented in Chart 14.

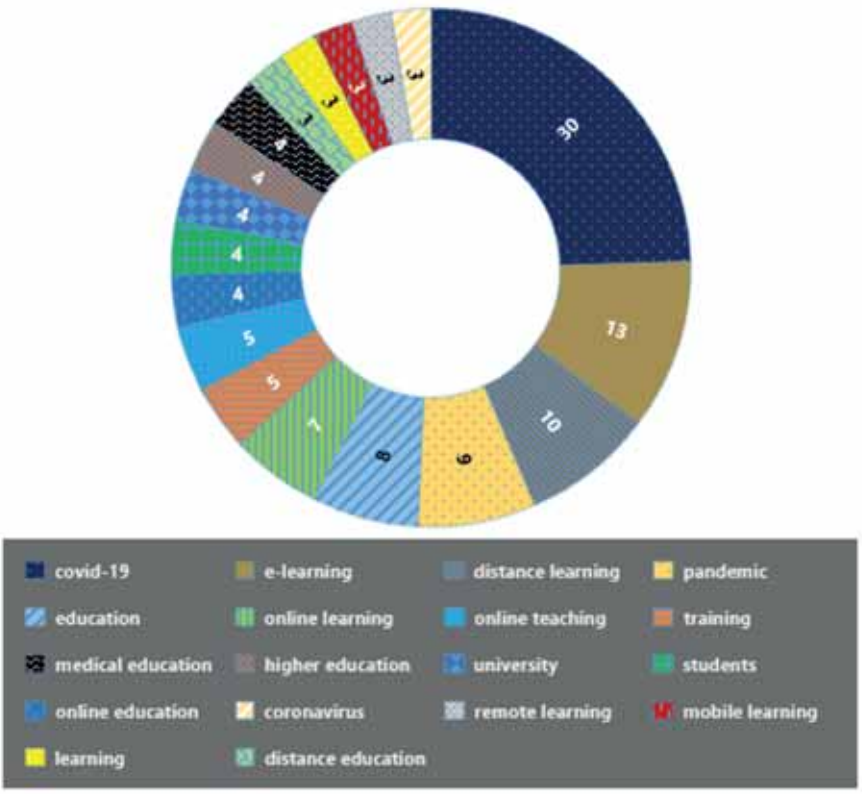

Chart 14. Distribution of frequently used field related keywords in articles

Among the 122 field specific keywords, the most frequently used keyword was "covid-19" with 30. The reason why the "covid-19" concept, which has a great impact in the sudden transition to distance education, is used so often in articles, may indicate that researchers investigated the effect of Covid-19 era on distance education. The other two of the most used keywords are the concepts of "e-learning" and "distance learning". These concepts are generic concepts that are at the core of distance education. It has been observed that keywords such as "education", "online learning", "online teaching", "online education" are also included in the studies, and it seems that researchers use different keywords to define distance education. In the content analysis study conducted by Bozkurt et al. [46], it is stated that the most used keyword in distance education articles is "distance education" and the keywords "e-learning" and "online learning" are frequently used. For the study(ibid), it has been stated that the use of the word "online" is frequently used as a concept related to

distance education. Although the findings in the study(ibid) are not compatible with the findings in this study, in which 51 articles were examined, it can be said that keyword distributions are close, with a few exceptions.

4.11. Page Count and Reference Count

The frequency distributions of the page count of the articles are presented in Chart 15 below

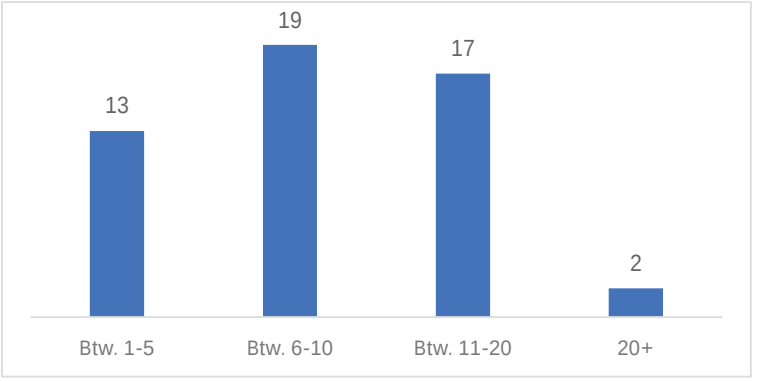

Chart 15. Distribution of page count of articles

It was observed that the density for the page count of the articles was in the range of "6-10". The number of articles between "11-20" and "1-5" ranges is also close to this density. Articles with a page count of "1-5" range are considered to be urgent Covid-19 responses. As the effects of Covid-19 on distance education begin to mature, it is thought that the researches will be carried out more comprehensively and, as it is known from previous findings, the count of pages will increase due to the intensity of quantitative studies. The fact that the article density with the page counts between "6-10" and "11-20" ranges is high is an indication that the effect of Covid-19 on distance education is tried to be explained especially with quantitative studies.

Specific ranges are determined for the count of references used in the articles. The frequency distributions of the count of references used in articles are presented in Chart 16 below.

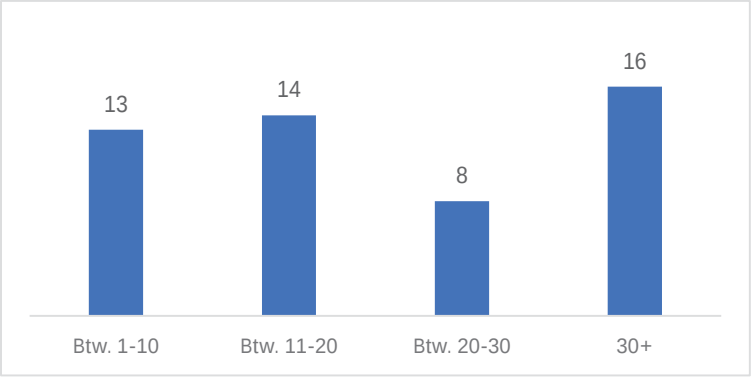

Chart 16. Distribution of reference count in articles

It has been observed that articles using more than 30 references are more intense. Researchers investigating the impact of Covid-19 on distance education are thought to give more reference to studies related to distance education than Covid-19. It may be due to the fact articles on Covid-19 are just beginning to emerge in the literature. In the study conducted by Yıldız et al. [44], it was observed that the range of reference numbers in articles related to distance education was the most intense "26-50". The finding that more than 30 references were preferred in most of the 51 articles complies with the findings in this study.

4.12. Distribution of Countries

For 51 articles, the frequency distributions of the countries where studies on the effect of Covid-19 on distance education were conducted were created. The frequency distributions of the countries where the studies are conducted are given in Chart 17.

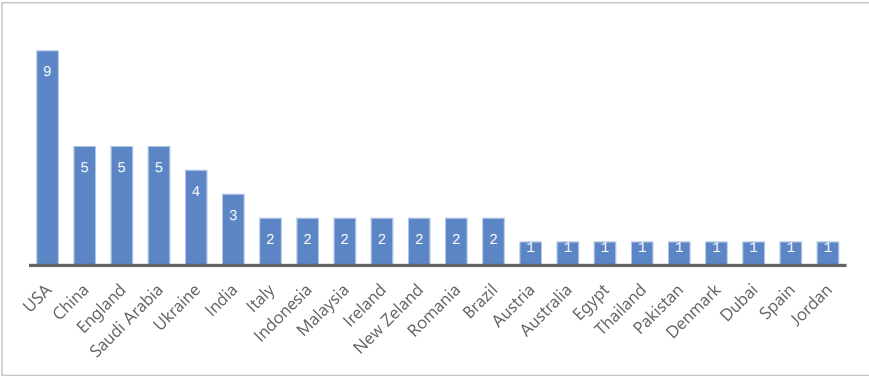

Chart 17. Distribution of countries where studies are conducted

It has been observed that the most studies on the effect of Covid-19 on distance education have been conducted in the USA. In terms of the number of studies, China, England and Saudi Arabia follow the USA. The fact that the most studies were conducted in the USA can be explained by the fact that the American education system is familiar with distance education and that it is one of the countries most affected by the Covid-19. It was observed that there are many studies on the effect of Covid-19 on distance education, especially in South Asia and Europe, which are experiencing the Covid-19 closely. In the content analysis study on teaching methods conducted by Uzunboylu and Özcan [59], the country where the studies were carried out the most was USA. In the research on educational technologies conducted by Bond et al. [57], the countries where the studies were carried out the most were observed as England and USA. The finding that the highest number of studies from the 51 articles examined was conducted in the USA, comply with the findings of these two studies. For this reason, it can be said that the studies on distance education in the USA are continuing steadily.

4.13. Research Topics, Aims and Future Works

In addition to other findings, the aims stated in the articles, the research topics and the future works mentioned in the articles were examined.

Research topics in the articles are given in Appendix A. In the articles, it has been observed that the effect of Covid-19 on distance education is discussed from many perspectives, and especially the perspectives of students and academicians are

included. In addition, how efficient distance education is in Covid-19 process has been one of the topics discussed in the articles. Another focus of the articles was the opportunities and difficulties that occurred with the sudden transition to distance education. The aims stated in the articles in parallel with the research topics are also presented in Appendix B.

As a result of the examination of 51 articles, the future study statements of 29 articles that include future work statements are given in Appendix C. As understood from the future study statements of the articles, it has been observed that new studies will be carried out on the subjects such as ways to increase efficiency for universities and students for distance education and what changes the new situation will bring in education. In addition, it is concluded that new studies will be conducted on students' performance and satisfaction in the distance education process.

5. Discussion and Conclusion

The results of the study reveal trends in academic studies regarding the impact of Covid-19 on distance education in higher education. As a result of the studies subjected to descriptive analysis, it was observed that new concepts were formed and new processes occurred in distance education with the effect of Covid-19. In these studies, with the concept of distance education, concepts similar to this concept were also included.

The findings of the studies examined can be summarized as follows. While the most used research method in studies was the quantiative method, the most preferred research design was the cross-sectional research design. The most commonly used method as a data collection tool in the studies was observed as participant observation. As a sampling selection method, purposive sampling selection method was observed to be excessive. Studies are generally based on undergraduate students. Descriptive analysis has been the most widely used method of data analysis in distance education studies. During the pandemic period, studies conducted in China, England and Saudi Arabia, especially in the USA, draw attention. The fact that the most studies are in the USA can be explained by the USA's familiarity with distance education. The effect of Covid-19 has also been seen in tools used in distance education. As a result of the examined studies, Zoom, a video conferencing tool, was widely preferred in distance education during the pandemic process. It has been observed that the keywords "covid-19", "e-learning" and "pandemic" are frequently used in articles on distance education.

Our practical experience also confirms these research topics such as challenges and opportunities during the transition to distance education. Accordingly, future research topics could include comperative analysis of educational methods used in distance education and experimental studies can be done to test the efficacy of used methodologies. Also, content analysis of course communications in delivered courses via online communication tools such as Whatsapp and Zoom could be a future research suggestion.

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APPENDIXES

Appendix A

To present the challenges and opportunities of distance education
To define approaches to teaching online pedagogy courses at the university.
To present the challenges and opportunities of distance education
Presenting the problems experienced in transition to online education in higher education institutions in the UK through the eyes of academicians
to investigate MBBS international students' perception on online TCM course, and to assess the online learning efficacy.
To analyze the change in campuses during the quarantine period
Determine academic stress factors by analyzing the concerns and fears of students at King Saud University
To evaluate the effect of quarantine period on ophthalmic education programs in India
To investigate students' behavioral, cognitive and emotional responses to distance learning conditions
To evaluate students' knowledge and perspective on e-learning systems in Indonesia and Malaysia
To determine the effectiveness of the existing distance education process in higher education institutions in Ukraine
Identify the development of higher education institutions in Austria in e-learning activities
To evaluate the findings of transition to emergency distance education in the first weeks of the epidemic in public and private post secondary education institutions in the USA
To make SWOT analysis of anatomical trainings in England and Ireland in Covid-19 pandemic
Synthesize evidence-based information to rapidly develop and evaluate the digital learning package to support psychological well-being for all healthcare professionals
To investigate how online education is applied in China in the Covid-19 pandemic
To investigate how distance education and optometry education are applied in Covid-19 pandemic in India
To analyze the effects of blended learning through distance learning in pre-registration nursing education in Covid-19 pandemic
To evaluate the effects of online education offered in Covid-19 pandemic on students
To analyze the competencies of academics in mobile learning and mobile teaching in Covid-19 pandemic
To investigate Chinese university students' concerns about online education in the Covid-19 pandemic
To investigate the effect of the quarantine process on students in India

Determining alternative ways to complete the senior projects at the university during the Covid-19 pandemic
To investigate the critical challenges faced in current e-learning systems and the main factors supporting the use of e-learning systems in the COVID-19 pandemic
To create a teaching design for online learning according to the self-regulating learning framework in the Covid-19 pandemic
To investigate the effect of isolation measures on the physical activities of biomedical students in classes
Presenting the results of the study on the experiences of students on online learning in the COVID-19 pandemic
To determine the technological coordinates of the virtual education system developed in the Romanian educational background
Identify the obstacles faced by instructors during the virtual classroom sessions for hearing-impaired students in the Covid-19 pandemic
Sharing experiences in anatomy education in the Covid-19 pandemic in Australia and New Zealand
To investigate the awareness of the teaching profession in times of crisis
Investigating ways to manage education-related stress and health to increase well-being in the Covid-19 pandemic
To investigate the efficiency of team-oriented online education sessions implemented in the Covid-19 pandemic
To investigate the perceptions of students and trainers for online education in the Covid-19 pandemic
To explore the possibilities and challenges of using Whatsapp in online education as a social media tool
To evaluate web based education applied in Covid-19 pandemic
To determine the education strategies determined by the schools at the beginning of the Covid-19 pandemic
To investigate the effect of online courses on educational institutions and learning outcomes in online learning
To examine faculty members' online teaching experiences
To reveal the perspective of university students and understand distance learning preferences in the Covid-19 pandemic
Evaluation of e-learning classes in Covid-19 pandemic
To observe the effect of online courses taken by the interns in the emergency department with distance education
To determine the factors affecting students' satisfaction and performance in e-learning activities in Covid-19 pandemic
to assess the concerns of students of health-related higher education in Brazil regarding distance learning
to assess Utah State University Extension’s response to the COVID-19 pandemic of 2020.
To evaluate the effectiveness of distance education sessions
to understand the impact online neurosurgical education has on individual neurosurgeons

to analyse the degree of implementation of the mobile learning methodology in Spanish universities and to check the sociodemographic factors that influence the development of good teaching practices in mobile learning.
to assess the effects of the pandemic across six countries, including The UK, Australia, Belgium, Cyprus, Ireland and The Netherlands and to identify design principles for mobile learning
To describe the state of the art on nursing education and the challenges of using remote technologies in the time of Corona virus pandemic.
to examine a guided learning approach towards the use of mobile devices and to investigate the performance of language learners who were guided in the usage.

Appendix B

The challenges and opportunities of Covid-19 in distance education
Ways to apply pedagogy lessons online in the Covid-19 pandemic
The challenges and opportunities of Covid-19 in distance education
Academicians' view of the problems experienced in transition to online education
The efficiency of online learning and online courses in the Covid-19 pandemic
The effect of the quarantine period on campus networks
Psychological changes of students receiving online education in Covid-19 pandemic
The effect of the quarantine period on ophthalmic education programs
The effects of distance learning on students in the Covid-19 pandemic
Students' perceptions about e-learning systems
Analysis of distance education approaches in Covid-19 pandemic
Chronological development of e-learning activities in Covid-19 pandemic
Analysis of the findings on the rapid transition to distance education in the Covid-19 pandemic
SWOT analysis of anatomical education given by distance education
Evaluation of healthcare professionals' experience in digital learning in the Covid-19 pandemic
Online learning activities in the Covid-19 pandemic
Distance learning based optometry education in Covid-19 pandemic
Blended learning activities through distance learning in the Covid-19 pandemic
The efficiency of online education in the Covid-19 pandemic
Analysis of academicians' mobile learning and mobile teaching competencies
Students' perspectives on online education
The effect of e-learning systems on students
Online education activities implemented in the Covid-19 pandemic
Use of e-learning systems and difficulties in e-learning
Development of an instructional design for online education
Physical effects of online education on students
Students' online education experiences
Evaluation of online education systems
Virtual classes for hearing impaired students

Academicians' perspectives and experiences on distance education
Crisis management in education
Psychological analysis for the changing education process in Covid-19 pandemic
Efficiency of team-oriented online education
Perspectives of students and trainers for online education
Online education with Whatsapp support in the Covid-19 pandemic
Web-based distance education in Covid-19 pandemic
Adaptation of schools in rapid transition to distance education
The efficiency of online learning in education
Instructors' online teaching experiences
Students' approach to distance education
Evaluation of e-learning classes
Efficiency of online courses
Evaluation of online education activities implemented in the Covid-19 pandemic
Concerns of students about distance learning
Assessing capacity of professionals related to implementing online education
Students' reaction to distance education sessions
Effectiveness of online education about neurosurgical education
Implementation of mobile learning for universities
Assessing effectiveness of mobile learning
Evaluating effectiveness of remote learning
Performance of students in guided learning

Appendix C

analyzing organizational work of administrations and subdivisions, students' training process, dormitory functioning, communication links, as well as psychological and medical care.
study the pedagogical disciplines at university with the combined use of the online Moodle and Prometheus platforms, Zoom webinar software, mobile learning technologies and various web servers for teacher.
refining rapidly developed online educational opportunities and developing in the anticipation of increased emphasis on on-line learning in the wake of the COVID-19 pandemic.
to explore the extent of the challenge of private higher education providers to public universities in the context of digital pedagogies and online migration
to explore what students are going through in different disciplines and throughout universities, how they are coping with these changes and new rules and
to explore issues that need to be tackled in order to create a more strong, flexible and responsive system with contingency measures in place for emergencies.
to investigate whether the higher education system will be able to cope with the
To explore that how do the general conditions change the quality of teaching, the study-ability of the subjects and also the learning outcomes of the students.

To research that how to develop long-term online learning strategies that institutions need to address to deliver sustainable and high quality education
to assess the sustainability of the adaptations utilized by universities with a
to investigate healthcare workers' perceptions towards and use of the package and
to test student's performance and satisfaction on switching to the e-learning
to examine in more detail innovative strategies to support students to engage effectively with blended approaches while achieving work/life balance.
to explore the causes of the higher anxiety and to take measure to reduce the
to examine the impact of ongoing partial isolation measures and, in other nations, the impacts of long-term strict isolation measures on diet and physical activity
to explore related factors to better understand the conditions under which virtual classrooms and distance learning are apparent and from which the barriers
to explore how the rapid change effected correlation between student performance and satisfaction, and how the bridges that have been built impact on the future of
to examine how teacher development might happen over a longer time-scale in online education and how teacher participation develops and changes over time
to evaluate online education strategies, their adaptations over time, and their
to evaluate faculty members' dramatic conversion to digital instruction, the
to examine the system effectiveness by comparing students' performance pre and
to conduct an in-depth study using the structured interview to validate its findings
to explore ways of developing micro-video teaching in practice.
to examine about how the regular student feels to be forced to shift to e-learning and their intention to e-learning after this forced experience.
to conduct about Extension institutions COVID-19 response assessment to inform their delivery efforts and future responses to crisis and emergency situations.
to compare changes in students' knowledge, skills and attitudes after online participation compared with in-person participation.
to explore a variety of modalities with which online education reaches
to explore affects of including remote technology tools for the continuity of classes in the non-face to- face model resulting from the social isolation strategy
to investigate the challenges and adverse effects of the usage of mobile learning in the teaching and learning process.

Short Bios

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Postgraduate Online and Hybrid Delivery Courses for Student-centred Institutions – Has this recent Tendency got a Future?

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Abstract

Continuous competition in the field of Higher Education invited Higher Education Institutions to review their marketing positions in terms of the need to offer new marketing opportunities, ensuring much needed financial stability. Recent changes, such as continuous uncertainty in the international and national politics, world-wide viruses and demographic shortages in the UK population additionally forced the UK institutions to change their approach to the usual course provision, available for Postgraduate students. This paper indicates the future for the current wide-spreading tendency of online and hybrid delivery of Postgraduate courses, suggested to prospective students by the UK Higher Education Institutions as a response to the rising demand for more flexible delivery.

Keywords – Postgraduate online courses, hybrid delivery, adult education, digital content, UK websites

1.0 Introduction

Fierce competition in the global market not only required companies to adapt their current online offers to satisfy the increasing demands of the modern customers, but also suggested having new online products and services, which could be adapted to the needs of the clients. Furthermore, modern digital users globally and in the UK, are becoming more and more technologically savvy, requiring “modern software and technology; powerful social media presence; original, educating and entertaining

content; hence, overall – a new way of digital thinking for organisations" [1, p.130]. The issues are highly relevant to the Higher Education Institutions (HEIs) in the UK, particularly for the Postgraduate courses and hybrid delivery provision, as the current perception, dominating the educational market more and more, suggests that obtaining continuous education (following a Bachelor's Degree) could be seen as acquiring even greater financial burden. This is understandable, as the initial degree already leaves students with a debt of at least twenty-seven thousand GB pounds and, potentially, could include such additional expenses as accommodation and living costs.

On the other hand, a number of Postgraduate students return to an HEI, either immediately or after a period of time, with the opportunity for getting a sponsorship to cover the expenses for this level of studies, e.g., via corporate staff development. The latter option, nonetheless, would depend on the financial stability of an organisation, as well as the willingness for the company to add these expenses and/or intention and ability to keep this particular employee. In any case, this action would most likely be based on the company's financial viability for the activity, and it would be expected to seek the profitable gains for the company.

Therefore, the companies, in the first place, prefer to gain the flexibility, which not only ensures the presence of this employee at work, but also the flexibility of studies, which could be accessible off-work. This is equally relevant to individual persons, due to their need to gain flexibility in their employment, family responsibilities and/or other needs.

2.0 Methodology

A thorough document analysis was conducted for this research. The process also included a review of the courses available via Higher Education Institutions' websites for Postgraduate applicants. The focus of the review was concentrated on the Postgraduate courses, offered via online and hybrid delivery options. The latter could suggest a combination of an offer, e.g., comprising online and part-time modes.

3.0 Market Situation

Due to costs for "a bewildering array of substantive and procedural competition rules for businesses to follow", companies in the global market suffer from losing the efficiency, when operating across different countries [2, p.1]. This includes digital economy, where "global regulatory competition is a recent phenomenon that confronts us in various different fields" [3].

3.1 Competition

Despite the Internet being "global and borderless" [4, p.561], there is always the risk of extraterritorial regulation [5], due to the continuous conflict in the need to "square unilateral regulation with the principle of state sovereignty" [3]. A number of other factors also influenced the current competitive position for the UK businesses. Despite the "spark" of potential predicted opportunities for the UK with the Brexit for the commercial future in economical, legal and geopolitical factors via creation of "an impetus for law reform both in the UK now freed from the EU and, within the EU through a facilitated approximation of laws" [6], currently the situation shows that Brexit diminishes prospects for legal innovation via weakening legal competitiveness within Europe.

In addition to the power of having the ability in making independent decisions, not necessarily with a reference to the EU approval, the country received a significant increase in inflation and devalue in the currency [7, 8], as well as three million job losses, previously provided via exports [9]. The indication from political and financial reports identified "the twin pressures of Brexit and the COVID-19 pandemic" enormously impacted on Britain's supply chains, as trading with European Union substantially dropped, indicating in Third Quarter 2021 the lowest value relative to gross domestic product (GDP) since 2009 [10].

This negative financial position affected any-size of the companies, from large organisations to Small and Medium-sized Enterprises (SMEs). The negative affects included such issues, as customers' lowering purchasing power, shortages in the skilled labour, losses in EU subsidiaries, changes in taxes [8].

Furthermore, the conflict related to Ukraine, the applied sanctions, and the closure of major Chinese ports due to Covid, indicated further declines in GDP and energy crisis [11]. The impact of this crisis has already extended to the global economy, where "Inflation which is already ravaging most global economies is steadily rising due to the sharp increase in oil, natural gas, and food prices just a few days into this crisis", negatively impacting on "household consumption, increase uncertainty, unpredictable stock swings, supply chain disruptions, bulging utility bills, decreased investment due to political risks, and economic growth impediments" [12, p.144].

The Covid-19 crisis as another financial burden negatively influenced "households and businesses to consume and spend less" and added another matter of concern in congestion of financial markets, where "companies may still tend to draw on commercial banks' credit lines, which can lead commercial banks to either sell Treasury and other securities, or reduce other lending" [13, p.269, p.293].

3.2 Changes in Client's Behaviour and Demand for Flexibility

"Over the last three decades, global competition has changed dramatically. Given the changing customer needs with globalization, the marketing strategies for managing customer behaviours' have become even more critical." These changes in the global and the UK markets created unprecedented competition, changing

customer behaviour, in addition to Brexit and Covid-19. [14, p.845] Researchers emphasise that customer experience of modern digital users comprises of a number of factors, namely: functional (quality, trust and convenience), technical (website attributes, website design, perceived usability) and humanic factors (customer complaint handling), all of which have to be considered [15]. Digital consumer behaviour is constantly changing [16, p.60].

4.0 Higher Education Institutions and New Marketing Solutions

This significant political and financial situation inevitably influenced the UK Higher Education Institutions (HEIs), leaving them often in the position of financial survival, and now severe competition in a complicated market situation requires higher education institutions to adapt to the new digital marketing position [17].

4.1 Changes in the HE Market and the Demand for a Flexible Provision

According to the recent statistics, there are not enough individuals to study particularly at Postgraduate level from 2017 and for several consequent years, according to The Guardian. These students are needed to address the current and predicted skills shortage. There were almost 724,000 children born in England and Wales in 2011, increased from 595,000 in 2001. This is an astonishing increase, except that, ten years earlier, in 1991, the number was approximately 700,000. There is an obvious gap in the prospective HE population [18], making the future competition among HEIs potentially more severe. Overall, this market culture makes it impossible for the expansion of the HE sector, although it creates a strong competition for individual institutions “for market share”. The entry requirements for the new Postgraduate applicants would also be expected to be reduced for the HEIs in order to cope with the pressure. In the response to Covid-19 changes, a number of HEIs established new strategic alliances with other institutions, started creating franchises or opening campuses in other countries, as well as developing online programmes [19]. Globally, there is a recent tendency for adult learners to be able to combine a course that fits in with their working life [20]. Researchers suggest exploring online experiences of those engaging with professional education, particularly during the Covid-19 pandemic from the student perspective, considering the enablers and barriers to effective learning and taking into account the logistical, technological and theoretical considerations for facilitating an authentic learning experience in line with professional standards [21]. Researchers emphasise the need to research the online experiences, evaluating usability, particularly for postgraduate online courses [22], as well as the social and physical aspects of online postgraduate programmes [23].

4.2 Offers from Higher Education Institutions

To follow fast changing trends in technology adoption and customer behaviours (e.g., the availability of films for digital users to download on mobile devices in seconds and internet usage changes in shopping behaviour), it is vital for modern companies to review their digital marketing strategy to keep it relevant and "to combine analysis of existing behaviour with research into consumer trends, market dynamics, segment attitudes and motivations", as well as different potential responses from the consumers. It is suggested to research "behavioural personalization", which indicates an individual's behaviour (from the received data), as this would assist in understanding this behaviour to "optimize customer's digital journey with personalized experience" and possibility to retain these customers [16, p.52-63, p.276, p.323-338].

Higher Education Institutions, therefore, following the trends for the flexible online provision suggest new ways of course delivery for Postgraduate students, offering fully managed online and/or hybrid delivery modes, allowing for such needed flexibility and the level of control, which is now in the hands of the digital users, not fully with the institutions.

According to HESA statistics (Table 1), provided in January 2022, the number of UK part-time Postgraduate students is growing for the part-time delivery mode since 2016, which could possibly be explained by the introduction of Postgraduate loans in June 2016 [24]. First year postgraduate taught numbers continued to rise, showing a 16% increase compared to the previous academic year. This increase comprises a 24% increase in enrolments from UK students and 8% increase from non-European Union (non-EU) students [25].

Table 1. HE student enrolments on Postgraduate taught courses Academic years 2016/17 to 2020/21

	2016/17	2017/18	2018/19	2019/20	2020/21
England	157,795	159,745	160,825	161,535	186,360
Wales	8,540	8,780	9,430	9,475	11,190
Scotland	14,865	14,770	14,830	16,410	20,510
Northern Ireland	4,760	4,825	5,635	6,075	7,770
Other UK	400	355	360	390	375
Total UK	**186,360**	**188,470**	**191,080**	**193,885**	**226,205**

The data indicated a decrease in the number of qualifications obtained in the 2019/20 academic year, while 2020/21 indicated increases for all levels other than Postgraduate research (Table 2). This is explained by significant numbers of qualifications awarded in the 2019/20 academic year not being reported until 2020/21. This is likely to be linked to the impact on examinations and awards resulting from the COVID-19 pandemic. The impact is most noticeable in the number of part-time qualifications awarded [26].

