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Innovating Pedagogy 2020

Exploring new forms of teaching, learning and assessment, to guide educators and policy makers

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Executive summary

This series of reports explores new forms of teaching, learning, and assessment for an interactive world, to guide teachers and policy makers in productive innovation. This eighth report proposes ten innovations that are already in currency but have not yet had a profound influence on education. To produce the report, a group of academics at The Open University's Institute of Educational Technology (UK) collaborated with researchers from the National Institute for Digital Learning at Dublin City University. We proposed a long list of new educational concepts, terms, theories, and practices and pared them down to ten that have the potential to provoke major shifts in educational practice. Lastly, we drew on published and unpublished writings to compile the ten sketches of new pedagogies that might transform education. These are summarised below in approximate order of immediacy and timescale to widespread implementation.

1 **Artificial intelligence in education:** The term 'artificial intelligence' (AI) is used to describe computer systems that interact with people and with the world in ways that imitate human capabilities and behaviours. AI-powered learning systems are increasingly being deployed in schools, colleges and universities, as well as in corporate training around the world. While many people fear that AI in education means robot teachers, the reality is less dramatic but potentially still transformative. Student-facing applications of AI include intelligent tutoring systems, dialogue-based tutoring systems, exploratory learning environments, automatic writing evaluation, and conversational agents. Teacher-facing applications of AI, although less well developed, might support teachers to enhance their own teaching. There is a need to understand the skills that make human teachers and learners uniquely human, such as critical thinking, creativity, communication and collaboration. It is important that educators, learning scientists and other stakeholders engage with the topic of AI to help shape both the development of AI-powered systems, and teaching and learning approaches that make appropriate use of AI.

2 **Posthumanist perspectives:** The meaning of being human, and our relation to the world around us, is naturally of great importance to any conception of education. As a philosophy, posthumanism examines what it means to be human and whether being human extends beyond our bodies into the real and digital world. As a pedagogy, it opens possibilities to learn with animals and machines as partners. Technological advances blur the line between humans and the material world. For example, computer programs such as 'chatbots' that answer questions and deliver services through simulated conversations are designed to sound like humans and to evoke conversational responses from their users. In the domain of healthcare, we are seeing that humans seem capable of forming very real attachments to robots. Also, scientists might begin implanting microchips in humans to enhance their capabilities, which could improve lives, but could also have negative consequences for people and society. The potential of adopting a posthumanist approach to education lies in asking the provocative question of what students can learn from confronting these unsettling

ideas of a less well-defined separation between humans and technology. The hope is that we can imagine many beneficial relationships between humans, the environment, animals and technology.

3 **Learning through open data:** More than 250 national, local, and city governments, and a wide and growing range of global and local organisations are now sharing the data that they create and use in their work. Many of these organisations are keen to see the data used by the public, and the most mature services offer tools and resources to encourage learning with their open data. Further initiatives have led to innovative learning activities around the use of open data. What does Open Data offer as a material for learning and teaching? A key factor is authenticity. The data that is shared emerges from real processes occurring within important organisations. It is often data that is used in professional work that has a real impact on our lives and the world around us. A second factor is the potential personal relevance of this data to the learners. This has a strong motivational potential – learners may want to understand what is happening in their town, or how they or their class compare with others nearby or far away. They can also identify issues that require attention locally or across wider society. In one example, high school students in Italy explore data on public funding awarded to building projects around their country and collaboratively evaluate the outcomes of these projects. Engagement with open data connects learners with societal movements to encourage greater data literacy, transparency and evidence-based action.

4 **Engaging with data ethics**: The growing use of digital technologies in educational contexts is accompanied by an ever-increasing range of ethical questions. There are the many ethical issues centred on data, such as who owns the data, how the data should be interpreted, and how the privacy of learners and teachers should be protected. Several recent incidents have highlighted that data techniques are commonly being used to profile people without their awareness. It is perhaps only a matter of time before this is happening in schools and universities. There is increased pressure on educational institutions to start to develop policies relating to data ethics, to obtain consent from students to use and analyse any data from their interactions with their learning management system, and to provide effective training and support for students and staff. Typically, there is currently no formal training for students enabling them to understand how their data might be used and the possible consequences. When preparing learners for a changing world of ethics and privacy, teachers can enable learners to 'play' with their own data and learn what the limitations of sharing it may be. Engaging with data ethics is part of how institutions are developing effective learning cultures in a digital world.

5 **Social justice pedagogy:** Most people want to be fair and just towards others, but sometimes it is difficult to do this in practice or their unconscious attitudes get in the way. Education can help people address their unconscious biases as well as the injustices in their own lives and in society. Social justice pedagogy aims to educate and enable students to become active citizens who understand social inequalities and can contribute to making society more democratic and egalitarian. To achieve that, systems of power, dominance, privilege or oppression may be critically explored with students and they may be encouraged to engage with processes of activism such as protests. Educators committed to social justice value people's unique experiences and perspectives and do their best to treat all students in a caring and dignified way. They advocate fair distribution of

learning resources and a commitment to methods that allow full participation by all. Social justice pedagogy stresses the importance of involving and engaging students in building the curriculum, rather than having a curriculum imposed on them. It may also involve paying attention to how sub-cultures, marginalised groups or under-represented people are portrayed in published learning materials and in the wider context of local and global media.

6 **Esports:** Esports, or electronic sports, are a form of competitive video gaming which is broadcast and played on the Internet, individually or in teams. Some esports can involve physical activity, such as when dance steps are projected onto a wall and players follow them on a special mat with foot-activated sensors. Esports have become a global leisure activity, but they also offer opportunities for education. They illustrate a way to reach young people and connect them to virtual sporting activities. This might induce growing interest to partake in sports themselves. Variations of esports have been used in school subjects such as physical education to support students' understanding of movement, different rules or techniques of sports and games, and as a teaching aid. They can also be a way to support digital literacy, numeracy, socialisation and teamwork. For example, data from the end of esports games could be analysed by the participants to suggest team strategies to improve performance. A well-known esports platform, Twitch, enables recording of group activity, interaction between teachers and learners, and opportunities for amateur online instruction among peers. Esports have become popular among those participating in the gameplay and the spectators watching the game unfold online. They could be increasingly combined with virtual reality to enhance the immersive and physical experience.