Table 2. HE qualifications obtained from Postgraduate taught courses, part-time delivery. Academic years 2016/17 to 2020/21

	2016/17	2017/18	2018/19	2019/20	2020/21
Masters taught	34,765	35,520	40,175	36,845	40,350
Postgraduate Certificate in Education	795	905	930	815	715
Other postgraduate taught	35,985	35,710	37,455	32,350	36,185
Total postgraduate taught	**71,545**	**72,135**	**78,555**	**70,005**	**77,255**

The data provided includes the number of online and hybrid delivery courses, although, regrettably, officially there is no indication of those courses reported separately. The researchers, nonetheless, managed to find official records in Higher Education Policy Institute's Analytical Report [27] that, in 2020, there were officially noted twelve UK Higher Education Institutions offering fully online provision for Postgraduate qualifications. This has been a significant move from 2012, when merely a couple of institutions offered this opportunity professionally, i.e., using the 'Future Learn' digital platform by The Open University and SOAS University of London, offering online distance learning courses, though not necessarily Postgraduate.

There has also been 'edX' Online Learning option as a serious competition from America. The platform initially offered Massive Open Online Courses (MOOCs) from Harvard University and Massachusetts Institute of Technology. The UK's participation started from 2016 by The University of Edinburgh [28], then by The University of Oxford in 2017 [29] and The University of Cambridge in 2020 [30]. Records of other UK institutions were not traced. According to the 'Masters Compare' online directory, in June 2022, there had already been 511 Postgraduate courses, offered online, with 96, for instance, offered in the South-East of the UK.

This tendency had been actively supported by the Higher Education Institutions in response to the potential financial crisis and inability of the students to travel or even meet altogether in large groups due to National lockdowns and Coronavirus COVID-19. The universities had to adapt to the dynamically changing world of new types of learning and to react accordingly, having already some sort of experience, when institutions had to cancel in-person classes and replace them with online tutorials. The first even online instructions (as it had been called at the time) happened in 1993 in America, where since 2016 roughly six million students (one-third of all) were taking at least one online course [31].

The tendency for offering these courses, nevertheless, could then be traced in most of the UK Higher Education Institutions, as almost every HEI nowadays offering at least one course with the specified parameters, while previously this had been a rare occasion to find such courses online. In 2022, the University of Southampton, for

instance, stated that "All our programmes and modules support learning through multiple methods where appropriate, through online resources and face-to-face activities, where academic staff carefully design the correct blend for their discipline and students" [32]; while in the Postgraduate Prospectuses for 2018 entry, there was no mention of blended learning or hybrid delivery courses. The institution had merely offered MSc Education (online), MSc Geographical Information Systems (online), MA English Language Teaching (online) and MSc/PG Cert Gerontology (Distance Learning) courses via part-time, as well as MSc Health Sciences with the online Neonatal Studies pathway [33]. This included not only Russell Group Association institutions, but also Post-92 groups. The Post-92 Universities in the South-East, for instance, offer two-years part-time MSc and MA courses via distance learning (by Solent University Southampton) and one MA blended learning course with in-person taught elements on campus (by The University of Winchester).

4.3 Customising the Availability of the Courses for Digital Users

This failure of presenting the required information from individual institutions (rather than using a database for course search online) presents an issue of not being noticed by potential Postgraduate students, who wish to study at a particular institution, and would not necessarily be able to find the required online and/or hybrid delivery course. Furthermore, even though it was possible to find the Postgraduate courses available online, the hybrid version of these courses, comprising of in-person and online learning, was not clearly visible, as the researchers attempted to make this choice themselves online as potential Postgraduate students. The HEIs, as it is reflected from the above-mentioned global research, need to use research to identify the ways of improving visibility of these courses on their websites, potentially, using digital customer profiles and online customer journeys.

4.4 The Tendency for the Delivery of these Courses is here to stay

Despite various issues, the researchers, however, noted that there is the identifiable movement, in the last couple of years towards offering more online and hybrid delivery courses for the modern UK Institutions, which initiated the flexibility of this learning, much needed for the UK Postgraduate student online and hybrid education, i.e., blending digital and campus-based learning. One example of a Postgraduate course offered by University of Surrey, suggested having online and in-class delivery. The problem is still involving the search for these courses, as some of them, for example, are registered as part-time mode courses with hybrid delivery, e.g., Staffordshire University, Edge Hill University, Queen Mary University of London and University of Stirling.

There are academics, who questioned the quality of the online and hybrid provision, arguing that high quality programmes require the input of creative and innovative educators, and not focusing just on the income generation [34]. There are some who evaluated the online courses towards ecological evaluation, avoiding such educational elements as student satisfaction, but reviewing the quality of a broad

range of educational elements and the relations among them, highlighting the example where the applied evaluation of online courses can produce information that supports development of teaching and increases the formative value of evaluation [35]. Perhaps, this could have been explained by the worse performance in the online studies, noticed by US researchers in 2014, as there had also been a perception "If there is a class you don't want to take, take it online and get it out of the way. That way you can save room for the courses you like…" [36, p.347]. It was also possible that the tutors require (though do not necessarily have) additional skills for teaching online and that online courses required more preparation time, as well as hybrid courses [36, 37].

Researchers, however, agree that offering online courses making the institutions being more student-centred [38, p.568]. Having the opportunity to study online, students "mainly influenced by time management flexibility, avoiding going to school and the course curriculum interest" [39, p.123]; while institutions recognise that online education is critical to their long-term strategy [40]. As with any convenient product or service suggested to customers, the initiative to support this opportunity will be highly positively accepted by potential customers, if this product or service offers simplifying life and easiness of access to information, when needed.

5.0 Conclusion

To summarise, there had been this need for the flexibility from the Higher Education Institutions, offering flexible way of learning, marginally based on the distant learning particularly for Postgraduate students, some of whom have already try to "juggle" their full-time professional lives, families and study time. These students, therefore, highly value the flexibility factor [41, 42, 43]. The institutions, nevertheless, have to consider all other factors, which students expect and value during their online studies, such as: flexibility, contact and interaction with the instructor, feedback, clarity and adequacy of content and easiness of access to content, simplicity of access to resources, technological self-efficacy, technical support and student guidance, as well as ethical and legal concerns regarding resources used [44]; students levels of confidence in their ability to communicate and learn online, their clear understanding of the course requirements and access to guidance [45]; lecturer's professional competences, ICT-related and interpersonal communication skills [46]; the role of teachers and tutors, their online teaching competences, approachability and adaptability to students' learning styles [38], to name a few. It is obvious that there will be significant criticism of this actively wide-spreading new way of study, as with any fairly new initiative. The way these courses are seen on the universities' websites could in some cases be improved, or at least re-considered, be to more visible. This tendency for working online, however, already reflected the changes in the market, not only for educational institutions in the UK, but globally, and the Postgraduate online and hybrid delivery courses are there to stay in the UK market of Higher Education, although potentially, undergoing some changes in future.

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Teaching students using Design-First Test-Driven Development

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Abstract

This paper explores a test-driven approach to teaching within Higher Education. Test-driven here is derived from the Software Engineering approach, where the test cases for software are defined prior to the software being fully developed. The emphasis is thus first on the design of the application before any concerns about implementation details. This emphasises the central role of design in Software Engineering and HCI. This paper considers how realistically the test-driven approach can be applied to teaching. It explores several aspects, including how far this test-driven teaching is already practiced, especially with the adoption of e-learning which enables a whole range of automatic testing to be applied to teaching and learning. The paper explores how tests can be carried out, in terms of assessment of students' learning, as well as the other dimensions of the student experience. This work continues from the authors' INSPIRE 2021 talk, on Gamification and Agile development in teaching software development, in finding ways to better engage and motivate neophyte software developers. Whilst gamification offers one path for better engagement, this paper presents another route which starts from the bigger picture, with a focus on design.

Keywords: test-driven development, agile teaching, computing education.

1.0 Introduction

The teaching of programming is an acknowledged challenging activity in education, across all levels [1,2,3,4,5]. As the authors have considered in the previous work [2], there are numerous ways to attempt to address this, especially when it comes to motivating and engaging students. Amongst approaches taken in our previous work include:

- Program Visualisation and integration of other mixed media [6].
- Game Based Dynamics and Motivational Driven Approaches [7].
- Guided Discovery and Novel Delivery Approaches to Learning [8]

This paper explores test driven approaches, then how to apply them in teaching. One common challenge in teaching computing is that many novice programmers try to write their code before they have understood the problem or have a real idea about how to develop their solution. Test driven approaches, based on a design first principle, can address that by focussing on the functional criteria that software needs to meet, which aids in directing the developer to consider how to meet the requirements. This focus on considering the particular features of a problem that need to be addressed, and then designing a solution that solves them, often on a iterative process that adds more functionality as the different tests are met can be applied to non-programming disciplines. Specifying assessments as a collection of criteria that need to be addressed can encourage and direct students to consider the overall assessment criteria, as we consider later.

Agile Development has been considered before as an approach to teaching computer science [9]. In [10], McRae and Stevens review and discuss the use of Agile Approaches to teaching programming and the role test driven, pair programming, daily stand-ups, and iterative development can play. They note some of the benefits that group work can bring to weaker and less confident students, whilst also noting the usual caveat that group working may also hide individual problems that only surface later when an individual is more exposed without peer support. Here the approach taken is to build on the promise of such work, but to more specifically focus on the design based approach, and how test driven development can be used within this context.

2.0 Test-Driven approaches

A test-driven approach engages participants to consider the required outcomes of a project or activity before its commencement [11]. Rather than simply parroting aims and objectives, detailed requirements are identified, developed and analysed at a range of levels before design or implementation commences. A test plan is established through which each of the requirements can be measured and evaluated. At the outset, these tests are likely to all fail – the intention is that work is completed in order to make the tests pass. Theoretically, the project is complete when all tests pass successfully.

In addition to helping to assess and monitor the completion of sub-tasks and the undertaking as a whole, this process informs the design and architecture of the work [12]. By initially analysing the intended requirements and planning a solution that will successfully meet the tests we can reduce unnecessary deviations (actions that do not help to make a test pass) by frequently re-drawing focus onto the tasks that will have the most positive effect.

It is also critical to consider test development and testing as an ongoing activity. Without doing so we tend towards a test-last approach, in which tests may be designed early in the process but not evaluated until the end [13]. This practice is likely to constrain participants and hamper responsiveness to changing requirements. It is usually imprudent to assume that every requirement and outcome is clear from the outset of a project. Instead, it is appropriate to establish key requirements and benchmarks at the outset and regularly update/add to these as the work progresses and new needs become clear. Habitually running all tests regularly can assist in the identification of necessary changes but can also identify where tests which were passing are now failing – a sign that a recent change has caused regression [14]. This can assist in an easy recovery – something that becomes more challenging if not identified quickly. This ongoing testing activity is generally considered to be a cyclical process: design new or update existing tests, design a solution to meet a test, implement the design, evaluate whether the implementation meets the test, check the previously met tests still pass, repeat.

2.1 Test-Driven Software Development

In the field of software engineering, project development methodologies which include incremental test-driven approaches help to facilitate high quality adaptive design and ensure specification adherence [15].

There are up-front cost overheads to this approach which mean that it is often appropriate to analyse where tests will have the most positive outcome and focus on these. However, in perfect conditions a suite of tests are designed as a holarchy, with lower level tests, which verify the functionality of small individual components (units), and higher level tests, which verify the integration between units and the behaviours of the system as a whole [16].

2.1.1 Unit Testing

Unit testing is an established technique in software development for verifying behaviours at a component level. Each component is considered a unit that offers a single, specific and low-complexity function. Whilst these functions may be chained together to provide a high-complexity behaviour, unit testing is the process of testing the components in isolation with the expectation that if each function works correctly the sum of the parts should also be correct.

2.1.2 Integration Testing

Where units are chained together or used collectively, integration testing confirms that the high-complexity behaviour does function as intended. This may pick up issues where the units work as expected but they have not been combined correctly.

2.1.3 System Testing

System-wide behaviours are often reliant on many individual and separate sub-systems working together to fulfil required operations. System testing is concerned with verifying that these collections of high-complexity behaviours all cooperate successfully and produce the expected outcomes. These outcomes may be functional (e.g. the client can log in) or non-functional (e.g. 100 clients can be logged in simultaneously).

2.1.4 Acceptance Testing

Often, those closest to the development of software solutions have a narrow perception of how the system will be used. This can be different from how the users interact with the system or what the users actually need. Acceptance testing provides an opportunity for the users to verify that the system works as they expect and need it to, rather than how the developers expect it to.

2.2 Test-Driven Teaching

Adopting the approaches and technologies described in the previous section, we can develop a test-driven approach to teaching itself. The focus here is on teaching computing, but can be applied to other disciplines. Focussing on the teacher, then the test to pass could be student learning outcomes, competencies or other measures of student learning. These can be considered at module level (so akin to unit testing), or at programme/qualification level (akin to system testing). This approach is one that can be considered as natural within teaching, where the test is the assessment (exam, coursework or project) is defined, and the effectiveness of the teaching is assessed by how well the students pass that test. Then based on that approach, teaching should be revised based on experience of how students do. How far teachers actually do that can depend on their context, so schools that face league tables and external scrutiny tend to do more review of this, whereas Higher Education can be more averse to responding to this data.

2.2.1 Module level assessment

One approach to assessment that is increasingly viable in many disciplines, is to utilize computer based assessment, especially with e-learning and the hybrid approaches that have become the norm since the Covid pandemic impacted global education systems. The module level assessments become the tests that the students need to pass. Creating a suitable a mix of published tests, plus an unseen final test, these become the criteria for assessing the teaching itself. As we consider below, they also become the test cases that direct the students in designing their own learning etc.

Where assessment can be fully automated, the assessments (or tests) can validate that that teaching has met its intended outcomes through the student performance in the assessment. Where this is not passed, the teaching (methods, resources, support etc.) can be revised and the students reattempt the test until they pass it.

2.2.2 Programme level assessment

A collection of modules typically aggregate to give a level of study, or overall qualification. By starting with the overall intended level or qualification outcomes, suitable tests for this system can be identified. In practice in education, these are rarely instantiated in an undergraduate course - at best a final year project may offer a chance to validate/test a student but typically this is concurrent with other modules. Thus considering higher education from that test (assessment) driven approach, there is clearly a challenge in the typical design of degrees. Postgraduate programmes are typically better in this regard, where the final test (typically a dissertation) has the potential to be a true integration test of prior activity.

2.3 Assessment-Driven Learning

Utilising the test driven approach, it becomes possible to design assessment activities that can direct student learning. This requires that the tests are sufficiently varied and provided in the context of the overall learning aims. Thus in trying to pass these tests, the students have to plan their design of a solution that will meet the tests and other equivalent ones.

2.3.1 Automatic testing of students in programming

An increasingly common approach within computing is the use of automatic testing of student solutions. This approach is a direct application of test-driven development, where students are given the set of tests (the criteria) that their software must achieve. As they build their solutions, they can trial their current solutions with the provided tests – which may be specified as data and required results that they need to address manually, as standard unit tests that they use, or within a learning environment which tests their solution. Sometimes the tests the students have are supplemented with other equivalent tests when it comes to grading. This is necessary as students could meet tests without addressing the intended design requirements. As an example, if a calculator programme was specified as meeting the test that 3+4=7, then they could implement that as checking for inputs 3 and 4 and then hardcoding the answer 7.

3.0 Design First Test-Driven Development

Combining and adopting the ideas in section 2, we now describe our approach to design–first test-driven (software development) education.

3.1 Design first Test-Driven Teaching

The programme and module content and delivery is planned based on the intended learning outcomes/competencies, and the tests that will validate they have been

achieved. This requires identifying suitable assessments (tests) that will validate the individual module aims, and that there are suitable final/endpoint assessments to validate the overall qualification. This is constrained by other factors and design issues, with more effective applications in postgraduate courses.

3.1.1 Module level testing

Within modules, we have applied this, for example our approach to module design is to identify the test criteria for the module, in terms of the demonstration of particular learning outcomes or competencies. The staff design the module's content and assessments to achieve that. Based on the results when these are reviewed following student assessments, the implementation is revised.

3.2 Design first Test-Driven Learning

Students are guided to consider what they need to achieve and to design their software or other deliverables to pass those tests. In a programming module, they need to review the tests to identify what their software is require to pass. They can then begin to plan and develop this. Several modules have used a programming tutor environment to implement the tests, whilst others will automatically run the student code against the tests. In both approaches, the success in passing these provided the mark for this part of the module's assessment. A similar approach for non-programming modules has been to create a series of tests as small assessments that students can repeatedly attempt. These guide them in terms of planning their learning and then assessing their success within the tests. In team projects, setting weekly criteria (tests) that they have to achieve can be considered as akin to tests. These build up to prepare for the final deliverable/test for the module. We now provide some case studies to illustrate these.

3.2.1 Specification based testing

An example of this comes from a level 5 module on 2D Graphics and Simulation. Amongst other topics, the students are required to develop an understanding of the use of vectors and matrices for applying mathematical transformations of a graphical scene. The position, size, and orientation of the different features of a picture they are creating should all be programmatically defined using a series of matrix transformations. To help them have a deeper understanding of what is happening "under the hood", the students are required to create their own Vector and Matrix classes that will expose methods that they can then use to perform the underlying mathematical functions.

To help them achieve the creation of these classes, the students are provided with a specification for each class which includes a description of the methods that should be included. For example from the Matrix class:

"*Multiply function – your Matrix object should have a 'multiply' function that takes single Matrix as its parameter. The function should return a newly constructed*

Matrix object that has its cells set to the result of multiplying this Matrix by the parameter Matrix."

This identifies for the student important details that will allow them to develop the class as expected: the name of the method "Multiply", the number and type of parameters "a single Matrix", the return type of the method "a newly constructed Matrix", the operation to be performed "multiplying this Matrix by the parameter Matrix".

Alongside this specification, the student is also provided with a collection of unit tests that will be run against the student's implementation of the specification. They can run the tests as many times as they like and the tests are largely independent meaning that they can add functions iteratively (it is not all or nothing).

These same tests are used in the formal assessment of the student's submitted work. The option exists to run a super set of "hidden" tests, but in practice this has not been used as the existence and correct functioning of the Vector and Matrix classes is further explored through their integration in the animated scene that they are preparing. Attempts at "hard-coding" the test results would be reasonably ineffective and easily detectable as they would not work correctly in a dynamic graphical scene – things would start to look strange very quickly.

Correct use of the generated classes for the transformations is visually assessed in the graphical outcome when the program is run, and through inspection of the code behind.

A very satisfying outcome during one session was that the students identified some areas of the assessment that weren't covered by the original test set. The students had not only identified the omission, but independently researched and developed their own additional test cases to help find out what was going wrong. These additional test cases were subsequently rolled in to the master set to plug the gap in future years.

Currently the tests are "offline", in that they are automatically run against the student code, but they must be triggered manually. The automatic running of the tests helps the students have immediate feedback on their progress in creating the classes, and it also provides an efficient way of marking submissions as marks can be automatically assigned based on the proportion of tests successfully passed.

In future iterations it is planned to include the tests as part of a continuous integration workflow such that each time the students make changes and upload their code (to source control), it will automatically trigger the tests and present the outcome.

3.2.2 Staged Development

Staged Development or Stepwise Refinement [17] lends itself naturally to exercises in compiler construction as a compiler is built from a number of discrete steps that students learn. The weekly practical exercises in the compilers course can cover the theory material and implementational material in harmony supported by tests that give students feedback at each stage. The laboratory therefore has test driven development for the stages of developing a grammar, a lexical analyser, a parser, a symbol table, a decorated parse tree and finally a code generator. These tests can be automated and run by the students on-demand, for instant feedback. The final grading of the exercise can then use a similar set of test tooling to ease the generation of the results for the tutor and students can submit their work with a degree of confidence in the outcomes.

This method of using test driven development has been used for nine years on the compilers course with excellent results. The student feedback shows they appreciate the ability to test their code at regular intervals and get feedback without the need to wait for a teaching assistant or tutor to be available. This releases the teaching teams to assist those students who require more support whilst those who can develop confidently can get the regular feedback they need.

Although not all student assessment exercises can be conveniently divided into self-contained components in the manner of compiler construction a similar technique can be used by dividing the task into sequences of steps for the students. In the course on computer network protocols the development of clients and servers communicating using HTTP can be subdivided by developing the client and server in different steps and also implementing protocol commands one at a time. In the weekly laboratories for this class the students first develop a client that can perform a request (using GET) against a class provided server; then they can add another command (such as POST) and at each stage they can run tests provided for their feedback. Later they can implement the server side in the same sequence.

The students learn about the functioning of the protocol, learn about network coding and build a complete client and server solution using HTTP in a test driven development environment and get feedback on demand using automated tests. Again, as with the compilers course this enables the teaching team to focus on assisting those in more need of help. However, this course, which has also been using this method for nine years experiences that some students move their focus from the purpose of the assessment to satisfying the tests! A small number of students embed the text of the test results in their code rather than implementing the protocol and attempt to count how many test have been run or match pattern of input to guess the test in order to get a PASS delivered, without realising that it is the correct implementation of the protocol that is being assessed. When the exercises are graded different test data (but similar tests) are used so that students do not succeed when doing this. The downside is that they do not get this final feedback until course failure is the outcome.

4.0 Discussion and Conclusions

In this paper we have explored test driven approaches to teaching programming within the context of the Agile Programming Paradigm. In particular we have been prompted to explore design first test driven development as a pedagogically motived approach. We have addressed how this can be integrated into a curriculum that seeks to develop a user's journey of increase competences in learning journey. Via case studies we how shown how test driven development need not be just limited to individual tasks or exercises but to more specification-based considerations and staged development incorporating step-wise based refinement.

An important caveat here is the importance of design being as fundamental as the tests themselves. This is not to say that other aspects to the task of programming are not important. An introductory course needs to be designed to produce not just readymade programmers (so called "oven ready" or "zero to go" programmers) but ones with the necessary in depth understanding of the underpinning fundamentals and theory. The approach we have described here is a pragmatic one that seeks to develop practical computer science professionals that have, at the same time, the necessary co-requisites of technical proficiency.

Another part of a design and test-driven story is in deciding who writes the tests themselves: the teacher or the student (or both). The student, especially novice programmers, may not be capable of writing the tests An area of future study is to determine if and how students might be guided to produce their own tests. The design of the tests themselves adds to the ownership of the solution on the part of the student. Expressing a program in a high level form without this being confused, compromised, constrained, or suffer any corruption of purity by implementation considerations has long been a goal of Computer Scientists (e.g. [18]). The approach outlined here gives potentially another tactic to this problem, approaching it from a design focused consideration. Where design is the first criteria but must be informed by the relevant technical underpinning knowledge. Elegant coding solutions are not precluded by putting design aspects of the problem first. However, the design and unit testing can take place without consideration of implementational details. Here the design centred concept is rooted deep within a very pragmatic and leading software engineering paradigm – Agile Development. This maintains the conceptual hygiene of the design approach within a practical framework.

The Covid pandemic has seen an increasing focus on agile approaches, as a range of organisations have attempted to gain the benefits seen in software production using agile development. The particular aspect of test-driven development is another software engineering approach that has the potential to be applied more widely, especially in education. In education, we need to be aware of the dangers of purely assessment driven learning. However, with the challenges of teaching increasingly large and diverse cohorts, and especially where e-learning is increasingly pervasive, we can also recognise the benefits of test-driven approaches. With suitable planning we can utilise a test driven approach effectively where we do so explicitly and consciously.

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PEOPLE, E-LEARNING, AND THE HYBRID SOCIETY: LASTING CHANGES FROM THE HEALTH CRISIS?

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Abstract

In this paper, we argue that the worldwide COVID crisis has fundamentally changed learners, how they expect to be taught, and how they consume education. We argue that this is a very real change - not just one of same experience, different location which will gradually "recover" over time. Instead, we argue that a real and lasting qualitative change has taken place that effects learners, teachers, courseware authors, and includes a shift in how people interact with teachers and each other. The paper argues against the idea that we will all go back to how we were before and a return to the old normal of 2019. Central to the change in society is E-Learning and how a society looks to deliver its education provision. We shall in turn look at how the process of E-Learning has changed and posit that in the future we shall see more hybrid models of delivery and consumption of learning material, where some aspects of the traditional face-to-face delivery are retained from older models but much of the content and related experiences stay online. We argue that this new flexibility of learning, removing barriers of time and place, will be features that are retained. Indeed, even within the pedagogical debate the notion of things like flipped learning reinforce this hybridization of education. This hybrid culture is likely to remain in many other areas, such as consumer sales and the High Street, and indeed work in general. This will reinforce the new hybrid interaction

norm and cause this to be the expectation for learners and thus their use of E-Learning becomes part of that norm. We will also reflect on what this change means to those providing learning and the likely knock-on effects on things like pragmatics and logistics. It may also have profound effects for institutions in the long term, with the nature and focus of campus based education being about the broader experience beyond learning.

There are some other implications to this, not least for teachers who are forced to become courseware delivery designers and multimedia experts, something that didn't affect many teachers before. So, we have to consider a fundamental change in how we train teachers to accept that hybrid delivery models are here to stay, and all teachers will need to be trained to author material and plan assessment for this platform.

Keywords: eLearning, computing education, eLearning and Society, Teaching and Learning, Flexible Learning.

1.0 Introduction

It is quite common to hear the comment that because of COVID19 we have advanced ten years into the future. This jump has been like a shot-gun marriage with the future where we have had to rapidly adapt to change, embrace new technology solutions, and new ways of working [1,2]. As a result, we now live lives which are hybridised between what we did before and what we do now, what we used to do in the physical world, and what we now do in-part online, what we considered to be the norm then and what we perceive this to be now. This paper will focus more closely on these claims and in particular we will look at

- What has fundamentally changed?
- What is the same but now in a new location?
- What has changed but may be expected to return to how things were before?
- What new things we are doing now that we were not doing before?

The methodology employed will be based upon action research of our own experiences of adapting teaching during the crisis, and secondary accounts of, and research into the actions of others. We aim to present a snapshot of what the results of the upheaval were. We reflect on what is here to stay, what may return to as before, and what the changes will mean for future needs.

The context of these discussion is the Hybrid Society. This is a Society where interaction is split between the traditional and the virtual. Technology has stepped over the boundaries and now forms a part of the domestic, social, family, professional, and educational story. It is both ambient and ubiquitous and forms the basis of where we ended up at the end of the Health Crisis. This paper aims to assess

where we are now in the Hybrid Society and the current situation that has arisen. The crisis has forced a rapid rearrangement of practices for students, teachers, schools, and universities and caused them to reconsider how they engage in Computers and Education. What was thought about as a possible future had to be adapted to the here and now of the crisis, in an exercise of necessary pragmatics.

Before we go on to the discussion in the rest of the paper we first present a brief overview of the world before this period of change.

1.1 Technology Enhanced Learning – a move from Learning Outcomes to competencies.

Computer technology has developed as a tool for education since the 1960s, with various initiatives and approaches to adopt it within Higher Education throughout the 1980's onwards [3]. This development was concurrent with the growth of learning outcomes (from the 1950's) as they were increasingly adopted by Higher Education as a way to identify what should be taught. More recently, Higher Education and other frameworks have increasingly focussed on competencies as a way to describe what should be taught and done. Technology has enabled a greater focus on skills and competencies as they offer new ways to assess students.

1.2 Flexible Learning – how flexible were the old arrangement

Traditional teaching is teacher led – whether classroom or distance learning, the teacher plans out and delivers content in a way that the learner should follow. Delivery and scheduling is determined by the institution and the teacher, with the learner being expected to adopt that schedule or catch up later. Assessment is prescribed to assess learning outcomes or competencies, with fixed activities and deadlines. The introduction of technology did enable some areas of choice, but this was often limited e.g. to being able to watch lecture recordings in between other scheduled events. Whilst there has been an increasing availability or purely online and distance courses, the majority of higher education remains campus based, with at best token attempts at flexibility.

1.3 Computer Mediated Learning, the use of VLEs and MOOCs

For very many institutions computer based information management systems maintained the course notes, syllabus, reading lists and other academic and corporate information to manage, deliver, and update academic content to staff and students. Increasingly academic hand-ins and assessment delivery (e.g. tests) could also be delivered by this route as could multiple-choice style exams. Increasingly content was being handled by more specialised document management systems. These systems evolved into Learning Management Systems (LMS) and Virtual Learning Environments (VLE). They might also extend to the provision of communication channels, bulletin-boards, and chats. Moving on from this more social interaction and online communities appeared in the development of MOOCs (Massive Open Online Courses) that were able to deliver education at a distance and scale. At scale these could also handle program delivery.