7 **Learning from animations**: Some topics are hard to teach, for example explaining how the heart pumps blood. Showing learners short animated movies of a dynamic process can reveal aspects that are too fast to follow, or too small or inaccessible to see. Animations can show how an expert tackles a difficult problem, such as solving a complex equation. They can also show abstractions from the real world, such as the growth of a city. They are useful in stimulating interest and promoting engagement. Learners with special educational needs can benefit from animations that explain an important idea clearly and succinctly, such as how to stay safe online. Learner-created animations are also a way to support self-expression and have been used as prompts for creative activities such as story writing. Some early research studies showed that animations were no better than textbook pictures, but recent research has focused on the conditions that make animations successful as tools for learning. Studies have shown that animations can be better than pictures when they are well-designed, based on sound principles, teach processes or skills, and students are in control.

8 **Multisensory learning:** Listening to a teacher and using our eyes, along with visual approaches such as looking at books and watching videos, used to be the primary means of perception for learning. Yet human beings have many senses, including touch, taste and smell. Multisensory experiences, in which several senses are stimulated, have become popular in entertainment, tourism and healthcare in recent years. For example, they are often a feature in amusement parks and in 4D movies in cinemas. Researchers believe that the next generation of services in health, well-being and tourism, as well as in education and training, will be multisensory. All the senses are currently receiving more attention in education, due to advancements in

technology-supported learning as well as growth in research with learners who have special needs, such as those who have severe reading difficulties. Evidence shows that stimulation of sensory channels and combinations of channels during learning can prove beneficial, resulting in learning gains and deeper understanding, as well as greater enjoyment. Multisensory teaching and learning can enhance communication, engagement, memorisation and understanding, though it might not be suitable for every learner.

9 **Offline networked learning**: Networked learning via digital networks is a widely adopted pedagogical approach since it promotes connections among learners, teachers, communities and resources. But using the Internet for networked learning is not always possible. Reasons include a lack of access, a desire for autonomy and a need for privacy. In many rural areas, developing countries, and spaces where access to the Internet may be purposely limited (for example in prisons), there are opportunities to use smartphones, tablets or laptops without a connection to the Internet. Enabling users to harness the power of these devices and take advantage of networked learning without the Internet has been made possible by low cost, low power network hubs like Raspberry Pis. This approach is called offline networked learning; it can support conversation, collaboration, resource sharing, visualisation and consolidation, thus enhancing the process of learning as well as the outcomes. For example, the approach has been used in rural Zambia to enable teachers to come together from different village schools to access digital teaching resources, share their own materials with other teachers during training workshops, and take selected materials back to their own schools. It is argued that the approach can help teachers to engage in the slow and complex thinking needed to find more effective ways of educating learners. Technical and digital skills capacity and competencies must be sufficient to enable a successful initiative.

10 **Online laboratories:** Laboratories are an important resource in scientific disciplines, enabling students to apply their knowledge and develop their skills. However, there are circumstances in which using a physical laboratory is not possible or not appropriate, for example when students are unable to come to a lab or when they need to engage with dangerous activities. In these cases, online laboratories provide a viable alternative. An online laboratory is an interactive environment for creating and conducting simulated science experiments. The lab could be accessed through the web or as a program running on a computer, either in the classroom or at home. The aim is for a student to experience the procedures of carrying out a science experiment, including the consequences of making mistakes, and to get results. Online labs can also allow students to interact with real scientific equipment in 'remote labs'. Despite concerns that some aspects of practical work such as the sights and smells of experiments in the physical laboratory are missing from the experience, virtual labs are becoming mainstream in higher education for science and engineering in many countries around the world.

Introduction

This is the eighth in a series of annual reports on innovations in teaching, learning and assessment. The Innovating Pedagogy reports are intended for teachers, policy makers, academics, and anyone interested in how education may change over the next ten years.

This report is the result of collaboration between researchers from the Institute of Educational Technology at The Open University (UK) and the National Institute for Digital Learning at Dublin City University. As in previous years, the process has involved sharing ideas, discussing innovations, reading research papers, reports and blogs, and commenting on each other's draft contributions. We worked together to compile this report by listing new educational concepts, terms, theories, and practices, then reducing these to ones that have the potential to provoke major shifts in educational practice. This 2020 report introduces ten pedagogies that either already influence educational practice or offer opportunities for the future. By 'innovative pedagogies', we mean novel or changing theories and practices of teaching, learning, and assessment for the modern, technology-enabled world.

When sharing these annual reports and through feedback from our readers we have increasingly become aware of the diversity of our audiences across the world. What seems to unite our readers is a desire to keep up with emerging trends and ideas in very fast-changing educational landscapes, and a wish to understand current or future impacts of the innovative pedagogies we describe. Some of our recent reports have been translated into other languages. This makes us even more sensitive to the need to write clearly, to make unfamiliar ideas accessible, and to examine our assumptions about how innovations that originate in one place may be perceived elsewhere. This is not always easy, but it is a welcome challenge!

Confronting ethical challenges

Our previous reports have made references to artificial intelligence (AI), but over the past year growing interest in this topic has been reflected in news stories, international meetings, publications and discussions on social media. In this report we dedicate a section to **artificial intelligence in education**, and AI is also a major theme in our section on **posthumanist perspectives**, where we explore the idea that humans are not necessarily central to everyone's world view. In many societies people have concerns about computers acting in ways that imitate humans to the point where it is very difficult (and soon perhaps impossible) to distinguish between people and machines. People do not always understand how the technology really works. In education, gaining and sharing understanding is all-important. Pedagogical innovations therefore need to support understanding by guiding students in how to analyse emerging issues around technology, how to formulate challenging questions, and how to examine different perspectives.