Many of these techniques simultaneously (and sometimes as a fortuitous side effect) allowed education to be delivered at a distance. In some cases these systems were originally designed as classroom adjuncts (e.g. Canvas, SharePoint), however their use could be adapted to distance delivery.

Applying technology to the problem however only exposes some fundamental problems with distance education. The experience can be awful, lonely, un-motivating, alienating and is sometimes associated with mental health issues. It has long been known that studying alone, without peer support is very hard [4]. Reports of loneliness, alienation, and drop out are frequently reported [5]. Spotting such behaviours e.g. like wheel-spinning (repeatedly going over the same task/exercise, failing the assessment, and repeating) has become increasingly important, potentially enabling remedial intervention [6]. The events we go on to discuss in the rest of the paper only highlight that these fundamental issues are still very much with us – irrespective of hybrid technology solutions.

Before we embark on a look at the changes, we should note existing work that seeks to chronical the story of the health crisis in diary studies. Whilst these do provide a useful story of events there are some methodological problems from pure diary studies, particularly when trying to use them as a source for quantitative data. Such studies typically report local issues. They appeal as empirical work but without the necessary underpinning research question(s) or methodology to back this work up (e.g. they are often characterised as interesting but essentially *ad hoc* stories). Interviews and questionnaires may be employed, but again can be more diary stories and maybe very rushed and only locally relevant – so meaningful comparisons fail. We do not know what the situation was beforehand, so it is hard to judge the changes and verify them as improvements. The timings of the intervention may also be very improvised and problematic for like with like contrast e.g. is the questionnaire in the middle of the crisis or post trauma rationalization. Saying you are going online can mean a vast number of things – given the vast number of tools and ways of using them such diary studies turn out lots of lists of incomparable uses and events so limiting what can be learning from such an exercise. So rather than quantitatively trying to compare what people did, we can instead use these valuable diaries as way of understanding what they did qualitatively.

2.0 Where did we end up: What hybrid world did we end in.

What has now changed? The following is a brief summary of some of the changes that we observed, both from our own experiences but from secondary observation and reports and discussions with colleagues.

2.1 University

At the University of Hull we can tell our story and the actions, interventions, and outcome. Much of that we reported in Gordon et al (2021). In summary we replaced traditional F2F with Computer Mediated Communication (CMC) (e.g. Teams, FaceTime, Skype, and also in our own Computer Science context, the (frequently games) Communication App – Discord, lecture capture software (e.g. Discord), and specific topic chapter for Laboratories (e.g. YouTube)). The communication process of a normal university were transferred to the CMC and we proceeded from there.

2.2 Working from home

Again whole new cultural shift of working from home became the normal. Accompanying this was another cultural shift for more casual presentation of self (dressing normal not formal) and of work in the domestic scene. Whilst many replaced backgrounds with office or neutral scene, many were quite happy to show scenes of offices or kitchens. Even those with adopted professional backgrounds couldn't help being photobombed by kids, dogs, cats, and the like. It all became part of the norm.

The move to home working has also seen many people adopt this as a permanent move to working. The rise in house prices for country or seaside locations has been attributed to the desire of people to move away from an urban or city lifestyle and commuting to one of living in a more rural location and enlarged home real estate. Such a permanent move is unlikely to be reversed by an easing/removal of restrictions.

2.3 Zoom

A whole new culture and vocabulary built up about Conferencing software. This saw everything from formal Boards, Democratic Meeting, to social meetup moving to Conferencing Software, and family meetups and quizzes. Issue of tern taking, moderation, and conflict handling became common and even notorious [7].

2.4 Social Media

Social media use has accelerated widely and this has already been widely discussed elsewhere [8]. The Hybrid Society reflects upon inherent role that Social Media now has as part of it. Here we shall not go over this but rather reflect on where we are and where we go.

Truth vs Post Truth Debate. Where opinion was able to out trump scientific fact as the basis for discussion and argument. Whilst from a philosophical perspective the veracity of fact, empirical observation, and rational explanation are a slippery target (e.g. [9]), as he notes for the person in the street there were agreed hard facts and rules of nature that were shared in a society. In the contemporary context there is now a collective will of the majority to choose their preferred opinion as truth, rejecting other arguments, and urged on and bolstered in their views by a chorus of

co-travellers. We are now faced with a Hybrid Society that too often seeks to equate opinion with scientific fact.

Finding reliable references on which to Base Pedagogical Material is now much harder in the post-truth world. This has repercussions about how we teach in the future which we will discuss in the next section.

2.5 Machine Learning

As educational action moved online so did the digital footprint of all that we did leave evidence of what we did. This of course presented a field day for Educational Data Mining. Using VLEs/LMSs/MOOCs means that behaviour can be analysed in detail to find the smoking gun signs of good and bad academic achievement, alienation and drop out, and other calls for intervention and support. However such large amounts of data created by this more online line world opens up the world of Big Educational Data and with that the use of new Deep (Machine) Learning Algorithms (e.g. Tensorflow [10]). These new algorithms are already much in the news with major breakthroughs for medicine [11] or solving seemingly intractable issues in searching and gaming e.g. Alpha Go [12]). Where we are now is at the very beginning of being able to exploit these algorithms in Education.

2.6 Artificial Intelligence

In the Hybrid World we now find ourselves in we live with AI in our homes, phone, and Universities. Online world are populated like never before with AI or Intelligent Software Bots or Agents, be they called Siri, Cortana, Alexa, Google Assistant, or Bixby. They may be used in almost teacher/peer substitute as a source of facts “What Battle took place in 1815” and like most teacher/peer knowledge sources maybe right or wrong or both (e.g Battle of Waterloo or New Orleans)

2.7 VR and AR

The Hybridisation was not just in terms of CMC like Zoom or Social Media. Users can now live and move in Virtual Realities that mimic our perceived real world or Alternative Reality that don’t necessarily do! Alternative Realities for teaching have been available for some time, for example Second Life [13]. The shot gun marriage with the future has just hastened it. In our domestic context AR/VR interaction devices were making it into the living room through the area of games already. It was thus a natural extension that when the changes took place and education moved also into the living room, the very tools for adopting AR/VR delivery were at hand. That this type of technology was already familiar to many is because of its domestic use for gaming. The place we are at now is one where we can look to build upon this. What types of science or history for example can be built to explore this now established infrastructure? Once it is in place it is unaffected by whether learning is returned to a school situation, remains in the home, or exists in a mixture of the two in a Hybrid context.

3.0 Discussion - The Course of Change for People, Learning, and the Hybrid Society.

3.1 What is the same but now in a new location (and is it better for being in the location)

3.1.1 Interaction : Dialog

The Hybridisation see normal interpersonal interaction taking place alongside F2F and F2 Many interaction modes of dialog. Whilst the method of communication may have changed the essential content of this communication has not. Practicality and necessities of the Health Crisis may have changed how we have communicated but very often the contents of this communication has been the same. Electron messaging ubiquitous much of the rest of the message is as before. For many this has brought the advantages of synchronous and asynchronous communication across great distances, at the time and place of their choosing and in new media (like seeing the face of the person you are talking to and their non-verbal behaviour). Snailmail letters may be largely a thing of the past and F2F Video Conferencing here to stay but much of the content and the social role it plays is not altered.

3.1.2 Interaction : Working, Learning Management and Assessment

In traditional campus based settings, activities such as registration, attendance (e.g. Labs), quality/feedback/student satisfaction, completion of assessment, and exams formed a key part an educational institution management of the learning process. The shift to doing this by information systems and more educationally orientated means like LMS/VLE/MOOCs has been noted before. As a result of the rapid embrace of these forms of student/learning management the location for these measuring and managing process has changed, but the processes themselves largely have not. We still need data on registration/attendance, performance, and other key metrics. This change of location had already started before the Health Crisis, was speeded up by it, and is unlikely to see a returns. Much of the Learning Management Process largely remains the same however. They are in a different location, and the technology many speed their ease of capture and processing. AI and Machine Learning may revolutionize what we do with this data however.

3.2 What did change but may be expected to return to how things were before.

One of the great debates of our times is whether home working is here to stay. Whilst many have now embraced hybrid working as the future,liberating employees to be flexible in their working practive, there are notable opponents (e.g. Goldman Sachs [14]). Proponents of back to work argue the workers are more productive, more energetic, and fuller of ideas enhanced on by interpersonal interaction (e.g. The Guardian, May 2022). There are clearly other agendas at play here also. A return to our cities is good for our inner city economies (e.g. shops, food outlets, and real estate landlords) and transport links, so the debate is not entirely about the quality of work. Leaving the politics of the workplace aside and focusing on the educational

issues we can still anticipate that we will be left in a hybrid landscape in education provision. Lectures were increasingly being recorded anyway. This led to the problem of non-attendance before the health crisis. This is an issue when critical laboratory-based material can also be missed or ignored online. How in a hybrid system do we address vital engagement with materials and tutors and assess practical competencies?

Schools and Universities are places of much socialisation and fun, not just a location for learning per se. In other cases they offer a release from the grim realities of home. School kids in many cases were only too happy to get back to School. In many cases this was the case for many other returning to places of work, sport, or other shared activities. So any talk of the Hybrid future has to take this into account. We may engage in core activities in a Hybrid manner, but the social part of the story is very important. Sometimes some of the most important learning episodes are gained from not what you attended but who you missed it with. Things like Student Unions or Associations, Sports, Clubs, and other entertainment outlets are an equal part of the balance of a quality education experience. In [16] we reflected this in experimentation with virtual bars, guest lectures, coffee areas, and a virtual disco. Work on the social aspects of virtual education is much needed to complement the technical aspects of the problem.

3.3 What has fundamentally changed.

3.3.1. Are we the same people?

For some online is enough. Some people can stare at a screen all day, live on social media, and share their life on computer mediated communication. For them the change as people, and how they live their life, is fundamental and they will not go back to how they lived before. For others it is not so. There will be have individual differences between people and their buy in to Hybrid Society. As noted before there are the long standing issues of working alone and at a distance. The usual villains here include: alienation, loneliness, lack of interpersonal interaction/empathy, and online not being for many a substitute for many for real world experience.

That said we are changing. How much are people's negative affordances to online living a consequence of what they are used to or grew up with is an important empirical question. One that needs much urgent work. Is there demographics at play here? Has/will the shot-gun marriage hasten changes – how do we feel about these change? All these issues are currently being played out in the rollout of the Hybrid.

Being able to do something is different from the quality of the experience in doing it. Technologically *enhanced* learning (TEL) is what we aspire to, however the danger is that we actually delivering is technically *compensated* learning. Are we creating new and good experiences or a poor-quality substitute? Pragmatics (like economic cost) may that we will never go back to pre-Crisis classrooms. Research

questions as to things like the valued added that hybridisation may deliver are important concerns of the future.

What sources out there can be relied upon as evidence to use in an academic argument? In a Hybrid Culture where rumour or opinion is too often tried to be passed off as fact, we need to teach our students about what makes a trusted source. For example explain the process of peer review so that students can see which sources are safe behind an academic firewall based upon these processes, compared with sources that are based on opinion, politically (or similar belief) motivated dogma, fake news, conspiracy theories, and delusional fairy tales. Influencers and commentators pushing their beliefs as true are a major problem if we wish to tell our students "Go research X". That is not to say you will not find passionate, and contradictory messages behind our academic firewall! This has always been the case. This is the nature of academic debate. However, we have always encouraged students to find such sources and include them in their work in the traditional "compare and contrast" courseware task. The classical guidance being "there isn't a single, correct, answer to this question – go find and present the various issues and the different academic arguments that are involved". What has now changed is that whereas the books on the reading list/in the library might already have been pre-screened, now they must treat through the minefield of finding trustworthy sources in the new Hybrid World. Students will need to be trained how to navigate the available sources, quite literally distinguish fact from fiction. This problem was an existing issue but made more urgent by the accelerated race to the virtual.

3.3.2 What new things we are doing now that we were not doing before.

The shotgun mature of the crisis has meant that many who would never before have become users of this technology have now been forced to become users. So for many although the technology was not new per se, it was new to them. Before the crisis there was no reason for them to use it, and indeed many sought to activitly avoid doing so. However they were forced to use it, and how as a result have now changed and will not be going back to their old ways. In this sense for many people they will be doing this now, and seeing a far from different, digital hybrid world, than they did before. They are thus forever and permanently changed. We have noted earlier however, this is not true for everyone.

The potential for Deep Learning finding new patterns and insights into behaviour. We have know for a long time one of the problems for Computer and Education is being able to have the types of insights into our students as teachers naturally have. For all the efforts in things like user modelling [17] it has typically been at best a crude approximation to judge the state our learners and in and what might be the best next move for them. As discussed above we know from elsewhere the big, and unimagined, breakthroughs that Deep Learning has brough elsewhere. The ability to see patterns in behaviour, indeed currently it appear to be able to spot meaningful patterns that we can't, opens up exciting new possibilities in how we re-engage with student modelling and personalisation of educational provision. The changes indeed may be so profound as to redefine these very concepts.

3.3.3 What we require of educators: For Teachers, Lecturers, and Professors

The move to Hybrid signifies another shift that we require here also from those professionally engage of delivery. Traditional chalk and talk didactics now have limited opportunity. Existing skill base for professions need replacing, updating or support in updating. New entrants need a whole new set of multi-media and hybrid delivery skills so we need to look again at out education provision for teaching the teachers. Once skills just the preserve of the technological elite need to the heart of the system from elementary or primary school through to the Post Graduate School. Need to be taught multi-media education. This does not just mean that we need familiarty with the technical issues. If teachers are to author stand alone material that delivers its desired learning outcomes it must reach quality targets. The media expectations of modern audiences are now very high. As a consequence we have to start thinking about what parts of disciplines like documentary making, scripting, media editing, and cinematography need to be part of the modern hybrid teacher core skill sets – redefining in large part what they actually do. Most of the time they will not be sitting in front of a traditional class but authoring material to replace that delivery. However, in a hybrid world, F2F does not go away, so longstanding interpersonal interaction will maintain a role, only a changed one.

3.3.4 Use of global media and the world

Technology is for ever advancing and that it means that even if we wanted to go back to that which we were doing in 2020, that world no longer exists. Technology and associated agendas are continually advancing. Synthetic Characters, Realistic recreation of real people and things, latest models of computers and phones (and the device world that accompanies them), and any number of other emergent technologies mean that the world also changed whilst in Lockdowns. So that what we came out to was going to be a different world technologically from when we went in. If we as computer scientists, educationalists and users were pushed into rapid use of the old new, the new just changed on us. Maybe one of the lasting outcomes of all this is the reflection on just how fast the world evolved and continues to evolve.

4.0 Conclusions

Just applying technology to the problem, and one with know fundamental issues, was never going to solve the problem. There was perhaps a greater willingness of the population to “make do and carry on” during the crisis. People readily embraced change as the only way forward. Many were only too happy to return to classrooms and the familiar at the end of it. It will of course be interesting to see how hybridisation plays out in the long term. Perhaps the big question here is will F2F Universities exist in the future or has the crisis been premonition of things to come. If we get used to living, working, and learning online, will we need large campus with lecture theatres, laboratories, and support services – and the extra expenses that they bring. Whatever happens we will need accreditation of courses and qualification so even in an entirely virtual, non-hybrid world, some types of institution will be needed into the future.

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A 16-Week Program of Physical Activity and Stress Management Education and Their Effect on Heart Rate Variability - An Analysis of Stress following the Coronavirus Pandemic

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Abstract

Life as we knew it ended. On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 virus a worldwide pandemic. Universities and colleges shifted from face-to-face learning to fully online learning and students were sent home from university housing. Numerous studies have been conducted and indicate that stress, anxiety, and depression increased during the pandemic lockdown. Stress is a phenomenon that influences heart rate variability. Heart rate variability (HRV) describes the time interval between heartbeats and is correlated to overall aspects of health. During stressful events, the sympathetic nervous system is activated. Physiologically, stress appears in the form of lowered HRV, with decreased parasympathetic (PS) activity, increased sympathetic (S) activity, and increased levels of cortisol. Alternatively, shifting the

autonomic balance towards increased PS activity can be achieved through stress managing training and practice using management methods. Research has also established a relationship between physical activity (PA) and HRV. **PURPOSE:** The purpose of this study was to explore the relationship between PA, biometric variables, and stress management training on HRV and stress inventory scores over a 16-week semester-long course that teaches healthy lifestyles and stress management the first semester back to face-to-face instruction following the pandemic lockdown restrictions. **METHODS:** Subjects for this research were 47 students enrolled in a 16-week semester course. This lecture/lab class is delivered in a hybrid format. Students were assigned a pedometer to track daily steps, with biometric data and HRV collected at the beginning and end of the semester. Students completed the State-Trait Anxiety Inventory for Adults. Stress management technique education, lifestyle education and exercise were the primary focus of the curriculum for the class. **RESULTS:** A paired samples t-test for means was conducted. Results indicated statistically significant changes from the pre- to the post-test for VO_2 and steps. **CONCLUSION:** Although our findings indicate no statistically significant changes in HRV or Stress Index, we believe our study was largely influenced by external factors, including the coronavirus pandemic. Further research is needed to establish a relationship between the coronavirus pandemic, stress, and PA on HRV.

Keywords: online learning, stress, heart rate variability, pandemic.

1.0 Introduction

1.1 Shift to Fully Online Learning

Life as we knew it ended. On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 virus a worldwide pandemic [1]. The result of this declaration was that, in an effort to mitigate the spread, restrictions were placed on public life. Universities and colleges shifted from face-to-face learning to fully online learning and students were sent home from university housing. Our university transitioned to fully online learning in March of 2020. The university remained fully online during the 2020-2021 academic year, returning to traditional face-to-face instruction in August 2021. According to a report by Celia Miller, [2] in the United States (US) only 46% of faculty members stated they had taught an online course prior to the transition to online due to COVID policies. Furthermore, 43% of college/university students enrolled in traditional face-to-face classes had not taken online classes prior to the transition to online. Given that, consider that about half of the student population had little to no idea what to expect for online learning,

while only about half of the faculty had any experience designing or teaching in the online environment, all in the midst of a pandemic with its own fears and unknowns.

1.2 Pandemic Stress

Numerous studies have been conducted since the onset of the pandemic that examined students' perceptions and reactions to the pandemic. Results of these studies indicate that stress, anxiety, and depression increased during the pandemic lockdown [3]. According to this study, 25% of students in China were afraid because of the COVID-19 outbreak. A study by Akdeniz et al [4] asked 3,040 Turkish students between the ages of 18-30 what their emotions about the coronavirus were and 38% reported being worried. A majority of European students also reported an increase in stress and anxiety. A study of French university students reported that 60.2% experienced increased anxiety as well as moderate to severe stress, especially among those that remained in confinement alone and not living with family members or roommates [5]. Social work students in southern Spain also experienced increased anxiety, with 34% experiencing severe anxiety and 28.5% experiencing mild to moderate anxiety [6]. A study of Polish students reported that a majority of students (65%) showed mild to severe General Anxiety Disorder with 56% experiencing a high level of perceived stress. This study by Rogowska et al concluded that university students experienced extremely high stress and anxiety during the time of quarantine, and that they may need professional help to cope with the pandemic [7].

1.3 Heart Rate Variability: A Measure of Stress

Stress is a phenomenon that influences heart rate variability. Heart rate variability (HRV) describes the time interval between heartbeats and is correlated to overall aspects of health. During stressful events, the sympathetic nervous system is activated. Physiologically, stress appears in the form of lowered HRV, with decreased parasympathetic (PS) activity, increased sympathetic (S) activity, and increased levels of cortisol. Alternatively, shifting the autonomic balance towards increased PS activity can be achieved through stress managing training and practice using management methods. Rhythmic breathing and active self-generating positive emotion training may shift the ANS balance towards increased PS activity [8]. Research has also established a relationship between physical activity (PA) and HRV. Studies have stated that as one increases PA there is a decrease in resting heart rate and increase in HRV. Our previous studies have demonstrated the relationship between physical activity, physical fitness and HRV [9]. PA intensity had a larger impact on HRV rather than weight status (as measured by BMI) [10], and achievement of moderate intensity physical activity recommendations may have a greater influence on stress then total steps per day [11].

1.4 Purpose of This Study

The purpose of this study was to explore the relationship between physical activity, biometric variables, and stress management training on heart rate variability and stress inventory scores over a 16-week semester-long course that teaches healthy lifestyles and stress management the first semester back to face-to-face instruction following the pandemic lockdown restrictions.

2.0 Methods

The subjects for this research were 47 students enrolled in KNR 113 Personal Fitness, a 16-week academic semester course. This lecture/lab class is delivered in a hybrid format. The lecture component is delivered fully online, while the students meet in-person two times per week for activity labs. Students were assigned a pedometer to track their daily steps. Each student had biometric data (height, weight, body composition, VO_2 (ml/kg/min), HRV, and stress health risk appraisal collected at the beginning and end of the semester. HRV was collected via HeartMath emWave® pro software. The software uses an infrared pulse plethysmograph ear sensor. Students also completed the State-Trait Anxiety Inventory for Adults [12] through the Polar Tri-Fit® software program. Students self-reported their steps each week of the course through pedometer logs. Lifestyle education and exercise were the primary focus of the curriculum for the class. "Release It" stress management technique education assignments were given through the HeartMath Institute and focused on breathing techniques, attitude, and the heart-brain connection.

3.0 Results

3.1 Demographic Results

Basic descriptive statistics were completed to describe the subject population. There were 47 total subjects. 57.4% were female (n=27) and 42.6% were male (n=20). The age of the subjects ranged from 18 to 30, with the majority of subjects being between 20 -22 years of age. See Table 1 for breakdown of the age of subjects.

Table 1: Subject Age

Age	Frequency	Percent
18	2	4.3%
19	3	6.4%
20	13	27.7%
21	14	29.8%
22	10	21.3%
23	4	8.5%
30	1	2.1%
Total	47	100%

3.2 Analysis of the Data

A paired samples t-test for means was conducted to test for statistical significance. Results indicated that there were statistically significant changes from the pre- to the post-test for VO_2 and steps. Cohen's *d* effect size value shows a small effect for HRV and Stress Index, and a large effect size value for steps. Table 2 shows the pre-and post-test scores of the variables, with statistically significant (*) changes revealed in $V0_2$ (ml/kg/min) and steps.

Table 2: Pre- and Post-Test Scores and Significance

HRV Variables	**Pre M (SD)**	**Post M (SD)**	***t*-value**	***p*-value**	**Cohen's *d***
HRV (SDNN)	116.0 (43.7)	117.4 (44.0)	-.191	.849	-.028
Steps*	97026 (55,580)	54094 (29,189)	4.735	.000	.865
VO_2*	44.74 (9.7)	47.5 (10.3)	-2.419	.020	-.365
Stress Index	33.49 (7.13)	32.81 (7.74)	1.073	.290	.176

The Stress Index pre- to post-test results, while not statistically significant, did show a slight decrease in overall stress. The classification metric for Stress Index is as follows. Low stress = 0-30, mild stress = 31-45, moderate stress = 46-60, and severe stress > 60. Thus, while students in this study started off the semester with a "mild" stress classification score, they did not make any statistically significant improvements in their stress score despite the stress management education and the improvement in VO_2.

4.0 Conclusions

This study examined the relationship between physical activity, biometric variables, and stress management training on heart rate variability and stress inventory scores over a 16-week semester long course that teaches healthy lifestyle, physical activity, and stress management. This study was conducted the first semester back to campus for students following the Covid-19 pandemic. At our university, all teaching and learning was conducted remotely from March of 2020 through the 2020-2021 academic year. This course was delivered in a hybrid format the first semester back on campus the fall of 2021. The content for the course was delivered asynchronously online, while the students met twice each week for in-person fitness activity. We expected that following this course, students would notice an increase in both VO_2 and HRV, with an accompanying decrease in Stress Index score. Although our findings indicate no statistically significant changes in HRV or Stress Index we believe our study was largely influenced by external factors. These factors include, but are not limited to, cooler temperatures towards the end of the semester and lasting effects of the coronavirus pandemic.

Daily steps from the beginning of semester to end of semester significantly decreased, possibly attributed to the increase in colder temperatures outdoors as the semester progressed. The cooler temperatures may have kept students indoors using exercise equipment that did not count steps, such as stationary bicycling. It is clear from the data that students did participate in cardio-respiratory fitness training as there was a statistically significant increase in VO_2 (ml/kg/min). Even though there was no increase in HRV that accompanied the increase in VO_2, this is still an important outcome of the study aside from the obvious cardiovascular benefits. A review conducted by Mohamed and Alawna [13] found that increasing VO_2 could produce short-term improvements in the immune and respiratory systems, particularly those specific for Covid-19 infections. Increased cardio-respiratory fitness may both decrease the risk of contracting the virus and decrease morbidity and mortality rates of Covid-19. Inclusion of this additional benefit of cardio-respiratory training in course content may help alleviate some students' fear of contracting or having poor outcomes if they do contract it, thereby allowing for stress reducing education to be more effective.

The lack of statistically significant changes in HRV or Stress Index may be related to the ongoing coronavirus pandemic which potentially contributed additional direct and indirect sources of stress. Our previous studies have shown a correlation between increased HRV intervals when physical activity and stress management education seminars are utilized. Despite our subject's improvement in VO_2 in this study, there was no significant improvement in HRV or Stress Index. Our previous studies were conducted pre-coronavirus pandemic. Ongoing stress and anxiety related to the Covid-19 virus may have contributed to the lack of statistically significant improvement in HRV found in this study. As winter approached at the end of the

semester, news reports warned of possible increase in positive infections related to spending more time indoors and the upcoming holiday season when families and friends gathered. Despite a semester of stress reduction education, combined with improvement in VO_2, there was no increase in HRV, possibly related to consistent messages from the media about expected increases in positive cases in the winter months.

When designing and implementing online courses in the age of Covid-19 it is important to consider effective strategies for combatting the negative psychological and physical effects of the virus, as psychological and physical stress can have a negative impact on achievement of course learning outcomes. The results of this study indicate that while students did not experience moderate or severe levels of stress, the stress management training and increased VO_2 did not increase HRV or lower stress index, as it had in studies prior to the pandemic. It may be beneficial to include discussion about Covid-19 and anxiety associated with this virus directly with students, along with education on preventative measures. Emphasis should be given to the discussion of infection prevention practices, including cardio-respiratory fitness training to decrease risk of contracting the virus, as well as knowledge of decreased morbidity and mortality from Covid-19 with higher VO_2 levels.

Rogowska et al [7] concluded that university students experienced high anxiety and stress during the pandemic and needed support and guidance to better manage stress and fear. They suggested implementation of protective strategies focused on preventing mental disorders as well as psychological intervention and treatment. While it can be difficult in online courses, especially if delivered asynchronously, to know if students are having increased stress or anxiety, faculty should be attentive to individual student engagement and participation in the class. Decreased quality of work or disengagement from the course may be signs of increased stress and anxiety. Have available and be prepared to offer students contact information to university or other mental health resources.

When designing online courses, consider course interactions: learner-to-instructor; learner-to-content; and learner-to-learner, and maximize human interactions. Husky et al [5] reported increased mental health problems during the Covid-19 confinement time. While society is currently, for the most part, out of confinement strategies for containment of the virus, feelings of isolation can still exist in online courses, especially those that have that have minimal learner-to-instructor or learner-to-learner interactions. This may be especially relevant if pre-pandemic social engagement and activity habits have not resumed. As discussed previously, consider use of discussion forums for interactions. Recorded video presentations or synchronous live presentations increase interactions with both the instructor and other learners. Small group projects or collaborative work also increase interactions, and this may provide students with the needed human interactions to alleviate stress and anxiety caused by the pandemic.

The stress management training and practice included in this course consisted of education of rhythmic breathing and active self-generating positive emotion, however this training was not linked directly to consideration of stress pertaining to Covid-19. Further research is needed to establish a relationship between the coronavirus pandemic, stress and stress management training, and physical activity on HRV.

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Online Education at the HEIs as Impact on the Society: Case Study Bosnia and Herzegovina

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Abstract

Globally unexpected transfer of education to online mode has caused a lot of challenges that had to be surpassed in the course of work.The issues had to be dealt pending on different countries' conditions but the consequences caused would have a long term impact. It is especially related to the non-developed or countries in the transition. The aim of this research was to discover the long-term consequences that will have impact on entire society such as lack of acquired knowledge, international mobilities' experience, losing of students' attention, incorrect grading and especially lack of laboratory or practical works. The research was held at state and private universities throughout the country of Bosnia and Herzegovina. Not only has the paper discovered these unwanted consequences but it has also suggested ways to overcome them.
In order to prevent negative long-term consequences for society as a whole, it is necessary to gradually overcome these effects of online teaching during the usual process after the end of the COVID pandemic. The paper not only lists these ways of overcoming, but also states the consequences that will happen if this is not done successfully.

Key words: online education, COVID pandemics,impact on society, SWOT analyses.