Debates around AI increasingly focus on what is unique to humans that we need to preserve and perhaps amplify. It is often argued that critical thinking and creativity are uniquely human. Aspects of communication and collaboration are also (still) uniquely human, such as the ability to appreciate a humorous remark, or to work towards a solution to a problem by conducting several conversations across multiple media.

Humans are also needed for activities such as defining core values, identifying ethical concerns and setting standards in respect of how computers should be used. A contemporary concern is how data about ourselves and our online behaviours is stored and shared. In the section on **engaging with data ethics** we highlight a range of ethical questions and practices around the issue. How can this topic be brought to life for students? An experiential approach might work well here – for instance, helping students to attempt to track in detail what happens when they share personal data or allow applications access to it. We need more experts in this field to develop engaging learning activities of this kind that any teacher would feel confident to undertake with their students.

Students can also build their understanding of data ethics by **learning through open data**. As outlined in our report, many organisations now make their data openly available so that it can be used by the public and educational institutions. This can be a basis for the development of stimulating learning activities that relate closely to students' interests and perhaps their desire to understand how organisations work or their impact on the environment and on society. Analysis of open data might reveal some biases or injustices that would not have been noticed otherwise. The aim of **social justice pedagogy** is to raise awareness of social injustices, biases and inequalities, and enable students to act on addressing these issues. Teachers might allow students to contribute to the design of their curriculum or produce content that explores and reflects on their own perspective, or the views of a marginalised or misrepresented group of people. The approach is based on ideas of consciousness-raising and active involvement. They may not sit comfortably within educational systems and structures that emphasise a set curriculum and formal assessment.

Engaging multiple senses

Pedagogical innovations can originate within educational institutions, companies and organisations, but often they arise outside of these settings. Leisure activities are one example of how knowledge about how such activities are organised and who participates in them can lead to new ideas in pedagogy. This has been the case for a form of competitive video gaming played on the Internet, known as esports. **Esports** are a global leisure activity, yet the online platforms supporting it provide facilities that can be used in educational ways, or that already support informal education offered by amateurs to a global audience. Esports engage participants in a variety of ways, stimulating their senses and connecting with a global and social network. They also appeal to large numbers of spectators viewing the games online. The addition of virtual reality (a three-dimensional image or environment that allows a seemingly real or physical interaction) typically when a person is using special equipment such as a helmet with a screen inside or gloves fitted with sensors, can enhance the immersive and physical experience of these games.

We can imagine that in the near future these virtual reality environments will involve more human senses, particularly smell and taste. As outlined in this report's section on **multisensory learning**, education has traditionally involved listening, looking and watching, but there is growing interest in designing learning activities in which several senses are stimulated. Learners who have special educational needs are among those who can benefit from such multisensory experiences, as these support processes such as memorisation and understanding. For similar reasons learners can also benefit from **learning from animations**, a pedagogical approach that enables them to see important

processes close up or in slow motion, with the ability to be in control of the viewing. Sounds and other sensory experiences could be part of the animation, although a simple approach that does not overload the learner may be best. Design principles are available to help teachers and developers engage in designing animations for learning.

Overcoming barriers to learning

Our final two pedagogical innovations are concerned with overcoming barriers to learning while also connecting people and enabling them to collaborate. On the one hand, to combat lack of internet access or prohibitive costs of using the internet, **offline networked learning** offers an approach based on low cost, low power network hubs that enable teachers and students (or any other participants) to connect with each other and share resources via their mobile devices. On the other hand, taking advantage of the power of the internet to overcome barriers of distance, **online laboratories** enable students to participate in and undertake laboratory experiments without having to be in the lab. This is important for distance education, but it is also a step forward in terms of enabling all students and scientists to collaborate internationally. For now, the sensory aspect of lab work is not an integral part of this approach, so for example students are not using their sense of smell; however, in future even that will likely be possible.

Artificial intelligence in education

Preparing for life and learning in the age of AI

Potential impact: High
Timescale: Ongoing

Artificial Intelligence (AI), the use of computers to do tasks that normally require human intelligence, seems to be rarely out of the news, with technical advancements and novel applications being announced almost every day. In fact, in many contexts, AI is already a part of life. Many of us happily talk with AI agents (such as Siri or Xiao-i), we play with apps that allow us to age or swap faces in photographs (such as Face Changer or Zao), or we enjoy personalised recommendations (such as in Netflix or QQ Video).

Artificial Intelligence has also quietly entered the classroom. AI-powered learning systems are increasingly being deployed in schools, colleges and universities, as well as in corporate training around the world. While many fear that AI in education means robot teachers, the reality is less dramatic (robot teachers remain unlikely) but potentially still transformative.

AI is impacting on educational contexts in many different ways – most of which may usefully be grouped as either learning *for* AI, learning *about* AI, or learning *with* AI.

Learning *for* AI

AI-driven automation is likely to impact on all of us. This might involve AI-driven innovations in transportation (e.g. self-driving vehicles), in medicine (e.g. the automatic analysis of medical images), or in employment (it is likely that many jobs will be replaced by AI-powered automatic systems).

The multiple uses of AI also raise a number of ethical questions. These include:

- Bias (e.g. some AI-powered recruitment systems have been shown to be biased against women).
- Privacy (e.g. when we are simply going about our lawful business, is it right that our faces are automatically recognised and compared with faces in a database of criminals?).
- Fake news (e.g. AI-systems that automatically write untrue stories to influence the outcomes of elections).

All of us need to better understand AI ethical issues, as well as the wider potential impact of AI on society, which is increasingly a pedagogical responsibility for schools, colleges and universities.

However, helping students learn how to live effectively in a world increasingly impacted by AI also requires a pedagogy that, rather than focusing on what computers are good at (e.g. knowledge acquisition), puts more emphasis on the skills that make humans uniquely human (e.g. critical thinking, communication, collaboration and creativity) – skills in which computers remain weak.

Learning *about* AI

As well as preparing people for living with AI, schools, colleges, universities and corporate training organisations also have a role in training the AI engineers of the future. This begins with young children, for whom there are already a wide range of tools to help them learn to code software (such as Scratch), which is necessary for learning how to develop AI tools. However, learning to code is only the start of it.

All Artificial Intelligence depends on an in-depth understanding of some mathematics and statistics. This is especially true of the AI approach known as 'machine learning' that has recently achieved such rapid progress. Machine learning involves the statistical analysis of massive data sets in order to automatically identify patterns and make predictions. For this reason, if they are to train tomorrow's AI

professionals, schools, colleges, universities and corporate training organisations need to provide lots of opportunities for students to become skilled in mathematics, data analysis, and statistics (in addition to coding). A type of machine learning known as 'artificial neural networks' (which are inspired by the human brain) is the core technique behind well-known AI successes such as automatic language translation (e.g. Google Translate or Mr. Translator) and automatic face-recognition (e.g. in apps like WeChat and Facebook) as well as the AI behind the defeat of the world's best human player of the ancient Chinese game 'Go' (which was achieved by the AI system AlphaGo).

Learning *with* AI

Developing AI tools to support student learning has been a focus of academic research for more than thirty years. However, only relatively recently have these tools become easily available as commercial products, partly thanks to the machine learning techniques mentioned earlier. Although there are many overlaps, it is useful to categorise learning with AI into applications that are system-facing, student-facing, or teacher-facing.

System-facing applications of AI

By system-facing applications of AI we mean tools that are designed to support an institution's administration functions. For example, this might include AI to support marketing or finance, to predict student numbers, or to analyse students' use of the institution's virtual learning environment (perhaps to identify students at risk of dropping out). It is likely that these uses of AI in education will increasingly impact on students (e.g. when applying to universities or seeking support) and teachers (e.g. when monitoring student progress).

Student-facing applications of AI

Most AI in education research over recent decades has focused on developing student-facing applications, in particular AI-powered tools known as intelligent tutoring systems (ITS). ITS present students with some information, a related learning exercise and often a quiz or test. Having closely monitored the student's interactions and responses, the ITS then adapts the next set of information, exercise and quiz to the student's individual strengths and weaknesses. In short, ITS adopt an instructionist pedagogy. Each student proceeds step-by-step along a learning pathway that is automatically personalised for them.

This personalised approach is promoted as being more effective than standard classroom practices (in which students progress through the same materials together and at broadly the same pace), although there remains insufficient evidence to support this view. Furthermore, a typical ITS personalises only the learning pathways and not the learning outcomes. The aim is still for everyone to learn the same materials, often to pass examinations, while little attempt is made to enable students to develop their personal aims or individual interests. Meanwhile, ITS also reduce human contact between students and with teachers. In short, typical ITS make various pedagogical choices with important ethical implications.

There is a rapidly increasing number of commercial ITS available, that any educational or training institution can purchase and implement. However, most are designed for school students and cover only mathematics and other clearly delineated subjects rather than the arts or humanities.

Two alternatives to ITS are dialogue-based tutoring systems and AI-enabled exploratory learning environments:

Dialogue-based tutoring systems (DBTS) adopt a Socratic pedagogy, which means they are designed to engage the student in a conversation, written or sometimes spoken, using questions to guide them towards an understanding of the topic being studied. However, DBTS also only personalise the learning journey not the outcomes. Currently, there are very few commercially available DBTS.

AI-enabled exploratory learning environments (ELEs), on the other hand, adopt a constructivist pedagogy, which is to say that they provide more open opportunities for the student to explore a topic and to construct

their own understandings. However, although exploratory learning can be very powerful, it usually does not work well without guidance. In an AI-enabled ELE, it is the role of the AI to provide appropriate guidance in the form of automated feedback[6]. ELEs are not yet commercially available.

Another student-facing application of AI is automatic writing evaluation (AWE), which may be summative or formative. Automatic summative grading of essays, especially for standardised testing and university entrance, is becoming very common, despite limited evidence for its accuracy. In classrooms, on the other hand, most teachers would be happy to save hours of marking each week. However, this misses the fact that marking can be one of a teacher's best opportunities to learn in depth about their students' capabilities. Formative AWE, on the other hand, can be very effective, by providing students with useful feedback on their writing (e.g. ways to improve the text's structure or use of language) so that they might enhance it before submitting it for summative assessment.

A final example of student-facing applications of AI are chatbots (computer programs designed to interact with human users in a conversational style), which are being widely deployed to support students outside the classroom. They might give students live information about their timetables, remind them about homework, or suggest how they might use their free time productively.

Teacher-facing applications of AI

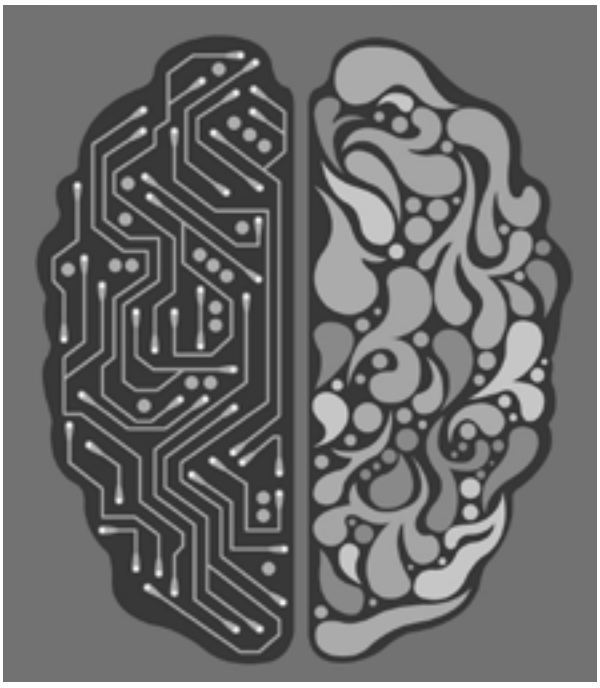
Most AI in education research and products are student-facing and are designed to replace some existing teacher tasks. If this continues, while in the short run it might relieve some teacher burdens, it will inevitably lead to teachers becoming side-lined or de-professionalised. In this possible AI-driven future, teachers will only be in classrooms to facilitate the AI to do the 'actual' teaching.