1.0 Advantages/disadvantages of e-learning and its effect on learning outcomes

From the very beginning of the COVID-19 pandemic, it was clear that no country had been sufficiently prepared for the situation, neither technically nor professionally, therefore the models used to resume with the teaching process were more than diverse. Soon after lockdown, it became clear that traditional approach to teaching, i.e. students' presence in classroom, would not be possible. In this situation, e-learning imposed itself as the only solution to that problem.

E-learning can be defined as a form of learning, teaching or education supported by using computer technology, more specifically, computer networks based on Internet technologies, as reported in 2002 by Fallon & Brown, 2002 [1]. It is an interactive, two-way learning process that takes place between teachers and students through electronic media, where the media are a tool in the whole learning process, sometimes the tool you cannot completely rely on.

Bosnia and Herzegovina as a diverse country with a complex constitutional structure provided different approaches to e-learning, various solutions, models and ways of using available technology and e-platforms. This is self-evident given the different levels of IT development in the country, the (non) existence of teaching aids, technical equipment, and the level of teacher/student training in terms of using such technology and tools. Many students did not have or did not use the appropriate equipment (they had to access the Internet from their mobile phones or to share the computer with their siblings or parents, some of them reported not to have proper headphones/microphones/cameras) so that the communication was further aggravated. The quality of the Internet connection certainly played an important factor in the whole process. Unstable Internet connection caused a breakdown in communication.

Private and state universities in Bosnia and Herzegovina allowed different possibilities of e-learning. E-platforms such as *Viber* or *WhatsApp* were occasionally used by some teachers. The e-learning platforms such as *Google Classroom, Zoom and Meet* were favoured by younger lecturers and TAs, which is quite understandable regarding the possibilities the last two offer – the possibility of sharing your screen on desktop which made their lectures very real-classroom like. From the perspective of some students teaching process realised by some of the aforementioned means has certain flaws because they themselves were not motivated to attend online classes as they missed the flair of the real classroom and interaction with others which resulted in switching off their cameras from time to time and skipping classes. Human being is a social one, and educational institutions, besides their primary role to pass on knowledge, are just equally important in socialization and the acquisition of certain social skills. Some other problems were reported by respondents like that of the prolonged exposure to artificial light sources (e.g. computer monitor) which caused vision or back problems, as well as the other health problems resulting from physical inactivity.

The highest negative impact has been notice when practical or laboratory works were in issue. The lack of those has to be overcome when the education returns to pre-Covid offline mode. Although extra efforts were done to show the way how to do some practical tasks the students had to have as per the syllabus, there were no possibilities to bring the sense of those tasks to the students, e.g. how to give injections to a patient, doing massages, feeling the laboratory tools in hands. Only a small group of students said they e-learning had provided better focus for them since they were excluded from disruptive external influences. The teachers who stuck to email correspondence put the outcome of their lessons at stake. Students who followed the instructions given that way reported not to be motivated to carry out their assignments and to face huge gaps in knowledge in their further education.

However, all of the respondents agreed that e-learning has a positive effect on the student's budget for it is free of travel and accommodation costs and students attend lectures from the comfort of their own home no matter whether they like it or not. Above-average students benefited more because they were able to communicate more often and directly with the teacher and other students, which also encouraged and developed a culture of team spirit and work.

Apart from the difficulties we already mentioned, there were some other problems arising from the concept of a course itself. Not all courses are appropriate to be taught remotely especially not those that require hands-on activities like scientific labs or practical work. Faculties that are based on lab or practical work like Faculty of Medicine lost a lot during pandemic. To compensate that lack they had to double the amount of practical work to be done in labs in post-Covid period which overloaded students with work and aggravated the process of mastering skills needed to pass the course. Even the lecturing has usually been done in shorter time (instead of 45 minutes it was limited to 40 minutes or even shorter by free platforms). The curricula scheduled for a semester had to be done in 75 % quantity only.

When it comes to learning outcomes, it cannot be said they have not been achieved, however, a true challenge was the assessment of students' knowledge in view of the limited possibilities imposed by the situation with COVID-19. Therefore, it can be said that COVID-19 influenced the assessment of students' knowledge, and not the learning outcomes as such.

2.0 Grading in e-learning

At the beginning of the COVID-19 pandemic all higher education institutions in Bosnia and Herzegovina, private and state, made the transition to e-learning. The logical step was to expect that the question of grading student's knowledge would be raised and debated.But those were mainly in-house questions and debates based on suggestions to use a pass/fail grading system or not to use grades at all. Any of the two would lead to breaching of the Bologna Process system of grading in which the student continually receives points for working on a seminar, attenting classes,

taking notes which are added up and added to the points that the student receives on the exam.

Since no unanimous agreement on grading was reached, it was left to teachers to decide on the grading system they wanted to use in their courses. Besides, teachers were faced with the dilemma of choosing between keeping grading expectations the same and abridging test questions to match what was learnt in e-classroom. Since learning process went through modification, grading system should go through modification as well to fit. One of the postulates of marking tests proposed in 2001 by Harmer [2] says that "before designing a test, and giving it to a group of students" we should" assess the test situation, remind ourselves of the context in which the test takes place". However, some teachers did not assess the test situation, did not take into consideration this newly-created atmosphere and sticked to their standard ways of giving tests and assessing them. That caused the imbalance between the quantity of knowledge they offered online and the quantity of knowledge they tested and the problemof unfairness.

During e-learning process, assessments of the acquired knowledge were either carried out online or postponed to be carried out in traditional ways. Teachers who preferred the latter type of assessment divided students into smaller groups and asked them to physically come to their classrooms to be tested.They could not rely on e-resources for testing but carried out their assessments in classrooms which were postponed until the minimal conditions were satisfied. Those teachers also created disruption in continuos assessment of student's knowledge suggested by the Bologna Process but provided traditional examination conditions.

Online testing was usually done via Google Classroom where the teacher would set a time limit and send a copy of test for each student. Despite these restrictions, students still had a chance to find ways of having things done instead of doing them themselves and teachers could not be certain that their students would be fair and honest. Even though some researchers like Bach, Haynes and Smith [3] do not agree that assessment and examination are much more open to abuse online than they are in another context, we did find evidence that students cheated in online testing if they had a chance. The old saying 'opportunity makes the thief' came true. In online space students had the opportunity to commit that 'crime' since there were no controls in place. Rules applied in the traditional classroom existed no more. Teachers and students were deprived of a face to face communication in which teachers set examination rules and have control of them. That is why grades for some students were unexpected. There were cases in which struggling students passed with flying colours which only confirmed the fact that this kind of e-assessment was not objective. That caused a stir among students who felt that this system of grading was not just and correct and made them lose interest in the subject in question. To prevent cheating some teachers resorted to giving a different test to each student.But this was possible only when the teacher had a small group of students.

On the other hand, there were teachers who pretended to have a real-life situation and carried out synchronous computer-mediated orals where students had to prepare

topics to present in order to get points needed for passing the course. This was safe,a very real-life environment of gathering points which did not breach the Bologna system of assessing student's knowledge. Yet, some students, as they reported, found this part of grading stressful.

What could teachers do in post-covid time to mend all the irregularities which occurred in e-grading? Teachers could provide an opportunity to resit the oral exam for all those who attended e-classes during pandemic, got graded at the time or felt that they were somehow docked for the points. That would give them the sense that justice had been done.

3.0 The lack of mobility

The pre-Covid mobility faced through various students and teachers exchange programs on national and international levels was completelly banned during the pandemic. In order to avoid the spreading of disease that process of knowledge and experience exchange had to be stopped.

Also the policy of hiring guest professors from other universities had to be avoided. It caused not only disagreement from students side because they understood the situation the whole world faced but the established way of knowledge transfer and exchange with the persons from other universities. All of the programs that were funded by the European Union related to mobilities were stopped and the funds were directed into other most important programs related to health protection and researches in that field.

Although there were lots of agreements signed between the universities from all over the world in one hand and with the European Union in other hand they had to be put on "stand by" for that period of time. It was confirmed that the students who participated in those mobility programs gained some new knowledge and experience that assisted them a lot not only in personal development but also job finding after graduating. Unfortunately, all those positive experiences had to be psotponed for uncertain future at the time. As the research conducted confirmed the students were impatiently waiting for pandemic to be over in order to go abroad and gain some new experiences and practices that were different comparing to the syllabuses at their respective faculties at home. Despite the obstacles still existing in the mobility programs the benefits of those have already been mentioned by Popa & Knezevic [4] showing the advantages of the students who participated in some of the mobility programs comparing to those who did not had a chance (or did not want) to join any of the programs in many ways.

The questionnaire made for this research confirmed again the students resolution to participate in many exchange programs across the world in order to develop various skills (foreign language, work in multinational environemnt, team spirit and many others) creating a brighter future for themselves and benefits for the scoiety where they would be working in the future.

4.0 SWOT Analyses

The SWOT analyses (Figure 1) of the research based upon the questionnaire sent to some state and private universities across the state of Bosnia and Herzegovina showed the following outcomes: the strengths should be seen in the satisfied level of Internet access before the pandemics, cheaper education for students as well as higher interaction between the students while learning.

However, the weaknesses were discovered in the lack of practical and laboratory work during the pandemics, supported also by the lack of prior knowledge of the used platforms. The opportunities were mostly noticed in cheaper education process and development of IT knowledge. The threats were very important especially when learning outcomes in issue, lack of knowledge that had to be acquired as per offline platforms, as well as when cyber-crime, privacy and security concerns in issue.

Strengths	**Weaknesses**
- Internet access before the pandemics - Higher level of interaction between the students and a student-professor relation - Cheaper education for students	- Practical and laboratory work during the pandemics -Prior knowledge of the used platforms and IT skills - Combining online education and offline traditional examination - Lack of IT equipment - No Bologna way of doing assessment
Opportunities	**Threats**
- Cheaper education process for society - IT knowledge development - Developing distance learning (more students attending lecturing) - More free time for the students - Easier assessment for professors	- Learning outcomes lower than before the pandemics - Grading inadequate (unreliable, inconsistent, unfair) - Lack of knowledge that had to be acquired as per offline mode (shorter lecturing) - Health risk (long time effects of PC) -Cyber-crime, privacy & security issue

Figure1**:** The SWOT analyses

5.0 Conclusion

The research has confirmed that there was a great impact of e-learning on the society. Lots of shortages and lacks that were noticed have to be improved while the education comes to the offline mode as before the pandemics [5]. However, the experiences gained while lecturing in online mode will be great experience for any further similar situation when all these lacks may be overcome faster than it was done in the past. The further research should be aimed to the possibility of acquiring the quantity of knowledge lost during the pandemics prior to the students' graduations.

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Teaching Sustainable Computing Remotely

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Abstract

This paper explores experiences of teaching sustainable computing remotely during the Coronavirus pandemic. The unanticipated rapid pivot to online learning meant that courses with traditional teaching, or blended approaches had to be adapted to be delivered entirely online. This created challenges for teacher and student alike. In the case of sustainable and green computing, this meant there were opportunities to highlight how computer science itself could provide solutions to the word's challenges during Coronavirus, and longer-term solutions that also address climate change through Green computing. This work was built on over a decade's experience of developing students understanding of IT and its impact.

Keywords: Green Computing, Education for Sustainable Development, computing education.

1.0 Introduction

This paper considers the way that computing and Sustainable Development are linked [1], [2] and how the teaching of these has been affected by Covid [3]. It considers sustainability and how it can be taught in the context of a computing degree, with a move to remote teaching during the pandemic.

Sustainability is achieving increasing prominence across the world, with the United Nations Sustainable Development initiative leading to the current set of 17 goals [4], and governments and organisations considering how to address sustainable challenges such as the UK approach [5]. This has seen sustainability become part of national policymaking, become integrated into company and institutional mission statements and strategies, as well as becoming integrated into education approaches and into other discipline requirements, such as the Computing benchmark [6]

Sustainable computing considers how computer science as a discipline has a role within the sustainability agenda, both as a challenge for sustainability in terms of the resources and impact it has on humanity, and as a potential enabler in terms of addressing these challenges.

This paper considers some of these aspects, from the perspective of delivering the material in the context of a module within a computer science degree, where the delivery transitioned from a traditional campus based format, through an entirely online format, and then to a hybrid one due to the constraints and requirements caused by the Coronavirus pandemic.

2.0 Overview of a sustainable computing module

The module in question is a level 4 (first year) module that is compulsory for all students. The module typically has between 140 and 300 students. The module is a second semester one that typically runs from January through to May. Students take it alongside modules on programming, computer systems and platforms, and software engineering and HCI.

The module aimed to foster student's understanding of the impact on and value of computing to society and the world around them, appreciating the potential ways to address some of the UN Sustainable Development Goals [1]. A linked aim is to provide a framework for student's legal, social, ethical and professional awareness of computer science [2]. A further aim is to encourage students to work collaboratively, with a focus on environmental and societal problems, and the scope for solutions, from the domain of computer Science. Students have to develop their research and independent learning skills, alongside communication and team working, as they investigate issues and provide a report and presentation on their findings.

The module includes material around effective team working, and the need for professional and personal development as a practising scientist or engineer. The module will also provide a background on the role of information and data in supporting a case, with an introduction to suitable data analysis and presentation approaches as well as relevant aspects from other science disciplines.

The module includes examples of issues and some initial areas where computing technology can provide solutions; alongside the problems and issues it creates [3]. Teams of students then go on to use their combined experience, knowledge and skills to develop a report on a particular topic. They are required to outline a potential solution.

Topics include:

- The carbon footprint of the University data centre;
- The impact of eLearning on student travel and carbon footprints;

- How to support and create the capacity in computing education – at all levels;
- The role of social media in encouraging widening participation to university in the Hull and East Riding region;
- Enabling the creative economy in the Hull region: what's needed next;
- How can technology improve the region's health;
- Enabling good practice in cyber security – for users and small businesses;
- The balance of data protection and freedom of information.

The module was assessed through an individual portfolio of computer-based tests, and a team based development activity. The individual portfolio enabled students to demonstrate their knowledge and understanding of the key concepts of sustainability and relevant skills for the research, analysis and team working. The team activity offered some choice and innovation, in terms of identifying and addressing a sustainability topic. The solution could be a data rich analysis of a topic, or developing a website, app or other software artefact that addressed the problem.

3.0 Transition of delivery

In this section, we explore the different teaching approaches adopted by the module, from the original face-to-face campus based, through the mixed mode that occurred as lockdowns were called and teaching pivoted to online, and then the final online only remote delivery.

3.1 Traditional campus based delivery

Prior to the pandemic, the module was designed and delivered as a campus-based module. This involved weekly lectures to cover the theory and provide an environment for students to engage through tools such as Menti. Lectures were routinely recorded using Panopto – though this only captured the computer display and the audio.

Table 1: example of computing addressing sustainability challenges

Reduce Computer Generated Pollution	Reduce non-computing pollution
Improve usage models (standby modes, auto switch off) Upgrade code to boost efficiency, maximise maintainability of software Virtualise/emulate to prevent the need to have lots of different devices Improve efficiency of components	Improve logistics (less wasted journeys) Virtual meetings (video conferencing) New manufacturing models and efficient designs (e.g. 3D printing, 3D modelling) More efficient buildings / intelligent buildings Smart Grid (smart electricity production and sharing)

The lectures were supported by workshops based in a computer laboratory where they could work on their individual portfolios and on their team project. Workshops were organised as one or two sessions, with tutor/demonstrators supporting the students with guidance and help on the work.

Sustainability and how that links with computing (see Table 1) was the key focus, though content and activities were designed to encourage students to develop a broader understanding of their professional expectations, and to develop different transferrable or key skills, including communication and teamwork. The topic offered ways to motivate the teaching of ethical considerations and professional skills [1], alongside developing innovation and exploration through discussions and teamwork. Research and development were introduced, linking academic staff research to the module, as well as postgraduate students. The experiences of overseas students gave other insights to undergraduate students as to why sustainable development is such as important topic, with global impact.

3.2 Mixed delivery during the early pandemic

In March 2020, teaching had to pivot from campus based to remote delivery, as the pandemic forced lockdowns and the cessation of face-to-face teaching. In terms of teaching, the main impact was a move away from large campus based lectures, to streamed teaching using Panopto. The initial pivot meant that content was limited – that is there was little time to either prepare materials or to adapt significantly.

Workshops became online activities, supported by demonstrators. The effectiveness of these was improved through allocating students to specific demonstrators, and creating smaller online channels for these. The allocation was based on the later teams, so that they could support both individual portfolio development and the team activities.

In terms of the specifics of the module, the pandemic gave some concrete examples in a way that could be integrated into the modules material. For example, the final campus based lecture was on data analysis. In March 2020, early data and models from China were becoming available that showed how the pandemic was spreading, and what the impact was in terms of infections and fatality for different age groups. This meant we were able to discuss modelling, and consider the potential impact of Covid in the UK using the Chinese models, and in the absence of any vaccines or immediate mitigating actions.

The pandemic gave some different context when considering the affordances offered by computing technology, and the learning experience of having to switch to online and remote teaching, learning and assessment. The transition to online teaching when the first lockdown started in 2020 was not envisaged in the original module planning, and the technology support available was limited in some ways, e.g. streaming of lectures and support for interactive sessions. The first few weeks of the lockdown followed the sort of learning curve of new concepts and tools, as both the

staff, demonstrators and students began to use the online tools and adapt to working without direct face-to-face support or environments.

For sustainability, this meant I could link the challenges of the pandemic, sustainability topics, and computing solutions within the lectures. Student feedback indicated a number of challenges that they faced – these generally related to any remote teaching, but did provide some ideas for how to develop the sustainability module and its resources. Particular issues were the lack of peer support, a lack of explicit guidance on "how to study", confusion over timetables and issues with collaboration on team activities. Whilst not directly content related, these problems showed how students were experiencing first hand problems that are directly relevant to sustainability, and the technologies that could assist. We will consider this more in the next section.

3.3 Full online delivery – teaching remotely

By the summer of 2020, the impact of several lockdowns meant that planning was put in place for delivering teaching fully online. This was building on the experiences from the mixed delivery of 2019-20, which had provided an opportunity to gain familiarity with the use of the online platforms and tools such as webcam and audio capture for live and recorded teaching and learning. Tools were evolving and improving, and alongside the VLE and Panopto, there was the opportunity to use Microsoft Teams to support modules. This provided a place to have online meetings, which could be lectures or workshops and seminars. For computer science, a benefit of Teams was the ability of students to share their computer display to get advice and assistance.

From a sustainable development perspective, this gave opportunities to show how technology can address challenges and enable new ways to live and work. A key one was for remote study. In the event, by September 2020 students were able to return to campus, but teaching was already planned as online. This meant that students could be supported through online learning where the timetable provided scheduled times to interact, supported by asynchronous resources. This approach to flexible delivery and learning is directly relevant to sustainability in several ways, which are detailed below.

The learning experiences of the previous academic year meant that some aspects could be structured and provided for from the start. One of the key factors identified was that students struggled with the full autonomy and full flexibility of online learning. They also misunderstood the expectations on them as learners e.g. assuming that the timetable was the entire expectation of their learning. This was addressed through having an explicit guidance on how to manage themselves and how to learn in the module, which was used in every lecture. See Figure 1.

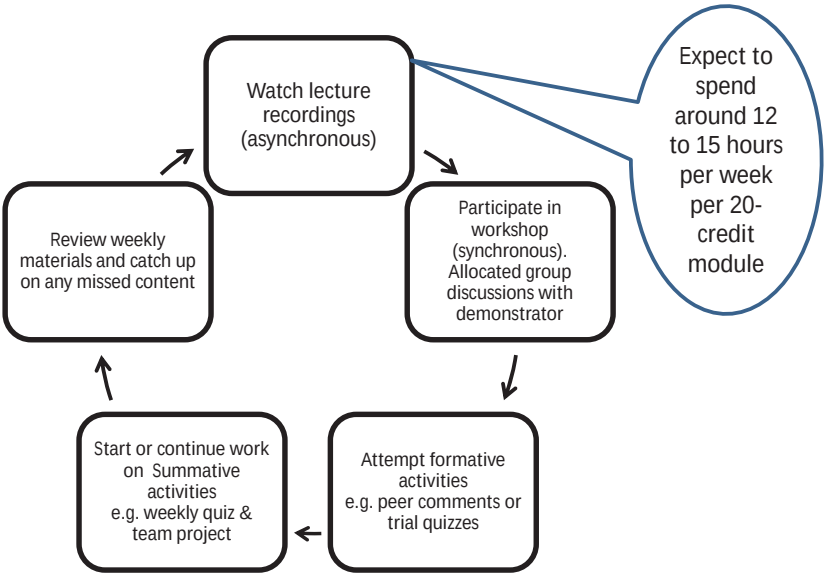

Figure 1: guidance on how to learn – weekly process

A sense of community and being able to ask questions is recognised as a key aspect of learning. This was fostered in the online environment by creating smaller channels within the module's MS Teams site, based on allocation to demonstrators. These demonstrator channels supported individual student work, and the later team activity.

Amongst the many things we learnt from teaching sustainability online, some are more general to any remote teaching. The issues that students identified as problems were it was hard to keep up with work, it was difficult to organise group work, and the complexities of multiple communication streams (different messaging systems and email).

There were a number of ways we addressed this, including:

- Providing detailed guidance on team work and entirely remote collaboration – this was relevant from a sustainability in practice viewpoint, as it illustrated how organisations and individuals can and need to adapt their behaviours and ways of working to reduce travel and help the environment.
- We explored what remote learning makes more sustainable – supporting communities, enabling and supporting different needs and thus enabling more equal learning environments;
- Plenary and breakout channels were a way to mirror online the sort of campus and face-to-face teaching spaces. Again, the practice in the module demonstrated a sustainable approach to education.

3.3.1 Computing, Sustainability and the pandemic

As discussed above, remote delivery of sustainability did enable discussion and highlights of issues around some of the changes needed for sustainable development. The sustainable development goals, and the necessity of online teaching during the Covid Pandemic, provided opportunities to consider and explore how computing can address these challenges.

Table 2: Using computing to address Pandemic and Sustainability Issues

Problem	**How Computing addresses it**
Lockdowns restricting access to shops	Online shopping and managing delivery and logistics
Working remotely	Virtual meetings, collaboration tools such as MS Teams and Google Docs.
Studying remotely	Effective use of Virtual Learning Environments; Digital and remote assessments; Online collaboration tools and meeting tools. Lecture recordings and capture.
Social separation and travel restrictions	Virtual meetings, social media and support for virtual communities
Understanding the impact and spread of a live pandemic	Population pandemic Modelling
Addressing the problem of treating Covid-19	Virus modelling (molecular)
Fake news e.g. vaccine deniers	Developing critical skills and understanding of knowledge management and information acquisition. The effective use of internet tools e.g. search engines, and of approaches to determine the authenticity of content.
Social hacking/increased cybercrime	Awareness of cybersecurity tools and approaches – such as validating URL locations, understanding phishing attacks and our responsibilities as computing professionals to support users

As explored above and in table 2, remote learning offers myriad opportunities to link directly to sustainable development and ideas around professional behaviours and responsibilities.

1.5 Return from pandemic – the new normal

As countries and society enter the new normal of living alongside Covid, there is a tension between returning to old approaches, and to maintaining the benefits of those adopted to address the challenges of the pandemic. Campus based institutions are

facing the challenges of justifying their campus experiences, with campus based teaching, whilst potentially allowing a hybrid and flexible education.[7]. From a sustainable development perspective, this is a question of how far people and societies are adaptable, or how quickly they want to return to the known world.
Experience is showing that many universities are planning a return to campus teaching, though taking advantage of the successful experiences with online teaching through the pandemic. There are a variety of other factors affecting the return to normal, including social and political ones (in the UK the government is keen to see this return to normal [8]). However, staff and students are showing that they have grown used to the flexibility of online and hybrid learning. The Covid legacy is likely to be a long-term change in behaviours, with institutions having to adapt to ensure they offer an engaging mix of online and campus based experiences.

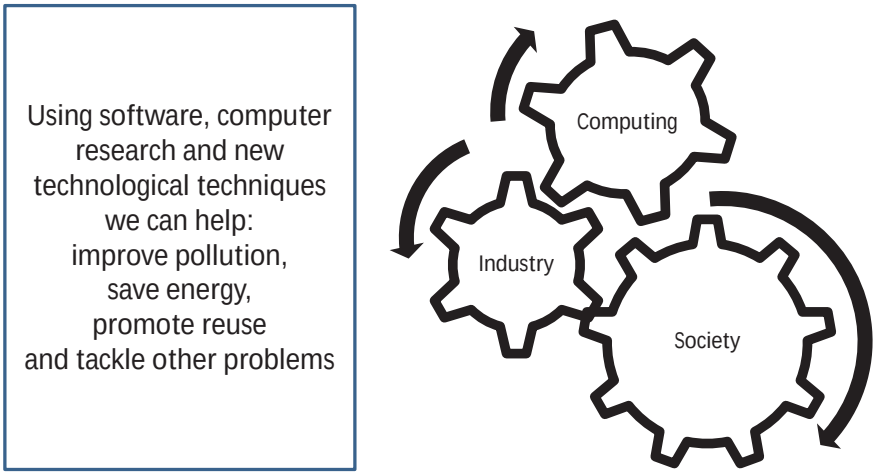

Figure 2: Computing as a solution provider

4.0 Conclusion and the future of remote teaching of sustainability

The impact of the Covid pandemic on teaching globally has been profound, at every level from nursery/pre-school up to university/tertiary. National lockdowns saw a mass pivot to online learning as education institutions adapted to the need to teach remotely. From a sustainable development perspective, the lockdowns showed the fragility of many existing systems, whilst also demonstrating that mass change in behaviour can be managed and supported. This is particularly important when considering the use of carbon-based fuels, and the challenges of commerce and travel.

The pandemic also demonstrated how computing – from bespoke apps, websites, video conferencing – can address societal and sustainable challenges. From a sustainable development perspective, the challenges and issues of 2019-2022 can be used as authentic problems for students to consider how to address through computing.

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Dr Neil Gordon is a National Teaching Fellow, and a senior lecturer at the University of Hull. Neil leads the Computer Science family of degree programmes. His research includes applications of mathematics to computer science, whilst his teaching duties range from first year core modules through to specialist masters' level computing courses, including software engineering. He has produced a number of national reports related to Higher Education, including issues of retention and attainment in computer science

Assessing the Potential of Innovative Borderless Hybrid Education for Practitioners in Emerging Economies

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Abstract

Today, hybrid learning is the most recent and most widespread form of distance education. It has significantly influenced postsecondary education within the past decade, and the tendency is only increasing. Hybrid classes in education are evolving more common in higher education in emerging countries. Moreover, universities recognize that the same effects can be achieved without requiring preservice and in-service teachers to join a physical classroom. This paper utilizes a mixed-method approach to study the impact of hybrid instruction on higher education, the faculty's experienced uniqueness and the role played by technology in this methodology. It delivers savings to students and promotes broader access to higher education through hybrid teaching and learning. This paper emphasizes practical and creative approaches as we analyze and examine practitioner experiences in the formation and execution of hybrid education programs. The paper discusses the initial program developments and the lessons learned to help guide educators, leaders, and researchers in institutes of higher education. The author made some general recommendations for those considering schedule change or creation. This research and experimentation will help determine how hybrid learning transforms teachers and the teaching occupation within higher education as many faculties remain uncertain about online teaching and suggest ways to address these challenges

Keywords: hybrid education, online teaching, borderless education, emerging economies, distance education

1.0 Introduction

Hybrid education is a model of teaching where educational tools are used by educators and students to meet their needs. Knowledge are disseminated through these tools to both the in- person and online learners. Hybrid education is an innovative model of disseminating and acquisition of knowledge which involves in-person and online learning system. It is a mode of learning that is mostly used in tertiary educational institutions of learning with the objective of providing a technological enabling environment for students to acquire knowledge through learning and understanding by using both in-person and online methods. Hybrid education involves some students attending classes in-person while others attend virtually or online, and the educators have the responsibility to teach both the in-person and virtual groups simultaneously, and it is flexible in scheduling and suits both the educators and the students. It is a way to balance virtual or online learning and in-person learning aimed at making the students to develop full learning potentials. Borderless hybrid education is driven by technological developments; enhanced interest in lifelong learning; and huge increases in the international demand for higher education [1]. Studies have shown students' satisfaction with online activities because of the benefits accrue from them [2]. Hybrid learning was found to be more time-consuming [3] but it instills confidence in students to accomplish the set learning objectives and goals [2].

Hybrid education is regarded as a new approach to learning in emerging economies such as Nigeria and others. The outbreak of coronavirus (COVID-19) pandemic has brought to the lime light the diverse learning platform such as hybrid learning, blended learning, and remote learning. The pandemic has transformed the styles and methods of education and learning, and has created the awareness on the available concepts and tools needed for the building of a better and sustainable educational future. Prior to the outbreak of the pandemic, the traditional method of classroom teaching was the only way of knowledge dissemination to students by the educators in most emerging economies. However, since the introduction of hybrid learning in tertiary education for example, in Nigeria, success stories has been reported by educators and students. The plausible explanation of the success could be that hybrid education offers an opportunity for students to be flexible in their education and makes active learning possible, and also proffers freedom for the students. This is so because hybrid education is innovative in the sense that students had the opportunity to get the best from both the traditional and online teaching instead of being at home for remote teaching. It provides accessibility to more learning opportunities for the physically challenged students and students with learning difficulties to participate in class works and learn alongside with their peers.

Hybrid learning provides flexibility opportunities for educators and also aided teaching through learning by self-paced and classroom learning. Research has shown that the perceived effectiveness of online teaching and in-person teaching by teachers did not differ significantly [4]. The higher percentage of teachers viewed

online teaching as not effective as in-person teaching while a lower percentage viewed online teaching as effective as in-person teaching [4]. However, a slightly higher percentage of students preferred hybrid learning but a lower percentage preferred in-person learning [4]. In a survey of medical students and teachers in Korea after the COVID-19, [5] reported that 84% of students and 48% of teachers prefer online learning. Similarly, [6] revealed that 53.2% of students and 38.6% of teachers preferred online teaching of theoretical curriculum in Germany. In Nigeria, the National Open University of Nigeria (NOUN) which is a distance learning awarding degree university has been teaching students predominantly through the online platform, but this is not the case in other conventional university whose method of teaching has been the traditional in-person classroom teaching before the COVID-19 pandemic. However, many educational institutions in Nigeria including post-primary and tertiary institutions have keyed into the new normal of teaching students. There are online educational platforms through which teachers teaches students to complement the in-person learning. For example, in March 2022, the National Open University of Nigeria (NOUN) in collaboration with the Commonwealth of Learning (COL) organized a 4- week open educational resource for online learning (practical approach) for facilitators to keep them abreast of open educational resources (OERs). This was a follow-up to the training on open educational resources for online learning (an introduction) organised by NOUN in collaboration with COL in October 2021. There are benefits inherent in teacher-student and student-student communications [7, 8]. Pre-recorded video materials are important tools for educators and students in hybrid learning while the online forum is important for discussion, brainstorming, questions, and answers on topics and topical issues. In addition, live-stream lectures enhance effective hybrid learning because it closes the gap that could be created by the non-physical interaction of teachers and students. However, both the live-stream teaching and the online discussions provides more interaction opportunities for the students and teachers because absence or poor interactions is a disadvantage to e-learning [5, 9, 10]. In a study conducted by Li, Zhang, Liu, & Tong [4], close to three-quarters of students had experienced Massive Open Online Courses (MOOCs) in China and a third-quarter had used other e-learning platforms, but in contrast, close to 90% of teachers had very limited exposure to online teaching which confirms the findings of an earlier study [11] that students' prior learning experiences were positively correlated with their evaluation of the online education and their satisfaction.

After the resumption of in-person classroom learning in the late 2020 in Nigeria, many tertiary institutions engaged in hybrid learning where only subjects that involves practical in laboratory settings were majorly allowed to be taught in-person while other subjects were taught virtually. Many teachers direct their students to experience through participation in the MOOC programs. This is because not all the teaching and learning materials need to be built from scratch, but the existing online educational resources for teaching and learning can be identified and used [12]. However, in most of the Nigerian educational institutions today, more teaching is done in person than online. Likewise in 2020, the Southern Medical University (SMU) in China mandates at least 20% of suitable course materials to be delivered by the teachers to students through the virtual self-learning space [4].

2.0 The Role of Technology in Hybrid Education

Technology is a support tool for the achievement of positive educational reforms [13]. This is because it makes learning to be flexible, easier, and relevant to both the teachers and the students. Technological tools allow for easy creation and storing of online educational resources and enables effective and efficient delivery of such resources on the online platforms [14]. It is however pertinent to know that the use of technology alone is not a guarantee for the 21st Century learning skills [15], and does not ensure the overall effectiveness of content delivery [16], but the absence of technology can make teachers not to achieve the set learning outcomes [16], especially in a technological-driven educational system. Therefore, the role of technology in hybrid education is important to the teachers and students.

For technology to become an integral part of the learning experience, it should be integrated into the teaching process to support the learning process [14]. Technological education can be implemented on a variety of subjects [17]. Given the various technological tools in education, such as online platforms like Microsoft teams, Microsoft classroom, Google classroom, zoom, WhatsApp, Telegram and other social media platforms, students can easily participate in both synchronous and asynchronous learning [14]. Therefore, to achieve considerably in hybrid education, teachers need to be trained in both the art and science of teaching and in technology because the technology supports the roles of teachers, especially in the area of feedback, monitoring, assessment and accomplishments [14].

3.0 Formation and Execution of Hybrid Education Programme

However, it is pertinent to know that forming and executing hybrid education programs in emerging economies such as Nigeria, should follow some steps and procedures that are important.

First, the basic needs of the educators must be paramount for effective teaching and learning. The lower order needs such as the physiological needs (food, water, shelter), safety needs (security, safety), and belongingness and love needs (friendship, relationship). The higher order needs are esteem needs (prestige, accomplishments), and self-actualisation needs (full potential, creative activities, self-fulfillment) [18] are very important to the educators for quality delivery of hybrid education. However, the human needs can be summarised as safety and survival; understanding and growth; love and acceptance; contribution and creation; esteem, identity, and significance; self-direction, freedom, and justice; and self-fulfillment and self- transcendence [19].

The second step is to determine the content suitable for online and in-person learning activities. The contents to be learnt can be posted and read online but teaching activities which focuses on the student's skills can be done in-person in the classroom. The contents could include educational resources and videos on the subject to be taught.

Furthermore, a two-way communication style should be encouraged between the educator and the students, where questions are asked by the students and adequate answers to the questions are provided by the educators. There should be a free flow of unambiguous communication that are clearly encoded and decoded unhindered. Therefore, teaching contents should be clearly structured and written in understandable ways for the students to grasp.

Teachers should focus on the best technology tool for hybrid learning and use it adequately. Doing this will not overwhelm the students unlike using the different online learning platforms available. For example, a teacher can opt for the use of Google classroom for the online teaching instead of using Google classroom and zoom for teaching the same subject.

In addition, teachers should keep updating their technological skills in the use of technological- driven educational tools. Training is important for teachers to increase their proficiency in the use of online educational tools. Although, it is noted that virtual online interactions cannot produce all the features of in-person interactions, but it does usher in the possibilities of technology-mediation which transcend the constraints of space and time [20].

4.0 Designing Hybrid Education

When designing hybrid education, educators should take into cognizance the contents that students are to read and deal with, therefore educators should design contents that are within the context of the student's experience in a decolonized and authentic ways, and which should be delimitated into smaller units to forestall overwhelmingness on the part of the students.

An academic collaboration which can foster a sense of community among students to learn at their own pace should be encouraged while the use of videos to approach asynchronous learning should be built-in by the educators. This will enable students to have access to video contents at their pace and discussion on such video contents can hold in the classroom. Contents that requires laboratory activities should be packed to allow for both self-paced and joint laboratory learning where students can spend some time to discuss the contents learned freely, at the end of which the teacher can questions or give assignments to the students on the contents learned in form of formative and summative feedback.

5.0 Designing Hybrid Education

Having a hybrid learning environment that is devoid of extraneous and confused variables is important. However, in creating a successful hybrid learning environment, teachers should be aware of these factors.

Firstly, teachers should set the goals they want to accomplish in the hybrid education. The goals could be short-time or long-term depending on the contents to be disseminated. Having set goals is a guiding indicator for the teacher and the students in the hybrid education learning activities. The learning expectations are easily known to the students and the assessment method is based on the set goals.

Secondly, teachers should create course contents to include course activities with a timeline in a set order of accomplishment. In doing this, teachers will notice any gap or unattended activities in the course contents.

Furthermore, educators should determine the course contents and course activities that can be served through the in-person classroom and the online methods. Activities that requires group discussions, group presentations, brainstorming sessions, and collaborative works could be done in-person while the asynchronous activities are reserved for online.

6.0 Prospects and Challenges of Hybrid Education

Hybrid learning comprise a range of learning objectives utilizing different pedagogical approaches and technologies. Depending on circumstances and preferences, it enables the learner to study in flexible modes either online or face-to-face. The online and information and communication technology (ICT) components are used to supplement or supplant real class activities. Hybrid teaching includes having heterogeneous learner groups with some students in class and others online. This gives students some measure of control over when, where, the direction and pace of study. The human dimension that facilitates effective hybrid learning need to be identified, analyzed and understood. This amongst others include role of teachers , the models of curriculum-oriented resources provision and distribution and successful pedagogical learning practices. The various pedagogical approaches include flipped classrooms, rotations, flex and a la carte models. The approaches used in hybrid leaning has enormous potential to transform the delivery of education. The nature of learning spaces and those utilizing them could be affected from the point of view of extending access to education including non-formal (informal) and social learning in communities of practice, provision of support for the use of enriched innovative pedagogical approaches by teachers, the creation and use of customized contents, the offering new opportunities for tutor's continuing personal and professional development and lowering of the costs of learning.

The digital divide poses a big challenge to policy makers, institutions, staff and students and the other stakeholders. Some of these included but are not limited to problems of unequal access to education and educational resources due to differences in affordability, unavailability of programmes for development skills to support hybrid teaching and learning, maintenance of engagement between tutors and learners resulting from the use of some inherently biased automated tools, lack of relevant research and appropriate contents that are learner-centered and limited use hybrid learning due to societal and learner contexts.

There are lots of challenges bedeviling hybrid education in emerging economies like Nigeria. These challenges need to be tackled for the realization of a smooth hybrid education.

Unstable power supply in emerging countries inhibits the success of hybrid education. Epileptic power generation and supply coupled with increased cost in electricity payment discourages the use of online learning. Poor network from the network providers disrupts the free flow of online learning. Many at times, the failed network could persist for hours without being resolved by the providers. The high tariff charged by the providers are ridiculously exorbitant and the rate at which data purchased from them are exhausted is unpredictable and, is annoying. Many students hide under this canopy of the poor network to embrace and perpetuate procrastination.

Temptations from other social network platforms such as Facebook, Instagram, Twitter, LinkedIn, Games, and the likes including chatting with friends, can distract students from concentrating fully on the online educational resources provided for reading. Online learning that involves online discussion can breed misunderstanding, disrespect, and negative feelings among students because of the inability to see or hear the sender of a message.

Political instability as a result of the change in government can bring about policy change in an education program that can nullify hybrid education. This is because a succeeding government may have its educational policy that differs from the preceding government. National or international insecurity that entails political, economic, and social insecurity can disrupt the smoothness of hybrid education.

Students' low typing skills on the use of keyboard, absence of face-to-face interaction, and inability to protect devices (computers and mobile phones) from malicious contents, malware, and ad scam are part of the challenges to hybrid education in emerging countries.

7.0 Conclusion

In the light of the present study, it is recommended that actions be taken to facilitate the development and implementation of hybrid learning that would be beneficial all sectors of society such as the education providers, the staff, students and the

economy include amongst others [21], (i) promoting hybrid learning for recovery from covid-19 pandemic, reimagining teaching and learning and narrowing or bridging the digital divide. (ii) adopting a national strategy for the development of digital skills for life, work and lifelong learning. (iii) promoting a holistic government and public-private-partnership ways of building and maintaining connectivity and infrastructure to achieve and maintain a sustainable and equitable system of education and training for everyone. (iv) making provision for a self-sustaining and stable financing solutions for connectivity and (v) proactively anticipating the impact of technologies that are emerging in relation to learning requirements for hybrid education in relation to digital skills and competencies.

In conclusion, it is important to note that both the teachers and the students are key instruments in hybrid education; therefore, their experiences, perspectives, and collaborations can facilitate improvement in hybrid education. It is therefore imperative for policymakers, administrators, and gatekeepers in educational institutions to formulate educational policy that can positively affect the curricular adjustments to encourage hybrid education, and also to support the full implementation of the policy with the necessary resources. It is also expected that the policymakers should create an educational policy that is enduring and responsive and which can achieve a multiplier effect in the educational sector.

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Bios

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James Uhomoibhi, is an academic of strong international standing in Physics, Computing, Engineering and Education. He has a first degree in Physics from Nigeria, a BPhil degree from Italy, MSc in Optoelectronics and Optical Information

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The Security Awareness Silver Lining of the COVID Homeworking Cloud

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Abstract

When people were sent home from work at the end of March 2020 nobody knew how the response to COVID would bring about the biggest experiment in working practice seen at least since the industrial revolution, probably before. Suddenly anyone who could was working from home, even for companies and managers who fundamentally did not believe that people would work diligently away from close supervision, was home-based.

Keywords: Security Awareness, COVID-19, Working from Home

1.0 Introduction

Meanwhile, while IT teams were chasing an ever-shrinking supply of computing kit those with responsibility for security education and empowerment were seeing the security awareness 'rulebook' become irrelevant. Almost overnight tried and tested subjects like: Clear desk policy, the use of screen savers, secure disposal, not taking sensitive documentation out of the corporate estate and the use of desk locks for laptops became irrelevant. Instead, there were new risks such as working in an environment containing people who were not authorised to hear or see corporate information, how to make sure hardware is safe from unauthorised access, spotting a phishing attack without colleagues around to check with and much more.

Not only did those super-innovators manage to adapt communication around existing risks, but they also identified and helped to mitigate newly identified risks around homeworking as they became apparent. The work of those great communicators played an essential role in maintaining the security of organisations. However, what few recognised in the early days was that a greater understanding of leading and motivating increased security awareness in the workforce, regardless of the environment.

2.0 Method

While working as a risk management contractor for Scottish Government in the depth of the lockdown the author became aware of the changes in risk from user behaviour on the system. Curiosity drove a dive into reports, blogs and articles to see if the impacts of home working on security was identified elsewhere. That research ultimately became a book Goucher (2022) [1] and was used in the writing of this paper.

3.0 Challenges

Finding a way to persuade busy members of staff to change their behaviour in order to protect the system from a threat that they don't really understand, believe or care about has always been challenging. In pre-COVID days the challenges could be set in four categories:
3.1 Resistance – where staff don't want to engage, often because they feel under pressure by work demands.
3.2 Reluctance – Where staff have time, but don't feel that carrying out training is the best use of their time.
3.3 Relevance – Where training isn't well communicated or targeted then staff will be unlikely to see a good reason for participation.
3.4 Revision – Staff feel that know all they need to about the area to be trained in already. This can be a particular problem with IT teams where their specialism may not be focused on information security, but don't see it as being outside of their existing knowledge.

A key challenge comes from the commonly mis-interpreted statement that "People often represent the weakest link in the security chain" Schneier [2]. The misinterpretation comes where that statement is used as an excuse for insecure behaviour. Indeed, it almost suggests that this is a weakness that will continue regardless, so no point in even trying to improve things. In fact, reading Schneier's original quote in the context of other of his writings shows that he was issuing a call to action to focus effort and exercise in this area to build it up. Much as one would do following significant injury or operation to a limb. As was stated by Gundu & Flowerday
"The unintentional insecurity by the employee is not an attempt to discredit the firm or make a profit from selling confidential data, but rather a result of inadequate employee training on security, or lack of security awareness of the consequences of their actions.

In their 2012 paper 'The Enemy Within: A behavioural intention model and information security awareness process' [3] describes what end users need in order to help them change their behaviour:

Knowledge – They need to understand the risk their behaviour instigates or fuels and also how to work in line with the behavioural requirement, Albrechtsen [4]
Perceived severity – If users are unaware of the seriousness the risk manifesting, then that will reduce the motivation to change behaviour. Herath and Rao [5] argued that if staff have a poor or inadequate understanding of the risk, they are less likely to understand the importance and effectiveness of the change of behaviour.
Perceived Vulnerability – how easy is it for that risk to happen in their business. Davinson and Sillence [6] argued that staff don't have good understanding of the likelihood that a risk will happen, then they are much less likely to evaluate the change in behaviour is worth the effort.
Attitude – This can be applied both to the attitude of the individual and that which is manifest in the culture of the organisation. Singh et al [7] stated that for a positive development of a security culture it had to be actively encouraged and supported from all areas and hierarchical levels of an organisation.
Self-Efficacy – If someone is to change behaviour, or instigate a new one, the user must believe that they will be able to carry out the behaviour. To take a trivial example, if staff were encouraged to ride a unicycle to work as that would improve their health (and the bikes were provided free of charge to staff) then the uptake of that will, to a significant extent depend on a large number of staff believing they could safely ride a unicycle to work from their home. Staff will not change behaviour to one that brings greater security if they feel that in doing so they would be unable to fulfil the tasks assigned to them.

Response Efficacy – If the staff member doesn't understand and believe that a behaviour change will make a positive contribution to the reducing of risk then Gundu and Flowerday [3] argued that the motivation to change that behaviour would be reduced.
Response cost – In other situations we are familiar with the idea of cost-benefit analysis and that is essentially what this is. In their research around the short cuts nurses took when they believed response costs were high Hedström & Karlsson [8] found if they believed that the action required to protect patient information was more time consuming than it was worth in the context of cost against benefit.
Security culture – is secure behaviour core to the way procedures and processes are designed, or are they attached later, and maybe less effectively. It is clear from the work of Walton [9] and others that having a strong security culture is fundamental to re-enforcing secure behaviour habits. This has been harder to access and develop while staff were almost entirely based outside corporate premises.

These elements were important in a pre-COVID, physically close workplace environment. Those working from home during COVID working restrictions and the more flexible working arrangements under 'New Normal' working require the more internalised motivation that these elements reflect. In other words the behaviour that re-enforces organisational norms is much harder to establish and therefore new staff may find it harder to learn the required behaviours, be those security or otherwise. There is no physical prompting or a colleague, working in the prescribed manner and thereby setting an example.

Further to that was how could it be identified when staff were working using their awareness to protect the security of the information, they were processing. If that was difficult, then positive re-enforcement, which is an important part of motivating any behavioural change becomes even more difficult to apply in a consistent manner.

4.0 Benefits

The third of those reactions; 'Relevance' is both a challenge, but also a key entry point for security awareness training. In recent years there had begun to be a growth in engaging staff in security awareness by focusing on that would be applicable in their personal life, and sometimes even that of their family such as older relatives and children. This approach is discussed by Renaud & Goucher [10] as a potentially powerful technique. To give an example, one senior security manager in a multinational company once revealed how, in order to help staff to habituate the selection of documents containing sensitive personal data for secure disposal he had provided more collection for secure disposal in their main office and encouraged staff to use that service to safely dispose of their own sensitive personal papers. After a suitable trial period they found a significant reduction in the amount of sensitive documents put into the standard waste system.

This was just an interesting example, until the time of COVID working arrived. Almost overnight the environment changed and not only was the information security threat now in the home of millions of staff across the world, but also involved family and friends of staff members. Home had become the office environment in fact the office became hundreds or even thousands of individual workplaces with a wide variety of conditions and risk associated with them with which risk focus staff as well as security awareness specialists could hardly begin to imagine.

So, the question became what an effective way would be to approach the communication of security awareness and positive security habits. The answer, that was reflected in a lot of the reports and papers focused on the individual staff member as the vector for security, rather than insecurity. Indeed, this introduced a particular need for respect of staff's personal work environment, not least because it was

not possible to know what the situation was that any message was arriving into, such as was the member of staff home-schooling children, caring for a dependant person, or even overwhelmed with not having the support of colleagues or a boss in a new job. All things that were not generally considered. Even finding ways to get that sort of information from staff was a matter of trial and error in many instances.

In many situations, organisations, and especially the security and communications teams, not only engaged staff with safer ways of working, but also improved the overall security culture. One security awareness team in the financial sector of the UK spent time with different parts of the business so they could better understand the business requirements and pressures. While this would be easier in a physical environment, it was possible online as well. While the exercise was not easy and did take more time and therefore staff cost to do, it made for more effectively targeted training and a greater respect both from the security awareness team member of the business and other pressures the other team had, but also visa versa. Some of the subsequent adjustments were hard but paid back in reduction of mistakes or actions that led to bad security outcomes. Arguably, in pre-COVID times that sort of 'ground up' rebuilding would not have happened because the effort required was too high balanced against risk or benefit. Staff needed more persuasion that not only should they sit in front of an online training package, or a presentation by the security awareness team, but they needed to be persuaded that either existing behaviour is good practice or make clear why and how a process or behaviour needs to change. This exercise gained pace with the move to hybrid working and the benefits continue to be felt.

5.0 Conclusion

In the summer of 2022, we are now in the 'New Normal Era'; past the time when business was forcibly conducted from private homes, but in many cases not returning to the '9 to 5' work in corporate offices. Whatever form of hybrid working each organisation allows will prove to have its own stressors and pressures. However, this is not a blank sheet. While 'good practice' approaches to security awareness will continue to adapt, much has been learnt about successful communication and motivation of behaviour that cannot be easily monitored. These lessons will help to build a more holistic approach that keeps organisations, their staff and their families and friends safer online. The path has been lit by the work done under COVID and this precious experience will be a powerful fuel for building a new, more secure working age.

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Psychological Adverse Effects of the COVID Pandemic Lockdowns on Students and Pupils: In their Own Voices

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Abstract

The COVID-19 pandemic affected the psychology and wellbeing of all people across the world. With the face-to-face learning having been moved rapidly to online, many learners (of all ages) experienced insecurity, anxiety, and even depression. Isolation from the peers, their teachers, relatives and friends particularly during the lockdown periods have not been conducive to concentration on studying and learning. The danger to themselves and to members of their family and friends contracting the infection resulted in psychological turmoil. This situation affected their wellbeing and their ability to concentrate on their learning. In this pilot study we provide a brief mention of relevant literature, and present individual cases from Cyprus, Greece, and the UK. We provide demographic information of all participants and through *their own voices* (and occasional views) we distil the findings in a consolidated picture of the psychological adverse effects experienced. We use the case study method in order to establish the different feelings, and, hence, the psychological effects of the lockdowns and emergency move to distance mode education due to the COVID-19 pandemic. The feelings of the pupils and students are provided in their own words. The results reveal a considerable number

of feelings given by the respondents (cases). The paper concludes with proposed mitigation strategies.

Keywords: psychological effects, COVID lockdowns, impact on education, mitigation strategies

1.0 Introduction

The sudden eruption and rapid spread of the COVID-19 pandemic resulted in unprecedented restrictive measures aiming to stop the rapid spread of the virus. The effects of these measures have been widespread and multidimensional (including technical, economic, and political) across all sections of society. Education was no exception. Lockdowns hastened the move from face-to-face to online/virtual teaching and learning. Most universities (at least in developed economies) had already embraced hybrid models, and, in the main, they had suitable technologies and technical knowhow, so they migrated to the online model quite rapidly. However, Primary Schools and Secondary Schools had no technical infrastructure and very little or no exposure to virtual/distance mode delivery of curricula. Most staff themselves at this level had no technical knowhow.

However, the technical accessibility and expertise are not the only challenges posed by lockdowns and isolation. There have been considerable psychological ramifications reported by several organisations (such as the OECD [1], UNICEF[2, 3], WHO (4) and researchers including Le, K & Nguyen (2021) [5] , Pragholapati M.(2020)[6] who reported that "about 24.9% of students have experienced anxiety because of this COVID-19 outbreak" . Georgiadou et al (2021) [7] examined the challenges of rapid transition to fully virtual education (tertiary sector) but did not focus explicitly on the psychological effects although several of the respondents to their survey expressed some disturbing feelings, and in some cases disagreement with government decisions to impose lockdowns. Lily et al (2020) [8] in exploring the sudden and urgent transition of face-to-face education to fully virtual which was termed Crisis Distance Education (CDE) explored the Social and Cultural Ramifications, the Procedural Ramifications and the Pedagogical and Psychological Ramifications.

In this pilot study it was aimed to hear from learners themselves (at primary, secondary, and tertiary education) about their feelings during the COVID lockdowns.

2.0 Cases: In their Own Voices

2.1 Research Method and Research Instrument

This pilot study adopted the case study research method because, as Galliers [9] advised, the case study method captures 'reality' in greater detail and helps analyse in greater detail more variables than is possible with other methods.

In order not to prejudice or 'direct' the respondents towards expressing specific sentiments it was left up to them to express themselves using any terms that express them. The conversations (akin to an interview instrument) started with a casual prompt/question "How do you feel/ did you feel during the COVID pandemic lockdown?"

The authors reported their feelings/sentiments (and in some cases their views) as they expressed them in their own words (shown in italics). All responses are anonymous and not traceable.

2.2 Primary School Children

2.2.1 Girl, Age: 11, Country: Cyprus

Urban, Multigenerational Household, with parents and grandparents, Own bedroom, and mobile phone. Exercises were sent by email. Some online lessons – too shy to activate camera. Parents were able to help with homework and technology problems. They bought extra mobile phone so that they do not share with siblings.
Contracted COVID with brother (age 9) – isolating together in one room.

"It was difficult to stay in one room. Luckily, we had our own toilet. Food was brought to us at the door. Enjoyed online sessions. Missed our friends. I was afraid that my grandparents may contract COVID and die as I was watching the news every day."

Feeling: Anxious, Frightened, Bored, Angry, Missing our friends.

2.2.2 Boy Age 9 (Brother of child 2.2.1)

Urban, Multigenerational Household, with parents and grandparents, Own bedroom and mobile phone. Exercises were sent by email and delivered by courier. Some online lessons. Father was able to help with homework and technology problems.
Contracted COVID with brother (age 9) – isolating together in one room.

"*Some lessons clashed -during the time we had COVID it was difficult to concentrate and attend sessions – we kept each other company but also disturbed each other."*

Feeling: anxious, annoyed, scared, and sad.

2.2.3 Boy, Age 7, Country, UK

Single parent family, 2-bedroom high rise apartment. Homework sent by email. Mother tried but found it difficult to help with homework and online sessions - on mobile phone.

"I missed my friends, I was bored and angry, I was scared in case my mum became ill.".

Feeling: sad, angry, and confused

2.2.4 Girl, Age: 11, Country: Cyprus
Two parent family (working and furloughed) – own tablet. Both parents able to help with homework and online sessions.

"I was able to do my homework but had to wait to hear from my teacher if my answers were right. I was in touch with my friends on the mobile but felt very scared. We took daily walks in the nearby green as a family which was nice."

Feeling: scared, comfortable

2.2.5 Boy, Age 11, Country: Greece
Urban, parents professional, working from home. Both parents were able to help with technology and homework. Homework was sent by email.

"I learned to use the technologies for the classes but also to contact my friends. I could not always concentrate. I wasted time and was feeling bored. I was also worried that I could not see my grandparents, my classmates, or my friends."

Feeling: anxious, bored, worried.

2.2.6 Boy, Age 9, Country: Greece
Urban, parents professional, working from home. Both parents were able to help with technology and homework. Homework was sent by email and some workbooks by post.

"I was bored. I missed my friends, my teacher, and my grandparents. I was doing my homework but was bored".

Feeling: Bored, annoyed, worried.

2.3 Secondary School Pupils

2.3.1 Boy age: 15, Country: UK
Two parent family, own bedroom, laptop provided by School, the Homework sent by email and brought to the house.

"I could not concentrate on my studies. I was frustrated – missed my friends. When I had questions there was no one to discuss them with. I was worried in case my parents became ill. I don't think they should have forced us to isolate. I am worried about my GCSEs. "

Feeling: bored, annoyed, angry, and scared

2.3.2 Boy, Age: 13, Country: UK
Divorced parents , staying with mother/very rare contact with father.

Did not like the online lessons but was able to contact friends on mobile

Mother able to help with technical issues.

"I feel worried, sad, scared, bored, and upset. I miss my friends from school and my teacher"

Feeling: bored, angry, sad, and scared.

2.3.3 Boy, Age 13, Country: UK
Two parent family – own bedroom, sharing a desktop computer with two older siblings. School registration and formal classes are online. School has Virtual Learning Environment (VLE), which shares online learning materials and provides for submission points to upload completed classroom assessments. Parents and older siblings assisted with any technical issues. Faster broadband had to be purchased by parents, and installed, to enable quality connection to online teaching.

"*At break time and lunchtimes, I had no interaction with my friends and classmates. Usually, we would play football and lark around but this way now missing in my daily routine. Sometimes because my brothers also had online classes at the same time, I would be forced to access my lessons using my mobile phone, which was not very good. I did worry that if the internet went down, I might miss something very important."*

Feeling: Bored and worried

2.3.4 Girl, Age 13, Country: UK
Two parent family, sharing bedroom with elder sister, own laptop computer. Formal classrooms were online. The school also provided links to various learning providers, e.g., the British Broadcasting Corporation (BBC), BBC 2, to allow their students to access content to support the curriculum.