A more exciting possibility are teacher-facing applications of AI designed to support teachers to enhance their own teaching. Perhaps such an AI teaching assistant will give teachers smart access to relevant information (either related to the subject they are teaching or about their students) or will help them manage their classroom more effectively (perhaps by automatically suggesting groupings for collaborative learning activities, taking into account the many student factors that the teacher considers important).

Conclusion

In this brief introduction to the application of AI in education, we have begun to consider the potential, as well as the social and ethical implications. Nonetheless, what is clear is that the topic of AI in education is too important to be left to engineers and entrepreneurs. Instead, it is critical that educators, learning scientists and other stakeholders engage, to ensure that the AI applied in educational contexts best supports the learners, the teachers and the learning.

> "while many fear that AI in education means robot teachers, the reality is less dramatic but potentially still transformative"



Artificial intelligence

Resources

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Posthumanist perspectives

Confronting the relationship between humans and technology

Potential impact: Medium
Timescale: Long (5+ years)

What is posthumanism?

The meaning of being human and our relation to the world around us is naturally of great importance to any conception of education. The role of human beings in global crises, from climate change to extinction, is under increasing focus. If we accept that the concept of learning has evolved from a basic conception centred on the transformation of an individual from one state to another, then we should also consider how in the process of learning we connect to and engage with the wider world, and how it connects with us. Posthumanism is the idea of moving beyond viewing humans as being at the centre of everything and considering how humans fit within a wider spectrum of existence. The traditional philosophical divide between human beings and nature, central to many hundreds of years of debate, seems lessened on a planet which appears to be changing radically because of human actions and despite efforts to mitigate their consequences.

Technological advances also blur the line between humans and the material world. Chatbots such as Amazon's Alexa (a computer program that answers questions and delivers services through simulated conversations on a smart home device) are designed to sound like a human being and to evoke conversational responses from its users. In the area of healthcare, robot 'nurses' are starting to provide support to patients. They do not replace human caregiving, yet humans seem to be capable of forming very real attachments to robots. Take the example of Zora, a French nursing robot:

"Staff members have been continually surprised by how attached patients have become. One nurse… said some patients get jealous of others spending time with Zora. Patients have told the robot things about their health they wouldn't share with doctors."

"It puts some cheerfulness in our lives here," says Marlène Simon, 70, who has been in hospital for more than a year. "We love her, and I miss her when I don't see her. I actually think about her quite often." (New York Times, 2018[13]).

In popular culture there are examples of a creeping anxiety that humans may be increasingly difficult to distinguish from advancing forms of technology. Fictional worlds in movies such as *Blade Runner 2049*, *Her*, and *Ex Machina* challenge us to consider what makes us human, and how thin the line is, or might be, between ourselves and other forms of intelligence or forms of life. The 'other' forms of life could be modified humans – already in the 20th century the idea of a 'cyborg' (a human being with mechanical parts) ignited people's imaginations with ideas of how a person could have some new physical or mental abilities beyond what humans are capable of. Nowadays there are discussions around implanting microchips in humans which could enhance people's lives, but which could also have negative consequences for people and society.

Posthumanism and education

The potential of adopting a posthumanist approach to education lies in asking the provocative question of what students can learn from confronting these unsettling ideas of a less well-defined separation between humans and technology. Key questions might be:

- How should we perceive our relationship with nature, given our extensive control over, and engineering of, the environment?

- What is our relationship with other animals, and are we very different from that which we eat, sell, care for, and co-exist with in this world?
- What is the relation of our 'authentic' selves to how we present ourselves to the wider world through social network technologies?

By moving away from the idea of human experience being focal and dominant, posthumanism asks us to reconsider the limits, and in many cases the arrogance, of humanist assumptions. It challenges us to consider ourselves as an inseparable part of a greater whole, as beings that are influenced by (and have an influence upon) the rest of existence, both personally and collectively as a species.

Practical examples to consider from a posthumanist viewpoint are the implications of the use of robots and artificially intelligent tutors as a means of assisting both teachers and students. Driven by economic and social concerns such as the potential for individual instruction through the use of personalised AI, computers and robots are being used experimentally as a means of "supporting learners". The posthuman concern is not whether such tools are useful or not, but rather the issue of blurring the distinction between humans and technologies. In Japan[17], for example, a concerted effort has been made to develop robots which can assist in classroom instruction, with over 500 expected to launch in language classes over the next year. In Finland[16], such robots have been used to provide friendship and camaraderie.

Principles and practice for a posthumanist pedagogy

As a relatively complex concept with strong philosophical grounding, the precise means by which a posthuman perspective can be incorporated into teaching and learning is challenging. Many posthumanist concerns may still seem futuristic or implausible. However, others are already rooted in current educational practices and perspectives such as post-colonialism (see 2019 Innovating Pedagogy report for 'Decolonising learning') and feminism. For example, from a feminist perspective the commonly accepted idea of a stereotypical human being in many societies might exclude human beings who are not white, masculine, wealthy, healthy and heterosexual. This then influences the debate about what it means to be human.

Many opportunities for research and exploration exist for teachers and researchers, such as considering the impact of robot instructors upon students: how such instructors are perceived, and why they are accepted or rejected by various student populations. An interesting recent example was Georgia Tech's usage of an AI teaching assistant, 'Jill Watson'[18]. Jill Watson was introduced as a means of reducing the load on human tutors of large numbers of easily-answered questions being asked by students. Jill took time to learn from interacting with students and offered some 'strange' answers initially. Yet ultimately for the majority of students who asked questions, Jill was indistinguishable from a tutor.