"*I had work set for me in the morning and I would complete it as soon as possible to free up time to enjoy the rest of the day with my friends on Snapchat and Instagram. I did miss my teachers. Some of the TV programmes on drama and history were good (more interesting than actual lessons). I was able to contact friends and fellow students on social media, e.g., Snapchat and Instagram."*

Feeling: Indifferent, comfortable

2.3.5 Girl, Age 16, Country: Cyprus
Two-parent family with 4 children. Respondent being the eldest with her own bedroom, each child had a mobile phone or a tablet.

"It was both fun and frustrating. I am a volleyball player and couldn't go training. I was at home gaining weight. On the other hand, I couldn't stop eating. Especially when I was home

with my younger brothers, sometimes I had my online lessons in the kitchen, and I was cooking or making sweets for them and myself. I was worried about my elective courses, it was hard to follow the teacher out of class, but for the rest it was OK because I could watch them in bed and the teachers could not see me. When I wanted to go out, I had to be very careful so I wouldn't get caught, I hardly met my friends and that was tiring. I could meet with my boyfriend though, either in my house or his. our parents don't mind staying over".

Feeling: Frustrated, mostly happy, mischievous

2.3.6 Boy, Age 13, Country Cyprus

Working parents, has own tablet, mobile phone, and bedroom. Has been online during lockdown but could not concentrate. Often interrupted the lessons and most of the times played Playstation games with other friends.

"I could not concentrate, found lessons boring. I felt annoyed."

Feeling: bored, unable to concentrate

2.3.7 Girl, Age 14, Country Cyprus

Working father, housewife mother. Shared a bedroom with her sister. She had her own tablet and mobile phone. Well concentrated and answered all my questions.

"I was feeling happy with the teacher and the online materials but *missed meeting my friends and going to school."*

Feeling: happy, sad

2.3.8 Male, Age 17, Country: UK

Two parent family – own bedroom, laptop computer, and mobile phone. No formal online classrooms. The college shared learning materials via its VLE, including pre-recorded videos, presentation slides, tutorial exercises and submission points to upload classroom assessments. Was able to contact friends and fellow students on social media, e.g., Snapchat and WhatsApp.

"*I had a real worry I was not having access to all the content to support the entire curriculum. It was an almighty relief when we were told that we would be teacher assessed as opposed to formal examinations. This made me a lot less anxious and upset. I was really frightened that I may not get the grades to go to university."*

Feeling: Anxious, frightened, and upset.

2.3.9 Male, Age 14, Country: Finland

Parents separated but both able to help with studies. Laptop given by school but had own mobile phone too.

"I am used to spending time at home alone after school. So during the lockdown I was comfortable and able to concentrate on my online lessons. I could finish my homework as I am familiar with technology. Also, I liked it because it was quiet – at school there is often disturbance with everybody talking."

Feeling: comfortable, happy, normal.

2.4 College and University Students

2.4.1 Female, Age 31, PhD student, Country: Denmark

Lived in a rented apartment with another PhD student. Access to the university was forbidden, so all work had to be done in isolation from home.

"*The pandemic has been one of the hardest and most intense periods of my life. Amidst an already demanding project (PhD studies) I had to spend large amounts of time practically interacting only with a single person (my flatmate) with the rest of my social circle being isolated in other parts of the city or the world. On work, the progress of my PhD has been affected detrimentally as stress and anxiety prevailed and distracted me from my goal. Without many stimuli, it has been hard to sustain my motivation. The greatest challenge has been worrying for my family which lived in another country. I was aware of everyone's vulnerability to the virus and being far away only intensified feelings of anxiety and helplessness in case anything bad happened. The pandemic has also had a grave effect on our sociability, in effect disrupting all social relationships and routines, and increasing my loneliness."*

Feeling: anxious, confused, depressed, fed-up, frustrated, lack of concentration, sad, scared, stressed, worried.

2.4.2 Female, Age 24, MA student. Country: Netherlands and Greece

Lived in a rented apartment with my sister. University access was forbidden. Countries closed their borders.

"When the pandemic started, I was in the Netherlands. Although, the compulsory courses had just finished, I had to write my thesis. The study material for my thesis was in Italy, and I didn't know if it would arrive at the lab on time. After a while, the universities closed and most of the EU countries started closing their borders. I was afraid that I had to stay in the Netherlands alone, closed in my room, unable to go at the university and far from family and friends. I managed to take the last flight to Greece. At the time there were not clear hygiene travelling rules and I was very scared of getting ill during the flight. When I arrived, I quarantined with my sister in a rented house. I could not go at my family house because my parents and grandmother were the most vulnerable. Moreover, I had to change my thesis subject and I had only three months to submit my research. The university did not give any extension and I had to finish on time, otherwise, I had to pay extra fees. It was a very stressful period to conduct research. It was difficult to concentrate, and I was very

disappointed that I could not discuss my research ideas easily with my supervisors and fellow students. I really missed my family and friends."

Feeling: anxious, scared, disappointed, lack of concentration, missing physical interaction with family and friends.

2.4.3 Male, Age 18, First year student of Chemistry, Country: Greece
Living in university town with another student in a rented apartment – upon lock down we returned to our families. All sessions were online. A big challenge without laboratory sessions. One lecturer used simulation of experiments. Technologies helped. We communicated with family, classmates and friends using social media.

"*I was very disappointed that my student life was not how I imagined. I don't think they should have locked us out of the university. I enjoyed the life of a fresher only for one term and then had to switched to virtual learning, away from the university. I found it unsettling and challenging during lockdown, but the technologies helped. Our generation sadly missed out on face-to-face interaction with our lecturers, we also missed socialising, friendships, and forming relationships. I was worried about my family and friends in case they contracted COVID. Indeed, some relatives became ill with COVID which was an anxious time for all the family."*

Feeling: anxious, unable to concentrate, sad, disappointed,

2.4.4 Female, Age 33, PhD student, Country: UK
Has 3 children, own home, with small garden, health problems and parent ill in Africa.

"My home is in England, but I was based in Northern Ireland, for my PhD studies. When institutions closed, I had been one of the regular users of the school office as having three children made it difficult to work from home. I commuted backwards and forwards every few weeks, and my research progress was on schedule. When institutions closed, we erroneously thought it would just be for a few weeks, so we left some books and notes behind. I felt frightened having asthma and COVID being a respiratory illness. I felt very vulnerable. The flight home was very traumatic as I thought every step of travel was risky and that I would catch COVID. I isolated when I got home as I had a cold. Testing was not available then, which added to my anxiety and uncertainty.

Working from home was a bit chaotic as all the kids were also at home, so I had to make space for a desk in my bedroom. I enjoyed working from the office because we could communicate with colleagues etc. I also had to re-work my system to do more online reading and accessing material, which could be frustrating. I missed access to online and physical books and papers for my research resources. I seemed to completely lack the ability to concentrate but obsessed over COVID symptoms, research and data and the global impact. I was apprehensive about family in Africa, knowing that healthcare is unreliable. My parent is old and was ailing, so this was

also quite worrisome. It was a very sad period as I really missed the physical interaction with my friends. I was also missing my family in Africa.

The pandemic has been quite difficult for me. I have failed to meet deadlines, and the progress of my PhD was affected. I could not sustain the motivation I had before. I was worried about my health and the health of my family both here and in Africa.

The need to control what one can and the helplessness in the situation was very frustrating. I felt intense anxiety and stress for the first time in my life. Doing a PhD meant isolating myself to get some work done, so as much as the family was around me, they were all also in education, so we were all anxious and stressed."

Feelings: Anxious, Confused, Depressed, Disappointed, Frightened, Frustrated, Lack of Concentration, Scared, Upset, Worried

2.4.5 Female, age 30, PhD student, Country UK

Married, one child (age 2), own home, small garden. Experienced disruption of studies during lockdown, lack of face-to-face meetings with supervisors, some new supervisors, and had to change direction of research due to COVID.

"*After I gave a birth to my child, I experienced such a loneliness, I thought I would never experience in my life, as due to physical abilities being able to walk no further than to a local shop and not having family nearby to help me. My loneliness, nonetheless, has doubled since the pandemic, as I was not only able to go anywhere, but also not been able to invite friends or other visitors to the house. Emotionally it was a strange feeling, as I thought that the whole world started to experience what I had been experiencing prior to the COVID-19, after giving birth. Furthermore, my husband, in comparison to other families, was not next to me all the time, as he had to be absent from the house for a long time, due to his profession. Even when he was at home, he had to spent most of his time studying.*

I had been highly productive in my PhD studies, as despite me working full-time and studying part-time, I had been managing to achieve the equivalence of full-time studies results. I was studying even in hospital, being able to use my laptop and the nurses were laughing with me about that. When arrived home, I realised though that I am no longer able to achieve as much as previously, being tired with health issues after giving birth, my newborn baby and no external help, gave me no time to allocate for my studies.

The Coronavirus also added to my personal worries, as both of my parents were abroad and had this virus, staying in two different hospitals, and their doctors called us to say that we should be prepared for the worst. Luckily,

both of them survived, despite not having vaccinations, though with severe health issues. I could not visit them for the same reasons.
I had been attempting to study anyway all this time. Then, when I officially returned to my studies, I encountered another issue, as two of my main supervisors left the university, and I had to adapt to the new supervisory team, who again I could not see in person, but via online meetings.

Moreover, I experienced serious issue with the primary data collection, as I had to speak to school children, which was the issue attempting to get the access to them online, as even the schools/colleges were unresponsive in their attitudes to researchers. The problem was that I could not call the teachers directly, as the persons who were answering the phone call enquiries at the schools and colleges were either rarely there or not able to make any decisions, and just passed the message to the heads of the schools. The situation had only improved after the end of lockdown.

Feeling: Angry, Anxious, Confused, Depressed, Disappointed, Frightened, Frustrated, Lack of Concentration, Sad, Scared, Upset, Worried.

3.0 Consolidation of results

3.1 Demographics

The cases reported in the paper involved responses to casual conversations throughout the pandemic lockdowns, with pupils and students we (the authors) know either as our students or from within own families, children of friends and neighbours. Thus, we know their gender, age, country of origin, and family situation.

In order not to prejudice or 'direct' the respondents towards specific sentiments it was left up to them to express themselves. The conversations started with a casual prompt/question "how do you feel/ did you feel during the COVID pandemic lockdown?". A total of 29 feelings were given by the respondents in Table 1. The authors report their feelings/sentiments as they expressed them in their own words in italics. Occasionally some respondents expressed their view as to the necessity of imposing lockdowns. All responses are anonymous.

The total number of cases (respondents) is 20 namely 6 primary school children, 9 secondary school children and 5 university students.

3.2 Tabulation and Predominance of Feelings

Table 1 shows the number of cases from each age category and the selection of the feeling(s). Although the samples were small when viewed as cases which are likely to be replicated it is noted that Sadness and Anxiety are predominant across all age groups.

Predominance of Feelings: Primary School Pupils expressed Anxiety (73%), Boredom (73%), Sadness, (73%), Fear (Fright), Annoyance (67%), and Worry 50%.

Predominance of Feelings: Secondary School Pupils expressed Sadness (50%), Anger, Annoyance, Anxiety and Boredom all at 33%. They also reported Lack of concentration and on one occasion Happiness (with studying from home), They also reported Lack of concentration.

Predominance of Feelings: University Students expressed Sadness (67%) Apprehension, Disappointment, Fright (Scare) and Lack of concentration all at 50%. The responses and views of the university students were more detailed but again they too felt anxious, confused, depressed, fed-up, frustrated, sad, fearful, stressed, and lacking concentration.

Table 1: Consolidated Conversations

How have they been feeling? [in their own Voices]	**Primary School Pupils Sample 6**	**Secondary School Pupils Sample 9**	**University Students Sample 6**
Angry	**III (50%)**	II (22%)	I (17%)
Annoyed	**IIII (67%)**	**III (33%)**	I (17%)
Apprehensive	II (33%)	II (22%)	**III (50%)**
Anxious	**IIIII (73%)**	**III (33%)**	**III (50%)**
Bored	**IIIII (73 %)**	**III (33%)**	
Concerned			II (33%)
Confused	II (33%)		II (33%)
Comfortable	I (17%)	**III (33%)**	
Depressed			II (33%)
Disappointed			**III (50%)**
Disruptive		I (11%)	
Excited		I (11%)	
Fed-up	I (17%)	I (11%)	I (17%)
Frightened	I (17%)	II (22%)	I (17%)
Frustrated		II (22%)	II (22 %)

How have they been feeling? [in their own Voices]	**Primary School Pupils** **Sample 6**	**Secondary School Pupils** **Sample 9**	**University Students** **Sample 6**
Happy		**III (33%)**	
Helpless			I (17%)
Indifferent		I (11%)	
Lonely			II (22%)
Mischievous		I (11%)	
Normal		I (11%)	
Sad	**IIIII (73 %)**	**IIIII (56%)**	**IIII (67%)**
Scared	II (33%)	II (22%)	**III (50%)**
Stressed			II (22%)
Unable to concentrate		II (22%)	**III (50%)**
Upset	I (17%)	II (22%)	**III (50%)**
Unsettled			
Worried	**III (50%)**	II (22%)	**III (50%)**

The responses and views of the university students were more detailed and reflective. However, they too felt anxious, confused, depressed, fed-up, frustrated, sad, fearful, stressed, and they experienced lack of concentration.
We had the occasional feeling of excitement and even happiness not to have to travel to school, switching off the camera and listening to the lessons from bed! Some also played games online by themselves or with their friends even during the online sessions.

As shown in table 1 Anxiety and Sadness were felt strongly across the three age groups. primarily when the respondents are happy with online delivery of the lessons, and ability to e-meet their friends and play games.

Inevitably the feelings of anxiety, sadness, fear, annoyance etc have a negative impact on the ability of learners to concentrate and enjoy their studies. The findings reported in this paper are in agreement with the findings by organisations like OECD [1] and UNICEF[2,3], as well as by researchers' including Pragholapati [6], Lee [10], García Ron &Cuéllar-Flores [11] and Wang et al [12].

4.0 Mitigation strategies and actions

4.1 General Agreement on the need for mitigation Strategies

There is general agreement that in an effort to control/reduce/avoid the spread of COVID lockdowns were imposed by governments across the world. The lockdowns and isolation caused considerable adverse psychological effects. The psychological effects caused problems with pupils' and students' learning as was demonstrated by the views presented in this paper.

Several researchers such as Wang et al [12] and Perez et al [1]) emphasised the need for mitigation strategies and actions. They observed that bombarding children with grim news can have a detrimental effect on their mental stability. "*The screen time devoted to the crisis event should be reduced to minimise potential confusion, worry, and fear. - Promote virtual contact with family members, classmates, friends and teachers through the internet and the phone to reduce the anxious feelings associated with isolation and frustration. - Schools play an essential role, not only in providing educational content to children, but also in offering students an opportunity to interact with teachers and receive psychological support ….. Children should be given an age-appropriate explanation of what has happened and of the purpose of being confined at home. - Children should be given clear information on how to reduce the risk of contracting the disease using language that can be clearly understood at the corresponding age*."

4.2 Our Proposals for Mitigation Strategies

Our proposals for mitigation strategies and actions are given below although this is not an exhaustive list.

a Provision of Online/Teleconsultations with Well-being Officers: As part of the duty to provide safeguarding to all pupils, Educational Institutions need to invest in either creating or maintaining access to mental health professionals, such as counsellors, for their pupils/students. Schools should have such dedicated professionals available for consultations with students, and families that require this service.

The use of social media and Online Group Chat: At Middlesex University London, there are examples of undergraduate and postgraduate courses that have made use of Social Media applications, WhatsApp, to bring the cohort of students together to combat loneliness and isolation, as well as providing mutual support for the learning. OECD (2020) [1] (reports on the Jigsaw project, in Ireland, that has made use of Instagram and online group chat to provide stress management and relaxation techniques "on around themes of managing loneliness and isolation, exam stress, and family conflict".

b Universal screening to identify students in need: The American Psychological Association (APA, 2020) [14] and Dowdy et al. (2015) [15] advocate the

systematic screening of the school population to identify students who may have difficulties with anxiety or depression. This screening process could involve teachers and students completing questionnaires regarding students' emotions and classroom behaviours. If the analysis of the data collected points to students with frequent and/or severe emotional concerns, then they can be referred to school mental health professionals. Such screening needs to be completed on a periodical basis, and must not be a one off, single occurrence.

c Free/Subsidised Internet Connection: In a new joint report from UNICEF and the International Telecommunication Union (ITU) [3] it was reported that two thirds of the world's school-age children, approximately 1.3 billion children aged 3 to 17 years old, did not have internet connection in their homes. This digital divide not only exists between rich and poor countries but also within the former. The Office for National Statistics (ONS) (2019) [16] reported on the scale of the digital divide in the UK. If remote learning and access to online mental well-being services is to be accessed then it is vitally important that children, and their families have access to free, or heavily subsidised, internet connection.

d Reliability of Information and becoming information literate: Pan et al. (2005) [17] in a post-quarantine study of young students, following the 2003 severe acute respiratory syndrome (SARS) pandemic, argue that students benefited from gaining reliable information on a pandemic to ease early anxieties. Students' levels of anxiety and suffering from feelings of being scared, upset and worried are compounded by accessing and reading false news and information on a pandemic. Thus, it is important that educational institutions make their students information literate to be able to determine the quality of information they are accessing concerning the pandemic and its affects.

5. Conclusions

The authors reported 20 cases which revealed a pattern repeating across the ages, genders, and countries. Almost all pupils and students felt anxious, sad, and scared not only for themselves but also for their parents, grandparents, and friends. They missed their classmates and their teachers. Only one of the secondary pupils was happy to work and learn from home.

Their academic work and progress suffered, and in the cases of the PhD students a large number of feelings were felt including anxiety, confusion, depression, frustration, , sadness, fear, stress, and lack of concentration. All of them experienced delays or changes in supervisory teams, research topic and focus.

This pilot study will be followed by a more extensive study which will aim to capture the intensity of the participants' feelings by again prompting with the same casual method but this time we will aim to ascertain the intensity of the feelings by giving

a blank table and asking them to enter their feelings one per row and, also, whether each feeling was extremely strong, strong, mild, very mild. We will also seek to establish the frequency (always, frequently, occasionally, rarely) with each reported feeling had been felt.

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AI serving the Economy and Society: Public Policy and Standards in Europe

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Abstract

Artificial Intelligence (AI) is experiencing growing interest as the society and the economy is accelerating its digitisation. To harness the potential of AI, already illustrated by proprietary developments from multiple leading Internet Platforms, while giving it a trusted and secure framework for users from Europe to be able to confidently benefit from AI powered systems, regulation is being developed (the EU AI Act). Such regulation is expected to rely on technology standards to be either referenced from Global Standards Committees, or when and where needed on standards to be developed by the European Standards Organisations (ESOs). This article aims at discussing the rationale for Standards for systems using AI, the candidate requirements they would be expected to meet, and how they would support regulatory, societal and market objectives.

Keywords: AI, Data, Risk, Standards, Regulation

1. Introduction

The European Union has launched an AI Policy relying on several policy and regulatory instruments, including the EU AI Act [1], currently being discussed at the European Council and The European Parliament, on the base of the proposal published by the European Commission. This future regulation, together with other legal texts such as the General Data Protection Regulation, aims at defining a trusted framework favourable to innovation and efficiency, with skill development, and market opportunities, starting with the Single Market, while respecting what is called by the European Institutions “European values”.

The impact may be felt beyond the European Union, throughout the membership footprint of the European Standards Organisations: anyone interested by trading in the European Single Market might consider complying with this regulation.

Technical Standards supporting EU regulation are called Harmonised European Norms (hENs).

In general standards are seen to contribute to three categories of objectives:

-Interoperability. Two systems communicate or share best, when interfacing through standards.

-Procurement. When a public administration or a company issues a call for tenders, describing the features needed and requiring compliance to existing standards helps suppliers assess the opportunity and build their proposal reliably. Conversely, the buyer issuing the call for tenders has an opportunity to get multiple suppliers to tender, on the base of known standards (instead of proprietary solutions, limiting usually the supply-side). Furthermore, at the time of auditing a Call for tenders, compliance to published standards is probably easier to assess than proprietary solutions. Transparency is made easier through the use of standards in a system, and in its description for a Call for tenders.

-Ecosystem. From a user perspective as well as from a supplier perspective, published standards help gather critical mass both on the demand side and on the supply side, thus increasing the marginal growth of the value chain/ecosystem. In short standards aggregate ecosystems (demand, supply), and developers who are often a rare resource get an incentive to develop, based on the expected market size.

For product suppliers, if your product category has to comply with regulation, it is necessary to consider carefully how you will implement the corresponding Harmonised European Norms.

This article will look at the need for AI standards, with particular attention to

-AI risk: more precisely the risks appearing in the use of systems using AI, and how to reduce or avoid such risks thanks to standards. Two issues have been identified as essential with this regard: AI risk classification and AI risk management

-AI data: such data is looked at from the AI data governance perspective and from the AI data management angle.

The two topics above are currently being addressed in ad-hoc groups endorsed by the Joint Technical Committee on AI of CEN-CENELEC (CEN-CENELEC-JTC21-AI).

2. AI Phenomenology and AI Criteria

We consider here the generic case of a system which has been planned, and assigned an objective to fulfil, has input parameters, executes tasks using AI towards the objective assigned, reaches an outcome, with output data, and feeds back an assessment of this output to the input branch.

One could ask the question of what difference there is between a basic digital system and a system using AI in some form?

We will discuss this question at two levels: AI data and systems using AI.

2.1 AI data: quality and governance?

Data (AI data) is consumed to:

-train models

-support or generate decisions

-trigger action and effect

-feedback assessment of outcome

Models implement a case of stochastic control, with potential adaptability either to real time or non-real time data flows.

The AI data consumed as above has several categories of requirements constraining it:

-quality of data

-governance in the handling of data sets (for instance privacy requirements, as already implemented by Statistical Institutes prior to the advent of AI, in Statistical Disclosure Control)

-robustness and resilience to

-adverse events

-context generated events

-system generated events

-human generated events

-acceptable/desirable

-adversarial

-unintended

The question of statistical relevance of data used for training a model, and an estimate of the dimensionality of the problem are two difficult issues to address with real world data and models: there is a risk of overtraining (too much data, and system parameters), and a risk of undertraining (not enough observations or training data).

2.2 From basic digital system to systems using AI

The question of stability or instability is important for systems, observing their behaviour, controlling them.

In linear system, Lipschitzian conditions where a derivative is bounded, might help, in applicable cases, guarantee stability of operation within a bounded or compact domain of operation (on compact sets, with a set view: the Bolzano-Weierstrass criterion; with a sequence view: a Cauchy criterion that a converging sub-sequence can be extracted).

For systems using AI, stability can be studied, albeit non-linearity. The Global Committee ISO/IEC JTC1-SC42 has produced a standard for the purpose of assessing the robustness of neural networks:

ISO/IEC TR 24029-1:2021 Artificial Intelligence (AI) - Assessment of the robustness of neural networks

Mirroring the question of AI data and its statistical significance above, one can ask the question if a system is fit for purpose. CEN-CENELEC-JTC21 is considering if

the objectives of AI systems could be formulated in a standardised way, and in this context if a utility function may be defined. An ad-hoc group may be tasked to explore this question further.

At the other end of the use of a system with AI, we find the assessment of the implementation, with criteria, and method, for conformity assessment. A Working Group has been launched on this topic.

2.3 From a single system to multiple systems using AI

Systems using AI could

-coexist

There is some awareness for each AI system that other systems are present, and rules of mutual respect avoid conflicts.

-coordinate

Some information may be exchanged, some data or other resource shared

-cooperate

This may lead to sacrificing part of an individual system's interest for greater overall advantage or loss minimisation

-compete

The same resource is of interest for two or more systems. This may lead to blocking, win or loss. Some fairness rules are likely to apply, and they need considering in an overall approach of inter-system optimisation.

-oppose

This is the adversarial case, where opponent systems try to seize a resource, potentially with no fairness requirement to the other party (fight!)

3. AI and European values: where are these values defined?

Although they are easily understood in a general form, European values are not that straightforward to address in detail. At the general level they are mostly understood

as democracy, human rights, some form of fairness to people but also to companies and their abilities to aim for economic success while respecting societal expectations. In short, the American “pursuit of happiness” (meant for individuals) with a more societally conscious and collective fairness, which would give to this pursuit a European flavour.

More concretely one could look at different formulation of Human Rights, with a consistent spirit, but some differences in their detail:

-The European Convention on Human Rights [2], managed by the Council of Europe, which is broader than the European Union.

At its first signature in 1950, one can observe that UK made a reservation for the human right to education, which in their view is acceptable but should not cost too much. Telling of a certain approach to rights, certainly limiting for their implementation, whereas most other countries consider human rights as a non-negotiable must.

-The Charter of Fundamental Rights of the European Union [3]

The European Parliament provides an analysis of the Legal basis underlying Human Rights formulated by the Convention and Charter above, as well as an EU human rights policy.

Other Legal texts apply for the governance of the Single Market, Competition Rules, and a framework favourable to innovation (with programmes such the Framework Programme for Research and Technology Development, currently called “Horizon Europe” and similar policy instruments, with significant public funding).

In Global Standardisation, not all countries agree with the values as they are expressed by the European Union. Democracy and Human Rights may receive less attention and other criteria may have higher priority: perceived national cohesion, perceived national economic interest, or others. This impacts how national bodies formulated New Work Item Proposals.

Imagine you would consider developing a new standard on how to locate personnel at work, at any time. This may be highly valuable in the case of hazardous environments, where a catastrophe might happen and rescuing people may be eased if their location is known and supervised. A Disaster Recovery Plan may be executed more efficiently. However, if the use case of “personnel in prisons/inmates” is included in the scope, caution is required: whereas prisoners keep most of their human rights, except for the freedom of movement, when entering a prison in the European Union, this may not be the case in every country. The same goes for personnel in Education. Not everyone chooses to participate in “compulsory education” or re-education programmes, aiming at producing calibrated “good

citizens". Caution is therefore required from a European perspective, and New Work Items Proposals from third countries may have to be amended so that they are fit to support the European values, hence candidates for use in Europe. Based on our real-life experience, we observe that the awareness of the European values is key for European citizens to contribute efficiently and positively to Global Standardisation. Such awareness help channel New Work Item Proposals towards revisions where the respect of European values, starting with Human Rights are duly considered. The associated benefit is triple:

-(i) such standard might be applicable in Europe

-(ii) the values carried by this standard may help bring de facto benefits to countries where these are not always considered

-(iii) if a global standard carrying the values is available, no local or regional standard contradicting such values will be developed, since global interoperability is likely to be preferred, with other advantages such as cost linked to critical mass, and the interest for a global market access for products demonstrating compliance with global standards.

Standards should aim at active respect of Human Rights, and other European values, not least:

-sustainability

respecting the Planet and its People. This includes the respect of the environment, energy efficiency, accessibility in the sense of the European Accessibility Act

-societal responsibility

-bringing innovation benefits to market and society

A recent example now widely implemented, with further potential through its use in conjunction with AI, is a digital citizen identity for smooth, secure, and private citizen to government interaction

-leaving space to innovation

Future-proof architectures, mechanisms, and criteria

An easy to analyse counterexample of this is Y2K, as a major design fault by which 20th century software developers considered in their "pragmatic software view" that no system would last more

than few years and that the last year to consider was 1999. Unfortunately for them, after 1999 came 2000… We know the rest of this story.

Other counterexamples to being futureproof exist as hindrance to upscaling (IPv6 was brought in to remedy the address space limit of IPv4) and hindrance to downscaling (network latencies below 1ms)

4. AI Data: the challenge of governance, and of management

For AI model developers as well as for AI users, the role of AI data remains central. Different phases of the AI solution development may call for different AI data sets to be made available and consumed, including:

-AI datasets for training

-AI datasets for validation and verification

-AI datasets for practical implementation and use

-AI datasets for audit and inspection.

Data quality criteria are essential, and a standard in 5 parts will be available from ISO/IEC JTC1-SC42-AI:

ISO/IEC AWI 5259-1/2/3 Artificial intelligence — Data quality for analytics and machine learning (ML)

— Part 1: Overview, terminology, and examples

— Part 2: Data quality measures

— Part 3: Data quality management requirements and guidelines

— Part 4: Data quality process framework

— Part 5: Data quality governance

Principles of data governance are set by EU legislation and some reference standards. GDPR aims at protecting natural persons when processing of personal data occurs. It provides enhanced legal and practical certainty for natural persons, economic operators, and public authorities, in order to both grant fundamental rights

and individual freedom, and it aims at creating the trust necessary to foster economic and social progress enabled by digital economy

The evolution of digital technology, and the widespread collection and use of personal data raise important challenges, in terms of respect of fundamental rights and freedoms, dignity, non-discrimination and self-determination of individuals. On this point let us quote recital 6) of GDPR: “Rapid technological developments and globalisation have brought new challenges for the protection of personal data. The scale of the collection and sharing of personal data has increased significantly. Technology allows both private companies and public authorities to make use of personal data on an unprecedented scale, in order to pursue their activities. Natural persons increasingly make personal information available publicly and globally. Technology has transformed both the economy and social life and should further facilitate the free flow of personal data within the Union and the transfer to third countries and international organisations, while ensuring a high level of the protection of personal data”. Artificial Intelligence is a new technology profoundly changing the paradigm of digital automation, enabling startling innovations in all sectors of economy, also impacting human habits in the interaction with the environment. The delegation of human critical functions to AI artefacts, such us collecting data from external world, making assumptions, taking decisions, and acting accordingly, may also highly threaten individual rights and freedoms.