The rise of social media, avatars (moving figures representing people) and other technological innovations in education presents rather profound questions as to precisely how students should relate to these new forms of instruments and technologies. Avatars can include cartoon instructors that can be customised (as an example, see Voki.com[14]); teachers can create avatars in their own likeness, which students (who can also create such avatars) interact with, listen to and respond to. Much educational research has focused on the relative effectiveness of such methods and technologies, but from a posthumanist viewpoint their use may also affect the dynamic relationship between teacher and student. So far, we have limited evidence of how students will relate to such avatars: is the avatar a distinct being, a representation of the instructor, or something in-between?

A posthumanist pedagogical perspective would also suggest asking students to consider these

problems directly, through questions such as:

- What principles can help distinguish increasingly-intelligent or representational forms of teaching assistant from teachers, students, and from the world around them?
- What is the role of the teacher, the student and perhaps even the human being, within a more complex world consisting of social, material and artificial elements, all interacting and perhaps inseparable from one another?
- Does the work completed on our behalf and for our benefit by non-human instruments change the nature of knowledge and knowing?
- When a student uses smart tools to speed up substantially the process of writing an assignment, what are the long-term effects of such actions on the student, the learning process, or education?

Looked at more broadly, anxiety and activism in the field of climate change, such as the school strikes movement pioneered by the Swedish teenager Greta Thunberg, provide evidence that questions of our relation to, and effect upon, the world are topical for the younger generation.

> “The real challenge for the future is understanding and defining what is real, and what it means to be real”

Traditional science fiction has written of the future as a bountiful and boundless world, with floating cars and interplanetary travel, but it may be that the real challenge for the future is understanding and defining what is real, and what it means to be real. A posthuman approach can provide a framework from which these questions can be considered, in a critical and constructive manner.

Conclusion

Posthumanism moves us beyond regarding humans as the central point of reference, towards perspectives which give more prominence to our relationship with the physical world and the increasingly dominant role of technology. An incessant drive towards technology adoption in education has left unanswered many deep questions regarding the actual functions of such technology and its relationship with the people who spend so much time with it, and are therefore shaped by it. Adopting a posthumanist approach in education means confronting some unsettling ideas around less-well-defined separation between humans and technology, with the aim to enrich our understanding of ourselves and our world.

Our relation to the world around us

Resources

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Learning through open data

Using real-world data for personally relevant learning

Potential impact: Medium
Timescale: Medium

In many countries, a wide range of interesting data sets are available in the public realm with open licences that allow them to be used and repurposed for learning. More than 250 national, local and city governments, and a growing range of global and local organisations are now sharing the data that they create and use in their work (World Bank, 2017[27]). There is the potential for this 'open data' to be visible and usable by citizens, and many of these organisations are keen to see it used by the public. There are increasing possibilities to make use of it in education.

What does open data offer as material for learning and teaching? A key asset is authenticity. The data that is shared emerges from real processes occurring within important organisations. It is often data that is used in professional work that has a real impact on our lives and the world around us. The data can be very insightful, and it can be a starting point to understanding society by exploring how the data is produced, and the real world that it relates to. A second aspect of open data is its potential relevance to learners and their personal interests. Finally, open data can offer opportunities for making a difference in the world around us: learners can identify issues through data that have relevance to local or even global communities.

Engagement with authentic data and real-world issues

Given the opportunities to use authentic, real world data there is an increasing onus on educators to use it in their teaching rather than imagined examples, making education meaningful and relevant to real world issues, rather than a more contrived activity.

There have been great opportunities in education for students to engage with data via pedagogies that focus on solving or interrogating real world problems. Many governmental bodies provide open data which students of civics and politics have used to interrogate and explore issues of governance and accountability. This allows students to build critical skills, and to engage with and impact directly on political debates. Census datasets can inform subjects from statistics to sociology.

A good example is A Scuola di OpenCoesione[25], an Italian initiative which guides high school students to explore data on public funding awarded to building projects around their country and to develop projects that collaboratively evaluate the outcomes of the funding. Through this they learn about local politics and economics, and develop important skills by engaging with the people and documentation involved in these projects.

Another initiative, the School of Data[26], focuses on creating impact by teaching journalists, civil society organisations and activists to be able to use open data effectively in their work. They support 'data expeditions' to explore important questions using open data sets. However, because all the data needed to answer the questions may not always be openly available, they also encourage the collection and sharing of new data.

The trend towards open data is also reflected in 'open science', where open access to data can support reproducibility of research results, transparency and accountability. Learning with open data is also an important way to help build contemporary scientific literacy in all students such that they can be informed and engaged citizens.

Scientists working via 'citizen science' initiatives, in which the public help create data (for example, by sharing images of the night sky from their location), can publish their datasets online in publicly accessible formats

that can be used in classrooms. In this way, a culture of sharing and engagement develops between educational and professional settings.

While data collection is a skill that many students should learn, constraints on time, location, or resources often mean that students cannot collect data themselves. Using open data made available by researchers enables more advanced inquiries and avoids artificial textbook examples.

Creating personally-relevant learning with shared data sets

While open data can be 'big data' (consisting of very large data sets), it can equally be very local and offer new ways to look at places or issues that are important to learners. This has a strong motivational potential for learners who may want to understand what is happening in their local community, or how they or their class compare with others nearby or far away.

Learners around the world can combine their local knowledge and share a learning experience in the same activity. For example, the activity can involve interpreting data about their countries' educational statistics or health and comparing it to others. This type of activity is particularly suited to learning at scale through MOOCs (massive open online courses) or participation in citizen inquiry initiatives that enable widespread involvement in science and empower citizens by helping them develop the reasoning and problem-solving skills used by scientists.

Kaggle[22] is an example of a data science platform and global community that combines open data sets and machine learning (computer programs that build models from data). It facilitates programming competitions and challenges, and is for anyone who has access to the platform. Individuals and teams can tackle ambitious problems with potential real world impact such as improving airport security or optimising the design of educational media to help children learn.

Exploring how data is produced

Challenges

Some of the challenges and requirements for using open data in learning are similar to those found for using big data in inquiry learning (see 2017 Innovating Pedagogy report). These include the development of data literacy skills and understanding the reliability and provenance of the data. Activities must be matched to the learners and the data available may put some constraints on this. Specific challenges with open data are often dependent on who has shared it and whether learning or public engagement has been considered as possible use cases. Open data has not necessarily been designed or released with these uses in mind. If activities are designed with awareness of the data source, then these challenges can become part of the learning.

The large volume of open data sets now available can be overwhelming and educators can struggle with where to start. Google[23] recently released its Dataset Search Engine as a service dedicated to cataloguing open data sets worldwide and making them easily searchable.

Issues of data privacy are an ongoing concern. Care and expertise must go into the creation of open data sets to ensure that people cannot be identified even after it has been anonymised. A notable case was that of an open data set of anonymised Facebook[28] activity of students in an unnamed university in the United States. Clues hinted that the university might be Harvard, and through further examination of metadata in the data set the actual identities of individual students could be discovered.

The most mature open data services offer well documented data and additional resources to encourage learning with their open data. Some have helpful tools for basic exploration of the data built in to their websites. However, many other open data sets require substantial work before they can be used with students who do not have advanced skills in the use of data. There is work for educators and students to do if the full range of open data is to be suitable for educational purposes.

In order to overcome barriers to using open data and engage the public, educators should collaborate more to share useful pedagogical examples from their practice. More collaboration is also needed between educators and data providers to highlight the availability of data sets and the powerful potential ways they can be used in education.

The same Gapminder[24] tools used here by Hans Rosling to give a keynote presentation are openly available and allow easy exploration of international data sets, in order to make comparisons and see changes over time

Conclusion

Because it is drawn from real world sources and reflects real issues, open data can provide an authentic basis for learning activities. The breadth of available open data creates opportunities for personal relevance, as learners could find data about their local area, compare their country or region with the rest of the world, or explore an issue that they really care about. Engagement with open data connects learners with a societal movement to encourage greater data literacy, transparency and evidence-based action.

> “ a culture of sharing and engagement develops between educational and professional settings ”

Resources

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20. An interview study of educators who use open data in their teaching, including the opportunities and challenges they see in using open data: Coughlan, T. (2019) *The use of open data as a material for learning,* Educational Technology Research and Development, [Online]. Available at: **https://link.springer.com/article/10.1007/s11423-019-09706-y** (Accessed: 26/11/19).

21. A free short course aimed at teachers, provided by European FOSTER project: *Use Open Data in Teaching* **https://www.fosteropenscience.eu/learning/use-open-data-in-teaching** (Accessed 26/11/19).

22. A wide range of open data sets are shared on Kaggle: **https://www.kaggle.com/datasets**

23. Open data can be found using Google Dataset Search: **https://toolbox.google.com/datasetsearch**

24. Gapminder provides resources for teaching and learning using openly-licenced international data sets: **https://www.gapminder.org/**

25. A Scuola di OpenCoesione provides a structure and resources for school teachers and students to learn through projects that explore the use of public funding: **http://www.ascuoladiopencoesione.it/**

26. School of Data work to develop awareness and engagement with open data through online courses, fellowships, and local workshops: **https://schoolofdata.org/**

27. The World Bank offer a short introduction to open data and a toolkit of further resources:
The World Bank (2019) ‘Open Data in 60 Seconds’, *The World Bank,* [Online]. Available at: **http://opendatatoolkit.worldbank.org/en/open-data-in-60-seconds.html** (Accessed: 27/11/19).

28. Article describing the ethical and practical challenges of releasing open data of a personal nature through an example of a data set released of Facebook profiles: Zimmer, M. (2010). ‘“But the data is already public”: On the ethics of research in Facebook’, *Ethics and Information Technology,*12(4), 313–325. doi:10.1007/s10676-010-9227-5.

Engaging with data ethics

Ethical use of data in digital life and learning

Potential impact: Medium
Timescale: Ongoing

The growing use of digital technologies in educational contexts is accompanied by an ever-increasing range of ethical questions concerning matters such as people's rights to privacy, online safety and fair treatment, as well as their evolving obligations and responsibilities.

Ethics is defined as "a system of fundamental principles and universal values of right conduct" (Ifenthaler & Schumacher, 2016[32]) and as a way of evaluating actions by making judgements about what we and others do. 'Good' ethical practice may be enshrined in codes of ethics and codes of conduct to be followed, but ethical decisions are also made dynamically in response to circumstances. As new and complex technologies increasingly pervade all aspects of life, there are more situations in which timely ethical responses are needed. That is particularly the case in relation to systems that collect and share data about people and their online behaviours. 'Data ethics', an emerging branch of applied ethics, considers the value judgements we make and the actions we take when generating, analysing and disseminating such data.

Big data and citizens

With the rising use of technology and extensive collection of 'big data' (large volumes of data) by organisations and governments alike, many people are concerned about the implications. For example, the fact that personal data may be shared across computer systems and online platforms leads to questions such as who owns the data, how the data may be interpreted, and how user privacy should be protected. Data from various sources, such as health, social media, and education may be linked and on that basis, conclusions may be drawn about individuals or groups.

As covered widely in the media, there is an increased alertness that companies, organisations, and governments are actively analysing, mining, and combining data either with, or without, the permission or awareness of users. Recent incidents of 'data harvesting'

Surveillance

(companies obtaining user data from online platforms or apps and using it for their own commercial purposes) have highlighted that users of digital media have been profiled without their awareness of this taking place. If we believe that people should determine for themselves when, how, and to what extent information about them is communicated to others, then such practices are ethically unacceptable.