Standards should consider such data protection provisions both for the necessary compliance to applicable legislation and to avoid “negative externalities” which organizations can suffer from, due to possible non-compliances. GDPR principles of lawfulness, fairness, transparency, purpose limitation, data minimisation, accuracy, storage limitation and security are, by the way, applicable also to AI systems, in the case of personal data processing. Moreover, GDPR provides indications on personal data processing, such as, among others, the accountability principle, the risk-based approach of the Controller, the due information to data subjects, the "Privacy by Design and by Default” principles, the technical and organizational measures to be implemented and the data protection impact assessment. The data protection framework established by the GDPR also regulates automated individual decision-making, including profiling, or similar involving the use of AI.

5. AI risk: illustrating the challenge of AI risk classification

A model shared by the Commission shows how low risk use cases using AI can be regulated with a light hand, whereas unacceptable risk use cases using AI are totally forbidden in the EU, and the legislation under development in the EU AI Act aims mainly at the high risk (high benefit) use cases using AI.
The challenge is therefore to study in detail how a use case involving the use of some AI is classified.

Naturally, the expected impact can guide. The negative effects with their probability of occurrence should be considered, as well as the established sectorial criteria for benefits and risks.
Let us, for the sake of illustration, ask ourselves the question of a sector of critical importance to Society: health, seen as health care and protecting health for everyone. Should the use of AI in health care be necessarily classified as “high risk”?
A common implicit reasoning and perception is that health matters should be handled with utmost care, since life comes under threat in the worst case, and this may be true, in a broad understanding. However, let us consider a blood pressure monitoring device and its use, with some AI data handling, in whatever form. The device itself is attached to your wrist or arm, on which it can exert pressure, uncomfortable in the worst case but not lethal for an average user. This use case might be classified as low risk (with the disclaimer that such device should only be attached to one’s arm or wrist, depending on the device category).
With this, we prove that Sectorial use does not automatically translate into one risk category.
Another consideration is the time and space stability of such risk classification. Let us illustrate first the time domain aspect:
-consider a system controlling a physical machine (robot) able to move in space and perform actions. Imagine that version 1.0 of the software involved has been tested and proven to meet safety criteria, making it low risk. Imagine that a version 2.0 is being developed, with more features, and new software. The switch-over from version 1.0 to version 2.0 and prior to it the verification and validation of version 2.0 requires attention. Once migration has been complete, after version 2.0 will have been tested and validated, it can be expected that authorisation will be granted to operate it, because it has similar safety credentials as version 1.0. Before this, in the transient phase, it is often preferred to observe the system with a lot of attention, and no real user, to decrease the risk, which is unbounded or less bounded during the migration. The “same” system, in its software instantiation may have different behaviours and risk categorisation over time.
-consider a vehicle or robot controlled by an AI pilot. Introducing a more efficient and safe braking system will decrease its risk level. This has been observed in the railways systems which became much safer after they became equipped with hydraulic braking (Westinghouse patent) in the 19th century.

A more detailed study of AI risk criteria, as well as AI risk management, with the objective to pave the road for the implementation of the future EU AI Act, is being carried out at CEN-CENELEC-JTC21-AI in its ad-hoc group AhG5 “AI risk classification and AI risk management”.
The broad lines are to consider potential harm, and its probability, then to consider candidate methods to counter, mitigate, reduce such risk.
“It all depends” naturally. However, risk identification and management is not new, and methods exist, including sectorial technology standards, as well as software standards. The challenge is in understanding precisely what makes systems using AI behave differently from systems not using AI. The first report of CEN-CENELEC-JTC21-AI/AhG5 is expected to provide first criteria and a methodology to address the AI risk issues.

6. Education for AI, Education with AI?

6.1. The recent acceleration of the digitalisation of Education

During the Covid19 pandemic, the Education system in general, from elementary schools to universities, had to accelerate its digitalisation, with students/learners as well as teachers being locked down in their homes during some phases, and other Non-Pharmaceutical Interventions (NPI) recommending or mandating a maximum of persons sharing the same (class)room, with distancing imposed, so as to limit the risk of propagation of the pandemic.
This highlighted several issues such as social inequalities, with regard to digital equipment and network services, and increased disadvantage for learners as well teachers, depending on their style and need of learning/teaching. In-room teaching and learning had migrated either fully or partially (several days per week e.g.) to remote learning, with each participant to a session in a different location.

As for AI in this accelerated and forced experience of digital Education, one can categorise it under two headers: “Educating for AI” and “Educating with AI”.

6.2. Education for AI

The target of educating for the AI age can be categorised along the different purposes one assigns to AI in their daily life. Humans may want to coexist with AI, so that AI do not interfere negatively with their own freedom and comfort: inevitably the physical and cyberspace will have to be shared with an increasing number of systems (some in the shape of a “machine”, others called “robots”, etc, but generically “systems” to capture all possible categories).
In other instances, humans may want to use AI, to “pilot it” or to just let it run for them. Lastly, humans may want to design, develop, and implement new systems using AI.

Let us highlight different purposes in personal and professional life, with an associated use case base/methodology approach of Humans and AI

- Coexisting with AI
  - Ex 1: Autonomous Cars driving in the city, coexisting as a pedestrian or cyclist
  - Ex 2: Garden neighbours using a system with AI (camera), what does is change for my privacy?
- Using AI
  - In life
    - Responsible use: of autonomous vehicles, autonomous garden systems, etc

- Maximising benefit from systems with AI component: how does the AI black-box work, what value do we get?

- In work ("no-life" 😇 in the teenage language)
  - Human robot/system cooperation
    - Do no harm (physical, mental, social, etc)
    - Help (skill enhancement, multiplier effect, etc)
  - Decision making using AI
    - Need to show the limits in human decision making too!
      - Ex. of human bias, of adversarial by design behaviours in organisations

- Developing systems
  - Developing Core AI
    - Symbolic
    - Behavioural
    - Etc
  - Developing systems integrating AI features/components
    - System Design and Engineering
    - Lifecycle management
    - Etc

One can observe that an important question of the jobs and roles for AI has already been answer in a neighbouring domain: the different roles and profiles of data scientists with an aim to offer adequate training to students for these roles, in the EU project EDISON, which has defined a data science framework as a tool for building university and professional curricula [4, 5].

6.3. Educating with AI

- UNESCO "AI and education, Guidance for policy-makers" [7] distinguishes four areas where AI can be used in support of United Nation's Sustainable Development Goal "Quality Education" (UN-SDG4)
  - **(i) education management and delivery;**
  - (ii) **learning and assessment;**
  - (iii) **empowering teachers and enhancing teaching; and**
  - (iv) **lifelong learning.**

In our perception this investigation is still at an early stage, except for specific areas, like administrative optimisation (the problem of schedules and resource allocation

in linear education is known to be NP complex, hence AI support is welcome when available), and the assembling of composite choice plans for university curricula well as for lifelong learning programmes.
Risks need to be identified, characterised, and mitigated. The balance between proactive support of the learner and keeping her/him some freedom of choice, the incentive to proactively undertake and experience, and the valuable experience acquired in trial and error, should not be endangered by what seems to reduce planning an education to a quick and automated optimisation.
AI used without care might reinforce biased assumptions, such as “work on your strength” or “work on your weaknesses” whereas hybrid efforts might have meaningful effects. One of the leading pedagogues of all times, Socrates, was constrained to commit suicide by a society which he tended to challenge and irritate systematically: a valid sanity check for specific uses of AI in education projects could be addressed by asking the question:
“-Would the chosen AI use in education allow for a Socrates effect in the Education System considered?”.
Education as Research often benefit from locally apparent de-optimisation, which triggers a creative and innovative attitude of the learner or researcher. This behavioural sequence can be compared with simulated annealing, whereby a system escapes local minimum traps, and explores more ergodically candidate minima. Another formulation of it would be that adding noise to a system might be beneficial in allowing its evolution to desired states, which a purely deterministic approach might prevent.

Let us end this section with a provocative question, for pedagogical science:
-Would a targeted Adversarial de-optimisation of the learning plan help regenerate the learning mindset?

6.4. AI and Education as a greenfield

Education as well as AI have an accelerated evolution. Their interaction may require careful handling, for keeping human freedom and diversity to learn and teach in such interaction.
The issue of modernising Education is not new, it has been known to Socrates, and to Abelard [6], a professor in Medieval Paris, but it needs revisiting for the AI age.

7. Conclusion and perspectives

The collaboration between human agents and Artificial Intelligence is expected to stay under human supervision. Whereas this seems obvious, the detail of it is more complex, as we have observed in previous phases of automation, or through the replacement of purely human action with tools and machines. I do not expect to put my feet on the ground to stop my bicycle, or even worse to use my fingers to touch its front wheel when I want to brake. In the same way, delegations of actions, and of decisions will happen when it comes to “letting the AI perform”. Naturally the

planning and the awareness of such action is by human design, and with hopefully human awareness and acceptance.

How can we ensure that the quality of life is preserved and if possible enhanced by using AI? This is a question requiring societal debate, and informed choice, in the spirit of the societal values commonly adhered to and recalled above.

What impact will the adoption of AI have on jobs and skills requirements? Clearly digital awareness will help future workers, but AI is not so different from any other feedback loop engineering and tooling, where a system observes, learns, decides and executes. A scale change may happen (due to larger data sets scrutinised, with higher frequency) but not a complete paradigm change.

A very important aspect of using systems with AI is to never lose sight of the multiple agents at play: the direct beneficiary of the system using AI, and third parties, always avoiding that the use becomes detrimental or even adversarial to such third party. It is hoped that the development of standards addressing risk classification criteria, and mitigation/management techniques for such risks, will help towards a confident endorsement and use of AI in systems.

Many of the points raised above are still open, and the future will tell, with experiments and trials preceding uptake.

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Standardisation of Artificial Intelligence: Making a "New World" Brave, with Support of Human Requirements in a Machine Intelligence Environment

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Abstract

In line with previous industrial revolutions, standardisation must accompany the deployment of artificial intelligence systems that promise to revolutionise the way we live (home automation, autonomous vehicles, EdTech, etc.) and work (collaborative industrial robots, agricultural robots, inspection and maintenance robots, LegalTech, FinTech, etc.). The standards produced and promoted in Europe will be resolutely geared towards the protection of people and property, thus promoting the acceptability of these intelligent systems and the common interest. They will have to cover

the requirements expected of AIs, but also the means and methods for assessing them. The new standards will have to cover not only technical aspects of AI, but also ethical, legal, corporate, national and international requirements to support and protect people in the new AI-driven environment. The paper thus discusses the society-relevant aspects of AI standardisation based on the recently started international and European standardisation processes.

Keywords: Artificial Intelligence; Standardisation; AI trustworthiness; AI sustainability; AI conformity

1. Introduction

The impact of AI on society promises to be much more far-reaching than earlier technologies in the previous industrial revolutions. The first revolution (late XVIII century – early XIX century) introduced mechanical machines and chemical manufacturing powered by water and steam, consuming coal no longer wanted. The second revolution (second half of the XIX century) was driven by mass production and use of electricity. The third revolution (middle of the XX century) brought automation and computerisation. The fourth revolution is now occurring, in which automation and digitalisation is increasingly being based on AI, with vital sustainability requirements for the people and the planet. While AI leverages the previous revolutions' achievements, it is now entering new domains that intersect with the physical and psychological existence of people and the expected sustainability for individuals and societies.

It is a crucial moment when the directions of AI development should be formulated so that AI serves the people and the planet in the best way. The European Committee for Standardisation (CEN: Comité Européen de Normalisation) and European Committee for Electrotechnical Standardization (CENELEC: Comité Européen de Normalisation Électrotechnique) develop European standards for the safe and convenient use of technologies, and for AI evaluation (acceptance test, certification, etc.) based on reproducible experiments with real and simulated test facilities, repeatable performance measures, and comprehensible and traceable evaluation criteria that are consensually translated into metrics.

Most standardisation organisations appeared in the XX century to avoid cases as poisonous dyes or lead components in the XIX century or flammable plastics in the 1930s. Back then, technological development was unrestricted, and learning from mistakes was the way forward. Today, well-established standardisation procedures protect health and safety. Regulations and associated standards are now followed in the manufacturing and implementation of products. New technologies, such as AI, will provide numerous benefits when the public, as well as organisations using AI, will gain confidence that such technology is safe, sustainable and reliable, thanks to minimal but needed standardisation, certification, and regulation.

Artificial intelligence has been subject to important technological developments in the past few years, building on increased computing power and the wide availability of machine learning techniques (some of which were developed as early as in the 1950s but were not usable until sufficient development of hardware and software).

The recent White Paper of the European Commission [1] has outlined the main pathways of AI development at the societal level. To address this at the level of standardisation bodies, CEN-CENELEC formed a Focus Group in 2019 that produced a response document [2] to the White Paper that identifies the main standardisation aspects of AI development. In 2021, CEN-CENELEC formed a regular Joint Technical Committee (JTC) number 21, which continues the work started by the Focus Group [3]. This Committee will be instrumental in supporting standardisation in line with EU legislations announced in April 2021 towards the Artificial Intelligence Act [4]. Once accepted by the EU Parliament, the act will regulate AI in the context of risks related to the application of various EU rules protecting fundamental rights of its citizens, to ensure safety and attribute liability. The legislation is currently at the Proposal Stage, and “the EU will ensure that AI is developed and used in an appropriate legal framework with the overall goal to stimulate the up-take of trustworthy AI in the single market”. The main goal of the AI Regulation is to identify and monitor "high-risk" AI systems.

2. Society-focussed AI standardisation

A number of Standards Development Organisations address AI. They have different territorial and technological scopes, as shown in Figure 1, where we list the main standardisation bodies (ASTM - American Society for Testing and Materials; ANSI - American National Standards Institute; BSI - British Standards Institution; CEN - Comité Européen de Normalisation (European Committee for Standardization); CENELEC - Comité Européen de Normalisation Électrotechnique (European Committee for Electrotechnical Standardization); ETSI - European Telecommunications Standards Institute; IEC - The International Electrotechnical Commission; IEEE - Institute of Electrical and Electronics Engineers; IETF - Internet Engineering Task Force; ISO - International Organization for Standardization; ITU - International Telecommunication Union; SAE - Society of Automotive Engineers; W3C - The World Wide Web Consortium).

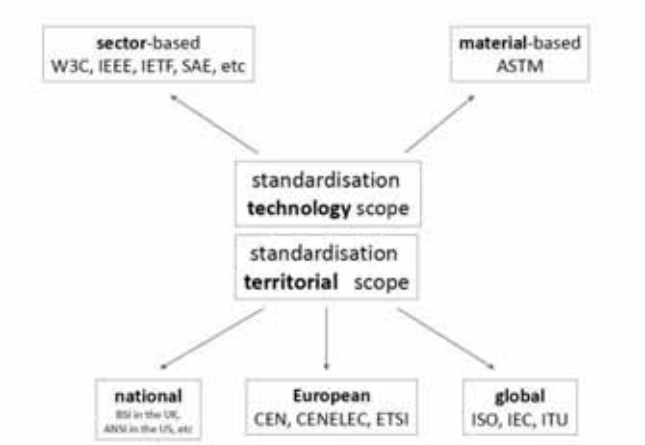

Figure 1: Standardisation organisations described according to territorial and technological scopes.

One of the main standardisation committees currently active in AI is in ISO/IEC JTC1 [5]. To date, SC42 has published 8 ISO standards (majority of them related to BigData) and has 22 other standards in development. There are various stages of standard development: 00 – preliminary, 10 – proposal, 20 – preparatory, 30 – committee, 40 – enquiry, 50 – approval, 60 – publication, 90 – review, 95 – withdrawal; each of these stages may have from two to seven substages. The active published standard has stage 60.60. At the intermediate stages, documents may be named with the following acronyms: AWI - approved new work item, CD - committee draft, DIS - draft international standard, DTR - draft technical report, DTS - draft technical specification, NP - new proposal, TR - technical report, TS - technical specification, WD - working draft. Because of the time scale of standardisation, a draft standard (not in its final form) can be available in the ISO portal.

It is necessary to note that most of the standards are not mandatory for industry to adhere to; rather, companies choose to follow the standards because these instil good practices and high level of competitiveness in their area. Regarding European harmonised standards, it has to be noted that they provide a presumption of conformity to EU regulation, but that they are not mandatory either. On the other hand, not following harmonized standards could come with risks and costs that should be identified.

AI has been intended to support humans, and make their life easier and more enjoyable, as the mechanisation of production and transport has been planned in the next few years. However, changes have been observed during the mechanisation transformation, from a dominantly rural society to an increasingly urban society, with concentration of production in factories and intensification of transport. It is not possible to precisely forecast all impacts of AI on humans, but it is possible to align it with human interests, as follows:

(i) protecting human life, which requires safe use, for the direct users of a system involving AI, but also for third parties, such as passers-by on a street with autonomous transport, neighbours of the user of AI-driven garden equipment, etc.
(ii) protecting humans against other damages, including physical and psychological or reputational harm. This includes privacy (as explained in the EU's General Data Protection Regulation and its transpositions in national law) and more broadly individual and collective freedom (as described in the United Nations Declaration of Human Rights)
(iii) ensuring fair access of all to the benefits of systems and services using AI. Any use of AI with bias or discrimination for or against particular group is highly undesirable and this aspect should be checked systematically at design stage as well as during the system operation phase.

Ethical considerations and their implementations should be monitored by committees with relevant expertise and stakeholder representation, and the formulation of ethical requirements should adapt as society evolves. In particular the AI system interface to human users or third parties involved in the use of a system with AI, directly or indirectly, should not have barriers relating to the sensorial or cognitive abilities of the users; this includes explainability of adapted sensorial and cognitive modalities, in the context of the European Accessibility Act, and its transposition into national and other local laws.

In the following subsections, we will outline the main aspects of the AI standardisation in more detail.

2.1 Explainability

It does not make sense to talk about explainability without defining what, to who and why to explain. The draft international standard ISO/IEC 22989 "Information Technology — Artificial Intelligence — Artificial Intelligence Concepts and Terminology" defines explainability (xAI) as the property of an AI system that important factors influencing the prediction or decision performed by the system can be expressed in a way that humans would understand. Understanding the complexity of modern AI systems often requires special knowledge in the areas of mathematics and computer sciences. Explainability, however, does not assume simplification of the methodology or implementation, but rather aims at explanations of main principles and dependencies of technologies, inputs and outputs.

Ex-ante explanations ensure that the system is well designed, serves its purpose and explains the general properties and features of a system in a way that provides relevant information to stakeholders other than the developers. Ex-post explanations interpret specific algorithmic results and the circumstances they were made in and provide an explanation of the properties and features that play a role in the making of a decision.

ISO/IEC 22989 discusses modes of explanation: causal – how a system functions; epistemic – how we know it functions; justificatory – on what grounds it functions. Levels of explanation vary depending on the needs of stakeholders, the need for human intervention, and the need to challenge AI-based decisions.

Explainability enhances trustworthiness of AI.

2.2 Trustworthiness

To fully benefit from the recent progress in deployment of AI solutions serving the various sectors of our life (inspection and maintenance robots, logistics robots, collaborative industrial robots, etc.) and domestic life (education technologies, intelligent medical devices, chatbots, personal assistants, etc.), common standards must be established. Standards, once available, will allow end-users to make an informed choice among the various existing solutions. They will also allow developers to drive their R&D efforts until the intelligent system is commercialized.

Agreed standards, developed transparently and in consensus, will provide the necessary guarantees to develop the trust associated with these new technologies, and thus promote their acceptability.

Among these standards to be developed, Trustworthiness has a particular importance. Trustworthiness is built around various factors related to regulatory or contractual requirements defined in a set of specifications that are usefully based on standards (cf. ISO/IEC TR 24028:2020 “Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence”, which is at the fully developed 60.60 stage). These factors are mainly safety, performance, robustness, resilience, security, and efficiency.

2.3 Robustness

The robustness of an intelligent system is characterized by its ability to adapt to different operating conditions. It is therefore determined by the size of its nominal operating domain. For input data located within this operating domain, the intelligent system manages to maintain performance in accordance with the requirements (regulatory, normative, specification, etc). The larger the size of this operating environment, the more robust the system will be.

2.4 Transparency

Transparency of AI and AI-aided systems provides visibility to the features/components and procedures of an AI system. A fully transparent AI system is repeatable, allowing for stochastic variation. Transparency is making data, features, models, algorithms, training methods and quality assurance processes

available to external inspection (conformity assessment bodies, end users, etc.). Transparency enables stakeholders to assess the fairness of the processing against ethical virtues or codes of conduct and thus enhance trustworthiness of AI.

There are various approaches to transparency of AI or AI aided systems. Artificial Intelligence systems may exhibit many forms of opaqueness, which hamper the responsible and accurate use of such systems. Firstly, the AI model itself may be technically opaque, in that the decision procedures it uses is not inspectable due to its convoluted or non-interpretable nature. Secondly, if the input data and data sources are not transparent, the whole behaviour of the whole system becomes opaque to an outside observer.

Thirdly an AI system is always implemented in a context of organisational practices, such as data collection, management, operationalisation of AI results, and system development. If these practices are undisclosed, even an interpretable AI model becomes an opaque system to users and other external stakeholders.

Integrating transparency into all levels of the AI processes is the only way to ameliorate the problems caused by such opaqueness. This means transparency in terms of the technical features of the systems, as well as the salient organizational practices surrounding it.

A transparent AI system informs the stakeholders where, why and what personal data are collected and when the decision-making is automated. A transparent AI system also explains the significance and expected consequences along with a meaningful information about the logic involved.

When profiling or assessing personal aspects, which result in a legal effect on the stakeholder, a transparent system provides a point to request for human intervention and the possibility to express the stakeholder's view.

The key question of transparency is how the AI system works, and whether the algorithms that have been used are suitable for purpose. Transparency makes the data, features, algorithms and training methods available to external inspection regarding their legal and life cycle features and source of data. What comes to privacy and business interests, transparency enhances the overall trustworthiness of AI [6].

2.5 Privacy and Security

Employing A algorithms on big data, privacy and security challenges becomes more complicated than before. The privacy in AI is intruded by raising the analysis on personal information. One main challenge is to protect personal information in AI, however, not to restrict AI developments. Several attacks and threats have been reported [7].

The complex nature of AI algorithms that unlike conventional data analysis algorithms combines several dimensions of data is highly compromised privacy in several unknown ways. Hence, the traditional anonymization solutions do not suffice to protect the privacy in the AI ecosystem. Instead, more advanced techniques called as privacy-enhancing techniques (PET) contributed to increasing the level of privacy for AI.

Figure 2. A general overview on the evolution of the privacy-preserving techniques with advancement of data (following [7]).

The initial privacy-preserving techniques were mostly focused on anonymization to avoid information disclosure by removing or encoding the identifiers. The emergence of Big Data in more complex formats than traditional tabular data raised concerns about the connectivity of the large volumes of data. De-identification techniques are used to prevent confidential information breach from being connected with other information in a dataset. Finally, ML and AI algorithms have increased the complexity of data analysis, so that more advanced technologies, such as privacy-enhanced techniques (PET), are utilized to protect the data.

Considering all the defence mechanisms that have been enhanced to protect AI, yet there are breaches reported from several attacks with the purpose of exposing information, extracting the underlying trained AI model for unauthorized purposes, and even poisoning AI to mislead and jeopardize human life [8].

The privacy and security of AI requires not only technical advancements but also standards, regulations, and certificates to increase the immunity and conformity of AI for society and individuals.

2.6 Resilience

The resilience of an intelligent system corresponds to its ability to operate in "degraded mode", when its input data is outside its nominal operating range (e.g., due to a sensor fault, damaging bands of pixels in an image generated by a smart camera).

2.7 Efficiency

Efficiency of a system is measured by useful output as a proportion of provided input. AI systems are assessed with similar approach, although with some other aspects as well: the efficiency measures of an AI system include the computing power spent to train an AI model (computational aspect of efficiency), amount of training data needed to achieve a level of outcome (model performance aspect of efficiency) and reusability of the knowledge acquired from training the model to perform similar tasks (transferability aspect of efficiency).

The computational aspect of AI efficiency (readily measurable) has been improving rapidly both by improvement in neural networks and underlying hardware. Performance aspect varies with task and is easy to measure using training and test data and different AI algorithms. OpenAI's GPT3 and IBM's GAAMA reading comprehension systems can answer most questions on any provided text without any question-answer pair training (traditional training of AI system with a corpus, to prepare it as Q&A bot); this is a huge efficiency gain. Transferability aspect of efficiency is that AI can be useful in a new problem of the same domain. For instance, can an unsupervised AI that is trained to spot traffic violation incidents in video stream achieve similar performance for shop break-ins from video streams? Transferability is hard to achieve; however, it may ultimately lead from Narrow AI (task-specific skills) to Broad AI (domain Intelligence), see [8].

2.8 Sustainability

Sustainability is widely understood as relying on two main elements: the respect of the planet (also named the environmental sustainability) and the respect of people (also named societal sustainability). While respect of people is primary, the respect of the planet remains a prerequisite for a successful or even acceptable deployment of systems and services using AI. For this purpose, energy efficiency should be addressed systematically, for every large-scale AI system.

The use of internet in general has a large carbon footprint: the data centres electricity consumption is 1% of energy demand [9], with carbon footprint ranging from 28 to 63 gCO_2eq/Gb [10]. As now computational load is rarely performed on a stand-alone computer, but rather operates distributed facilities, HPC clusters and clouds, this includes AI applications, which are resource demanding. As was shown by [11], training a single natural language processing model emitted 300,000kg of CO_2, equivalent to 125 round-trip flights between New York and Beijing. [12] reported

that the amount of compute used in the largest AI training runs has been increasing exponential with a 3.4-month doubling time.

Simultaneously, AI is used for targeting customers interests online, thus incentivising internet browsing and streaming. Large tech companies routinely mine their databases to address the customers profiles with suggestions for further internet activities. According to the report [13], online video in 2018 took 60% of online data use. And this growing use is continuously stimulated by such features as default autoplay and smart frame advertisements.

However, the AI community starts to recognise their responsibility to develop sustainable solutions, which reduce computational load, such as Once-for-all neural networks [14]. At the same time, cloud storages and data centres are transferred to the regions with low carbon energy supply, such as Norway with hydropower energy.

On the other hand, AI-based solutions modernise the energy industry, providing optimised forecasts of energy demand, reducing breakdowns, maximising plant outputs, and reducing energy costs and operational carbon emissions [15].

3. Conformity assessment of AI

Once the expected requirements of AI systems have been formalized within standards, the conformity assessment tools need to be specified. Conformity assessment relies mainly on two tools: audits and tests (ISO/IEC 17011). Audits for AI are not specific in their implementation (analysis of verifiable, qualitative or quantitative audit evidence, such as records, statements of fact, etc.). The performance of tests for AI, however, has some unique features (ETSI DGR/SAI-003, ISO/IEC TR 29119-11).

Since some AI systems are highly adaptable, their operating domain can be variable and vast. However, due to the underlying technologies, their behaviour can also be largely non-linear and non-convex. For these reasons, their evaluation and characterization require them to be subjected to large numbers of test layouts (different environmental conditions, obstacle and building geometry, road curvature radii, mission objective, etc.), the cost and time of which would be prohibitive to implement only on physical test benches. The use of virtual tests (based on simulators), in conjunction with physical tests, is therefore necessary to maximize the coverage of test scenario. These virtual tests and mixed tests (combining virtual and physical test benches) raise new issues (realism, design bias, interoperability, independence, governance, etc.) that standardization is called upon to articulate and formalise. In particular, these test environments must be validated in terms of their representativeness, namely their exhaustiveness/completeness (coverage rate of the test scenario) and their realism (results in accordance with those obtained in real conditions) [16,17].

The physical test environments can be of two types: real or laboratory. The real test environments are experimental sites corresponding to the real operating conditions of the AI functionalities to be evaluated. Living labs, increasingly common for artificial intelligence, are emblematic of these environments [18]. They aim at relaxing, in a well-defined geographical area, the regulations in force to allow end-users to test AI systems in real conditions, in an open and well-managed innovation process. In this context, standards have already specified good practices associated with open innovation (ISO 56000). However, almost nothing has been standardized regarding Living Labs for AI, even though many subjects, such as their governance, innovation processes, end-user involvement and feedback collection, could be usefully covered by standards.

Laboratory test environments are physical test benches located in a laboratory with control of the experimental conditions (temperature, humidity, etc.). The testing facilities used in the H2020 METRICS competitions have examples of underwater, aerial and ground laboratory test environments for AI systems [19]. Existing standards (e.g. ISO 18646-1) already cover many laboratory test environments for automated tasks such as navigation. This effort should be continued to cover new tasks such as dexterous manipulation and human-robot interaction.

Concerning the virtual test environments, they can also be of different types: simulators, replay datasets (real data), augmented datasets, artificial datasets. Simulator-based testing is becoming increasingly common due to the low cost and simplicity of generating new test cases once digital models (of controllers and components of the system, environments, weather, terrain properties, agents and objects, etc.) are in place. The main issue is therefore to specify and validate these digital models. Even though standardization work has been underway for several years (such as ISO/IEC 18023, notably fuelled by contributions from the Simulation Interoperability Standards Organization), it does not yet integrate the specific needs related to AI. There is still a lack of a standardized way to specify and set up (development, evaluation, maintenance processes) such digital models of the simulated world (unstructured and evolving environment, which may involve humans, human-machine interactions, agent-to-agent and agent-to-infrastructure communications, etc.).

Well-developed ontologies for AI simulation (integrating concepts such as fluid viscosity, material dissipation model, soil plasticity) are often missing in this context [20]. Just the modelling of perception capabilities requires the integration and structuring of knowledge (laws of physics, characteristics of the technologies used) related to GPS, inertial measurement units, cameras, LiDARs, radars, thermal sensors, etc. The specifications defined for data in ISO/IEC 5259, such as interoperability (to be usable by a large number of AI systems, which raises the question of what formats should be used for sharing digital models), validity (which raises the question of the number of scenarios to consider, the prioritization of scenarios, the level of detail to implement in these scenarios, etc.), fairness (to be unbiased), timeliness (to be up-to-date), also apply to digital models used in

simulators. Data quality standards for AI are thus a starting point for the standardization of simulators and the associated validation processes.

Tests on replay datasets are the most established in AI. They have been used since the appearance of machine learning decades ago. Since they are based on real data, the question of realism does not arise. On the other hand, it is a question of determining the coverage rate of the scenarios present in the dataset compared to the real operating conditions of the system. Concerning this point, the first standardization work has begun (ISO/IEC 5259). The notion of timeliness is particularly important for replay data. It indicates to what extent the data is up to date. Replay data cannot be easily and at low cost regenerated. They are therefore exposed to a certain risk of obsolescence.

To improve the coverage rate of the replay datasets, data augmentation techniques have been implemented. They are based on the addition of artificial perturbations to the data (meteorological disturbances, sensor noise, metamorphic transformations, etc.) [21]. These perturbations are based on digital models, which must also be specified and validated according to standards that have yet to be developed.

Finally, to study the boundary behaviour of AI systems, it is also increasingly common to use tools for automatic generation of artificial test data. This is particularly the case for the generation of adversarial attacks and corner cases [22]. The question of the realism of these data arises [23]. Standardization could provide answers by defining consensual methods for validating the performance of these tools and the quality of the data generated.

Thus, the standardization work dedicated to virtual testing, which is one of the most critical components for the conformity assessment of products with artificial intelligence, could be deployed in five main directions:

- To circumscribe and structure the scope of the work, identify the concepts involved and agree on an appropriate terminology, building on and feeding into ongoing standardization initiatives on AI terminology (ISO/IEC CD 22989-2, ISO/IEC CD 23053-2, ISO/IEC 20546:2019, etc.).
- To circumscribe a perimeter of applications to be targeted in priority for virtual testing (capitalizing on the standardization work underway aimed at identifying use cases for AI, such as ISO/IEC NP TR 24030, ISO/IEC TR 20547-2, ISO/IEC DTR 24372, SAE AIR6994, etc.):
    - the most advanced in development and therefore in need of evaluation,
    - the most important from a commercial/economic/social point of view,
    - a sufficiently wide range to cover the different categories of technologies / algorithms / systems and thus hope to cover all the simulation problems.

The critical application sectors of AI (autonomous transport, medical robotics and intelligent medical devices, smart grids and agricultural robotics, industrial robotics, inspection and maintenance robotics, logistics robotics, civil and military intervention robotics, biometrics, cybersecurity, etc.) should thus be the subject of particular attention.

- To circumscribe the scope of requirements to be tested and evaluated (building on ongoing standardization work) performance (cf. ISO/IEC WD TS 4213, ISO/IEC NP TS 5471, ISO/IEC AWI 25059), robustness (cf. ISO/IEC 24029-1, ISO/IEC AWI 24029-2), versatility, resilience, ethics (cf. ISO/IEC 24368, ISO/IEC DTR 24027), explainability (cf. ISO/IEC AWI TS 6254), quality of human-machine interaction, efficiency, safety (cf. ISO/IEC AWI TR 5469), etc.
- To analyse these scopes and list the parameters of importance and possible requirements for the virtual test facilities (addressing data quality as described in standards such as ISO/IEC WD 5259-1, ISO/IEC WD 5259-3, ISO/IEC WD 5259-4, etc.):
    - their representativeness, including their exhaustiveness (sampling rate, coverage of the operating domain of the AI system evaluated, etc.) and their realism (validation criteria, differential with real data, etc.),
    - the different types of simulation (SIL, HIL, on-line, off-line, use of real, virtual or augmented data, etc.),
    - the interoperability of the digital models of the technological bricks (sensors, etc.) and of the descriptions and specifications of the operating domains, etc.,
    - the data produced and its relationship with the expected service, metrology and relevant metrics when it comes to intelligence, functional versatility and a composite risk (such as legal) and sometimes little quantified (such as ethics),
    - the specialization, referencing, and governance of the virtual test environments regarding the protection of personal, industrial or sovereignty data, control of the risk of overlearning/overfitting the simulator and therefore of access to these simulators, maintenance (risk of drift and regression of the simulator), based on ongoing standardization work on AI governance and processes (ISO/IEC 38507, ISO/IEC AWI 42001, ISO/IEC CD 23894, ISO/IEC WD 5338, ISO/IEC CD 24668, etc.).
- Preparing and supporting standardization processes at European (CEN-CENELEC) and international (ISO/IEC) levels.

Figure 3. Number of standards on AI-related topics.

4. Conclusion

We have outlined the major aspects of AI standardisation and the priority areas of progress, which is in the beginning of its development. Standards formulate definitions, functionality and applicability of AI systems, often using the terms that require precise and reliable interpretation. A future challenge here is to define standards for cutting-edge research areas in AI such as scene awareness AI systems, AI systems where some model of artificial consciousness is implemented, AI systems equipped with artificial emotions. These areas pose a challenge for standardization, as they raise problematic questions about ethical and moral aspects, also in connection with the difficult question of the legal responsibilities related to AI systems. Because AI systems are going to be integrated in all areas of human activities, it is essential to make coordinated efforts in supporting this activity, at the same time avoiding unnecessary restrictions that could limit creativity of AI developers.

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Exploring the Use of AI Applications in the Development and Delivery of Biomedical Engineering Education Online

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Abstract

Computer-based learning (CBL) and Computer-aided instruction (CAI) have emerged as tools for teaching using computers over the past few decades. However, these systems have not been able to provide learners with optimized systems and instructions for enhanced, individualized and flexible learning compared to the use of face-to-face (f2f) and human tutors. This fails to offer a learner-centred approach to the process of both knowledge and skills acquisition using the full potential and abilities of the learner, all of which need to be taken into consideration. In recent years, Artificial Intelligence (AI) has gained popularity across all sectors, especially in education. Some novel AI applications have been developed and shown to be particularly useful for reinforced learning for natural and artificial systems. Biomedical Engineering (BME) Education relies on the use of both physical and virtual systems and tools. This involves the creation of models/experiments and their analysis for a deeper understanding of concepts. This study explores the use of AI applications for the development and delivery of BME education in United Kingdom (UK) universities. Emphases are made on the process that has been and those that could be highly improved for learning online, following the advent of the persisting Coronavirus (COVID-19) pandemic. Some pedagogical issues are considered and

the need to further understand ways of improving current platforms for delivery is noted. In this review, we examine how AI can be used to support collaborative learning, personalization of tailored solutions based on specific needs, and individualized learning in Biomedical Engineering education at UK universities.

Keywords: Artificial Intelligence, Virtual learning, Biomedical Engineering, Education, e-Learning

1.0 Introduction

The problem of enhancing learners' understanding of concepts associated with Biomedical Engineering (BME) education has been and remains a huge area of challenge. Therefore, the problem of visualisation such as data visualisation, physical visualisation or mental visualisation remains a great challenge and artificial intelligence (AI) provides the answers to some of these. The human-like intelligence displayed by processes or software is referred to as artificial intelligence [1]. The main purpose of AI systems is to perform functions considered to be intelligent.

For centuries, human societies have improved their practices by augmenting them through the use of various tools and technologies [2]. Attempts to augment cognition have always involved some form of language or language-derived culture or symbolic writing. Through the offloading of our thought processes and exchanges of ideas, we have been able to make tremendous progress as a society [3]. Over the past few decades, the introduction of computation has enabled us to do things we would not otherwise have been able to do due to complexity [4]. We have not just amplified what we can do but rearranged how we do what we do.

The usage of augmented and virtual reality, as well as their applications, encompasses large domains or disciplines of academic and professional interest, with each having its own unique set of obstacles. Due to their complexity, practitioners (teachers and students) may find it intimidating to delve into them. This presents significant difficulty for anyone offering higher education, secondary education, or any type of education, as well as those attempting to manage biomedical engineering-related teaching and learning.

The outbreak of COVID-19 led to a suspension of face-to-face academic activities at almost all higher education institutions, where the risk of community transmission of the virus is high. Many universities switched to online delivery as one of their modes. The laboratory and practical sessions suffered a significant setback during the period since most institutions of higher learning only made provisions for physical laboratory sessions. The COVID-19 pandemic and the restrictions it made have had a significant impact on education most especially the closure of schools in response to the pandemic whereby only a few education providers were able to effectively switch to online mode of teaching. As a result of the COVID-19 pandemic and its allies' social distancing measures, interest, use, and potential applications of AI are on the rise in education. The problem of enhancing the learners' understanding of concepts associated with BME education however

remains a huge area of challenge. Some pedagogical issues are considered and the need to further understand ways of improving current platforms for delivery.

This review seeks to critically examine BME education as provided in the UK universities and look at the biomedical engineering education provision in the UK arena. How AI can help advance collaborative and personalized learning experiences, in contrast to the approaches discussed in previous reviews, may lay the foundation for educators and developers to better understand the needs of students, while providing an interactive platform for both learning and communication.

2.0 Biomedical Engineering

Health care problems of the 21st century largely fall within the engineering domain, as they usually involve the analytical, design, and practical aspects of equipment and systems that lie at the heart of the engineering profession. Biomedical engineering involves combining concepts, knowledge, and approaches from almost all engineering disciplines to solve specific healthcare-related problems. Thus, BME provides numerous opportunities for interaction between engineers and healthcare professionals [5]. While many consider what is included in the field of biomedical engineering to be quite clear, disagreements about its definition often result in conflicting opinions regarding it. Among the terms defined in the Bioengineering Education Directory are biomedical engineering, bioengineering, biological engineering, and clinical (or medical) engineering. An interdisciplinary field of study like biomedical engineering involves the training of three types of professionals: the clinical engineer in the health care field, the biomedical engineer for industry, and the research scientist [5].

The scope of biomedical engineering is wide, its major focus is to understand, modify, or control biological systems using mechanical, electrical, chemical, and optical principles. Over the past half-century, the field has evolved from being primarily focused on developing medical devices to including a range of diverse activities. Figure 1 shows the numerous career paths available in biomedical engineering today. There is a great deal of opportunity, challenge, and promise in this endeavour because it offers both technological and humanitarian benefits.

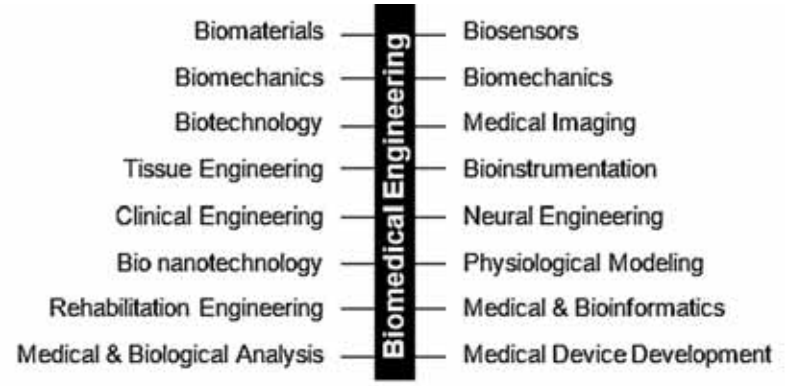

Figure 1: Biomedical engineering fields.

2.1 Biomedical Engineering Study

Engineering has an extremely important role to play in solving many of the challenges facing today's health professionals because these challenges require an understanding of the fundamental processes of device and system analysis, design, and application, which are at the core of the fundamental processes of engineering. Biomedical engineering entails applying concepts, information, and methodologies from almost all engineering disciplines to solve specific healthcare challenges [6].

Biomedical engineers often hold a Bachelor's, Master's or doctorate (PhD) degree in BME or another discipline of engineering having significant overlap with BME. Due to the increasing interest in the field of biomedical engineering, many engineering colleges have begun to offer Biomedical Engineering programs at various levels from undergraduate to postdoctoral. BME programmes are developing at all levels, and the number of biomedical engineers is expected to grow as a result of and in response to developments in medical technology [6, 7, 8].

Research is an integral part of the majority of BME-related professions, such as tissue engineering, biomaterial development, and the development of medical devices. An advanced degree is almost an absolute requirement for those who require adequate training and experience in research. The BME pedagogical practices vary widely around the world. In the U.S, considerable progress has been made in the area of BME education and training due to its large biotechnology industry, its many major universities, and relatively few internal barriers. The European Union has encountered difficulties in creating uniform standards as it attempts to remove some of the national jurisdictional barriers that still exist. Some initiatives have recently been undertaken in the field of biomedical engineering, such as BIOMEDEA [10]. Other countries, such as Australia, are currently addressing the issue of inadequate BME education [11].

2.2 Biomedical Engineering Modular Structure

The BME programme consists of a combination of lectures, assignments, presentations, group exercises, and a research project. Students are assessed through

written examinations (open and closed books), coursework assignments, a research dissertation and an oral exam. The Postgraduate programme offered by UK universities includes eight core modules (120 credits).

3.0 Immersive Technologies and Their Use in Education

3.1 Virtual Reality in Education

The application of virtual reality (VR) in education is not a new technology, nor has its use in education been a recent development. Virtual reality refers to the use of technologies to construct synthetic, three-dimensional environments that mimic real-world and imaginary environments. For several decades, applications for virtuality remained primarily restricted to the public sector until the release of a series of specialized arcade games by Virtuality Group in 1991 [12, 13]. Since then, the use of VR technologies have gained a great deal of popularity in the educational field due to their unique characteristics as compared to other ICT applications [14].

There have been several studies that have examined the impact of virtual reality on education and found positive results, such as increased concentration, enjoyment, motivation, deeper learning, and long-term retention [15, 16, 17]. VR technology enables students to customize their learning, choosing how much time they wish to spend on certain concepts and walking through simulations themselves. These immersive learning environments can provide hands-on experience as well as increase motivation. However, VR systems have not been widely adopted in the field of education despite these positive results. In 2011, Mikropoulos & Natsis [18] reviewed the use of VR in education between 1999 and 2009. In light of the research, and due to the rapid change in this area, Kavanagh et al. [13] sought to understand the practical challenges faced by educators as they try to incorporate VR into their curriculum. It was found that even though many of the literatures that were reviewed were created to inspire educational design, little of the research was grounded in solid pedagogical reasoning. This can be attributed to a lack of understanding of both the applications and the motivations behind the use of VR technologies in education, as well as the issues and limitations associated with them.

The Virtual Environment (VE) for learning may be defined as an electronic learning environment built around a specific pedagogical model, to provide the user with classroom experiences that would otherwise be impossible in the real world. As regards educational applications, Helsel [8] considers VR to be conceptual rather than technological and defines it as an experience in which users can participate in abstract spaces without physical contact or a physical viewer. VR can be exploited to enhance learning through 3D spatial renderings, in the form of VEs, user interaction through multisensory channels, immersion of the user in the virtual environment and real-time, and intuitive interaction based on natural manipulations. The use of VR in the classroom is attributed to some reasons by Pantelidis [19], the most prominent of which are active participation, high interactivity, and individualization. In a learning environment, factors that contribute to a student's success do not act independently, but rather interact to influence the learning process and outcome [20].

3.2 Augmented Reality in Education

Augmented Reality (AR) utilizes a variety of digital data such as images, audio, and other sensory data, with live video streams of the real world, to create an experience in which both physical and virtual objects are combined [21]. This experience consists of digital elements superimposed on real-world live video broadcasts, with real-time interaction between the digital elements and the user. As opposed to VR, which replaces the real-world environment with a virtual world using software and hardware [22], AR creates the perception of the real world in an engaging, immersive method without erasing it.

Through the use of augmented reality in education, students can learn more effectively by changing the way they learn and providing them with new and exciting ways to engage in learning. AR enhances the learning process by creating immersive learning experiences that enable students to learn in a real-world setting, which is a very effective method of teaching. The goal of augmented reality is to create multimodal learning environments that encourage students to participate actively in the learning process, inspire them to take action in their learning, and provide them with a more effective means of visualizing and interacting with abstract concepts using multiple senses.

3.3 User Interface

VR and AR applications are driven by user interfaces (UIs) that serve as the point of contact between the user and the program. Interaction techniques are the methods by which the user interacts with the UI. An adequate assessment of user satisfaction can significantly improve the quality of UI designs. In this application, wearable technology and a variety of display techniques are employed to overlay virtual information over the real world. These systems utilize user tracking to ensure that services are delivered to users according to their location. Interfaces that support multimodal interaction allow users to switch between modes such as 2D or 3D on the web as well as virtual or augmented reality. As a result of this benefit, the user is provided with a more fluid rendering experience [23, 24, 25]. There are many ways in which the user may interact with the user interface, including gestures and sounds. It is imperative to alter the UI to incorporate the appropriate virtual elements. In this way, applications may be more easily utilized. The optimization technique can be employed to achieve this objective. As pointed out by Cheng *et al* [26], usability is an important element of UI design. Depending on the programme, and interaction method is selected to be used. While an effective user experience is crucial for effective engagement, designing an effective user experience can be challenging. Software and hardware development are required in user interface design, to transfer data from traditional 3D rendering to the learning environment.

4.0 Methodology

To give this research background, several published research were reviewed. Also, university websites, reports, policy documents as well as opinions were considered. Most of these reports and academic papers were written by academics at all levels of the University. This study explores the variation of BME modules across the UK

universities, the method of teaching these modules, and the resources available for the module.

The data size for the study is from 132 universities that span all four geographic parts of the UK. This data was derived from the 132 universities ranked in the 2022 Times UK university ranking, which is considered to be a reliable indicator of the quality of UK universities. A review of the websites of each university and the programs offered by them was undertaken. Furthermore, the modules were reviewed using data from the individual university websites to find out if there is uniformity in the modules. Student and program data from the Higher Education Statistics Agency (HESA) and The Quality Assurance Agency for Higher Education (QAA) were also used to review the BME programs across the universities.

5.0 Findings and Discussion

Out of the 132 universities considered, 48 universities offer undergraduate programmes in Biomedical Engineering for Bachelor of Engineering (BEng) and Master of Engineering (MEng). 26 universities offer a postgraduate programme in Biomedical Engineering (MSc). The BEng programme is a 3-year programme while the MEng programme is a 4-year programme. The BME modules across all these universities vary. Nonetheless, the manner of delivery of the course: lectures, presentations, assignments, and assessments are similar. Several of these institutions use blended learning approaches whereby web-based activities are used to support teaching and learning activities. A widely used web-based platform is Blackboard, which is a virtual learning environment used to facilitate the sharing of learning resources, lecture notes, assignments, module outlines, announcements, and e-mail communication between tutors and their students.

The Biomedical Engineering programme requires a high degree of practical exposure. Several modules, such as Tissue Engineering, Medical Device Development, Advanced Biomaterials and Bioinstrumentation, require these practical exposures that are necessary for the development and design of new life-saving machines as well as for meeting current healthcare challenges. Unfortunately, several institutions have restricted access to some of the essential equipment, such as Bioprinters, Spectrophotometers, X-Ray Diffraction (XRD) devices, Raman Spectroscopy (RS) devices, Centrifuges, real-time polymerase chain reaction (PCR) devices, EEG systems, Cell culture facilities, and optical sensors. Therefore, the number of laboratory facilities and learners' access to the ones available in the laboratory is consequently restricted. These difficulties may stem from financial constraints, insufficient technical expertise, political reasons within the university system, economic factors or restrictions based on COVID-19. Unfortunately, the current learning structure does not provide adequate support for remote laboratory practicals. As a result, the students have been unable to acquire the detailed and solid experience required for this program. AI propose a solution to some of the challenges through the provision of virtual experiments, modelling and simulation for the practical-based module.

5.1 Experiential Biomedical Education Tools for Teaching

As an engaging and interactive teaching tool, AR and VR enhance students' learning experiences in BME modules like Tissue Engineering and Biomaterials where laboratory work can be virtualized especially where there is limited access to practical laboratories and equipment. A virtual or augmented reality tool for education is a viable digital solution to this issue since students can concentrate on a virtual environment which minimizes distractions. Among the options for using VR in classrooms is to equip students with headsets that are synced with central devices to experience the same content. Alternatively, lectures can be held in a virtual classroom with students wearing virtual reality headsets and collaborating from different locations.

An example is a virtual anatomical laboratory based on holographic images that were developed by zSpace as a way to allow students to learn in a more immersive environment [27]. Through the use of polarized glasses with embedded IR markers, zSpace has created a unique approach for combining AR and VR immersion to create an isolation-like feeling to inhibit collaboration. By using zSpace, students were able to divide an anatomical image into several regions and analyze different body parts to learn more interactively. As an added option, the AR experience might also be captured as a video or a photo that can be shared.

5.2 Limitations of Experiential Biomedical Education Tools for Teaching

Essentially, virtual environments, which include VR, AR, and MR, enable information to be manipulated, and as a result, improve the teaching and learning process. In addition, a virtual environment offers a lot of benefits, and many resources and efforts have been saved through the use of virtual environments, but its drawbacks can't be ignored. The finances of some educational institutions may prevent the use of these technologies. Also, several instructors or lecturers may avoid using new technology because they have limited knowledge about how to use it, so they emphasize on theory instead of applying this tool in Education. Limitations can also come from how an institution is legislatively managed.

Furthermore, these technologies can also have a big impact on disregarding traditional education materials. It's more likely that students use this technology more than traditional education materials. Also, frequent and prolonged use of VR, AR and MR technologies may lead to medical consequences, such as migraines and vision problems.

5.2 Existing AI strategies and Challenges in Education

An overview of how learning analytics information can be used to support student learning outcomes assessment efforts in higher education is provided by Klein and Hess [28]. In addition to examining traditional measures of assessment, the study discusses how timely, visually appealing, personalized, and predictive data in learning analytics can be used to supplement traditional methods. They demonstrate, using examples from existing theoretical and empirical research, that incorporating learning analytics into assessment delivers dynamic formative feedback to users,

enabling them to make more timely, informed decisions throughout the learning process. Additionally, they emphasize the importance of learning analytics-enhanced assessment initiatives being inclusive of informed and empowered data users as argued by Johri [29], DeBoer and Breslow [30], built on trusted foundations, and cognizant of the unique implications of using learning analytics data in practice, with recommendations for implementing learning analytics-enhanced assessment initiatives.

Johri [29] examines the potential benefits of learning analytics for higher education practice and argues that higher education has been slow to implement learning analytics, particularly in comparison to business settings. He also demonstrates, through a series of case studies, how the capability and routines of both companies and their members frequently impede the successful implementation of learning analytics programmes. Johri develops a novel paradigm for how colleges and universities can more effectively integrate learning analytics by addressing capacity and routine challenges throughout design and implementation.

Reinholz *et al.* [31], focus on the evaluation of instructors, to determine how learning analytics can be used to create more accurate evaluations for promotion and tenure decisions. The authors demonstrate how several types of data, including those from students, faculty peers, and faculty members' comments, can be linked to online learning analytics platforms to more precisely and effectively evaluate faculty instruction.

Using the case of a California research university as an example, Hora [32] explores the convergence of data-driven decision-making and learning analytics. According to Hora's argument, educators should draw on numeric data and other sources of information, such as student feedback and conversations with colleagues, work within institutions poorly designed to support continuous improvement, and design novel and often low-tech solutions to the lack of high-quality data, engage colleagues and students in the use and analysis of instructional data, and respond to external mandates for data analysis. The study illustrates the challenges inherent in data-driven decision-making and the interplay between organizational ability, human habits and routines, and technical alignment in data-rich environments.

A major challenge in education is the reduction of student contact with the real world. It is often remarked that the presence of people on university campuses enriches the student experience. The importance of the connections between students cannot be overstated. Nevertheless, they remain an essential component of any good program, just in a different format. Cohesion, trust, respect, and belonging within a group are therefore important, as are innovative approaches to establishing and building relationships [33].

5.3 Current Trends in Biomedical Engineering

A new Google-developed AR Microscope (ARM) uses machine learning to analyze biological tissue samples and automatically identify abnormalities caused by cancerous cells in the body in real-time [34]. ARM system's components include an augmented bright-field microscope, and a computer, with pre-programmed deep

learning algorithms. A deep learning model (DL) in ARM has been trained to find cancer in prostates and metastasis in lymph nodes in breasts. Based on the DL predictions, the microscopic sample was projected as contours, heat maps, or textural information using AR. With the aid of this system, pathologists can scan large images of whole slides more rapidly to detect cancer.

ExMicroVR offers a virtual reality tool that can be shared among up to six users simultaneously enabling remote collaboration among scientists. The combination of a nanoscale imaging technique, expansion microscopy, and virtual reality enables the analysis of cell structures that would be inaccessible by using normal light microscopy [35]. Using expansion microscopy, the sample volume for the tissue sample is greatly increased, which allows the collection of more information about the tissues and molecules in the tissue.

Another VR application, ConfocalVR, was employed to examine the complex organization and composition of cells and the distribution of proteins and molecules [36, 37]. Using the application, users could visualize 3D cellular images in RGB volumes, such as those collected from confocal microscopy zStack images. With ConfocalVR, users were able to manipulate the displayed image by rotating and scaling it to focus on a specific area. The Colour, lighting, and opacity of the display can be adjusted. Like many virtual reality applications discussed, it supports the simultaneous collaboration of multiple users. ConfocalVR was capable of visualizing high-resolution images but did not provide image-based metrology, such as the calculation of distance, intensity, or location within pixels based on the displayed data.

The Microsoft HoloLens holographic MR head-mounted display provides engineers and doctors with an interactive way to view 3D images of anatomical structures, with greater clarity. Surgeons and medical staff were able to examine complex organs during surgery using HoloLens-based MR interfaces [38]. Annotating specimens during an autopsy was achieved using HoloLens. Navigating whole slide images was accomplished using HoloLens, and real-time pathology-radiology correlation was achieved through telepathology [39]. Due to its ease of use and support for high-resolution imaging, the device is well suited for digital pathology.

6.0 Conclusion

As a result of COVID-19 and advancements in technology, the recent shift toward remote learning and work, practices have advanced even faster. Although, incorporating artificial intelligence and ethical reasoning into the engineering curriculum appears like a daunting task considering the variation in the modules across different universities, however, it is exceedingly important. It has been established that many of the BME modules could benefit from the integration of AI. Virtual experiments could be run from BME virtual laboratories which will provide equal access to students, especially in the situation where there is a restriction on the number of students that can access the limited resources. In addition, the use of artificial intelligence could significantly reduce the workload of instructors and lecturers in this field by automating assessments, feedback, and similarity checks

with high degrees of accuracy and efficiency with minimal human intervention. Consequently, teachers will be able to provide guidance and support where needed. Based on the current research and findings, it is expected that the application of AI will improve student learning outcomes and that management of online educational environments will become more effective.

This work is focused on Biomedical Engineering education and Bioinstrumentation. Some of the important areas of interest in this large field of BME education have been highlighted. Furthermore, the work currently being undertaken, through this study, will assist researchers, developers, instructors, and learners in this area in the future, in generating a better understanding of the challenges that exist in the field, of the current state of the art in this field, and of possible solutions moving forward.

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