In the well-documented Cambridge Analytica scandal[31], Facebook handed data from 87 million users over to this company. Cambridge Analytica used Facebook and other consumer data to psychologically profile individuals. This data was subsequently used to profile voters for elections, and micro-target specific news feeds and advertisements matching their psychological profile. Apparently even individuals who did not have a Facebook account could still be psychologically profiled, as many websites include Facebook logos and cookies, that also allowed non-Facebook members to be tracked. As argued by Isaak and Hanna (2018, p. 58)[31].

"The public must be able to learn the types of data being collected by any website or other electronic means, what data is retained, how it is used, and what is shared with third parties (directly or indirectly). The same information must be available from those third parties."

Several recently reported data leaks of customer data from Sony and British Airways, and foreign governments actively "influencing" beliefs and political views by using social media data have highlighted that even when people may be aware of the benefits and risks of their online and offline presence, data techniques are commonly used to profile people with and without their awareness.

All citizens should understand the emerging ethical issues, but there is a special moral responsibility to engage with them widely in education – to identify, understand and debate the issues, and to propose actions to address them.

Ethics in education and digital learning

Schools and other educational institutions instil values in their students and support moral development. The use of digital technologies in life and learning has introduced many new scenarios and ethical dilemmas that need to be considered, for example how to deal with issues arising from use of social media in education. At Maastricht University in the Netherlands students are given formal lessons in social media technology and the benefits and risks of their public profiles, yet at most institutions there is still no formal training for students or teachers in these matters. In cultures where there is 24/7 social media use, knowing how data is used and understanding the ethical and privacy implications is more vital than ever before.

In the early days of the Internet, guidelines for good online conduct and communication were developed in the form of rules of 'netiquette', and these were quickly adopted in educational settings. Later, there was interest in defining acceptable use and sharing of online resources. In the current era of 'big data', students need to better understand how their data might be used and the possible consequences; for example, a university might be capturing how often students access their Virtual Learning Environment (VLE) or tracking their online interactions with other students. Ethical questions include who owns the data from learners and teachers, who can and cannot use this data, and why.

Engaging with ethics can help institutions develop new learning cultures in the digital age. This begins with discussions about relevant open questions, such as the following:

- What is the role of educational institutions in protecting students' privacy?
- How should ownership of data be decided and by whom?
- How should teachers and students learn about how to work safely online?

Educational institutions deal with ethical issues in unique ways. For example, The Open University, UK (OU) publishes its policy

on ethical use of student data for learning analytics (i.e. the collection and analysis of data generated during the learning process in order to improve the quality of learning and teaching) and obtains consent from students to use and analyse such data. It explicitly does not analyse data from third-party systems like Facebook, even though students actively use these systems to share their educational experiences. Global guidelines for ethics in learning analytics have recently been launched by the International Council for Open and Distance Education, building on initial experiences from the OU.

Teaching how to engage with ethics

In most ethics courses and module units taught in higher education, ethical instruction typically focuses on the legal component of ethical dilemmas. Legal aspects have been widely researched, however much less is known about how students can move from understanding ethical principles to adopting appropriate attitudes and behaviours.

One way to prepare learners for a changing world of ethics and privacy is (perhaps controversially) to embrace digital technology. For example, at the University of Technology Sydney a MOOC (massive open online course) on connecting your student data allows learners to play with their own data and learn what the limitations of sharing may be. By working with data and discussing different practices, learners are actively engaged with ethics in a digital environment.

Similarly, a range of MOOCs provided by the University of Michigan on Data Science Ethics and Privacy, Reputation, and Identity in a Digital Age, provide opportunities to learn how to effectively engage in a global connected world. An additional added benefit of these kinds of MOOCs may be the opportunity to learn from diverse, cross-cultural perspectives on fairness, privacy, and ownership of data, as many MOOCs have learners from across the globe and enable them to work together.

> “In cultures where there is 24/7 social media use, knowing how data is used and understanding the ethical and privacy implications is more vital than ever before”

Conclusion

With the rise of digital technologies and data mining from large organisations there is increased pressure on educational institutions to start to develop policies and effective training, and support teachers and learners in how to deal with the complex ethical and privacy concerns. As highlighted in this section (and in the section on AI in Education in this report) there is an emergence of good practice across the globe showing how educators are trying to teach students to become good digital citizens. However, many of these initiatives seem mostly on a small scale, and often focus on legal narratives rather than moral imperatives. Teachers and other education practitioners can actively engage their students with ethics by presenting authentic case-studies and giving opportunities for active discussion, ideally with people from different cultural settings and backgrounds. Only by engaging with ethics can we learn that our own mindset might not necessarily be shared by others.

Resources

29. Short article in the Stanford Encyclopedia of Philosophy: Sullins, J. (2019) 'Information Technology and Moral Values', *The Stanford Encyclopedia of Philosophy,* vol. Summer 2019 [Online] Available at: **https://plato.stanford.edu/entries/it-moral-values/** (Accessed: 26/11/19).

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31. Critical review of privacy and user data following the Cambridge Analytica data harvesting revelations in 2018: Isaak, J., & Hanna, M. J. (2018). 'User Data Privacy: Facebook, Cambridge Analytica, and Privacy Protection', *Computer,* 51(8), 56–59, [Online]. Available at:**https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8436400** (Accessed: 2/12/19).

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36. Global Guidelines on Ethics in Learning Analytics, from the International Council for Open and Distance Education (ICDE): ICDE (2019): *Global guidelines: Ethics in Learning Analytics, Oslo,* [Online]. Available at: **https://www.icde.org/knowledge-hub/the-aim-of-the-guidelines-is-to-identify-which-core-principles-relating-to-ethics-are-core-to-all-and-where-there-is-legitimate-differentiation-due-to-separate-legal-or-more-broadly-cultural-environments** (Accessed: 26/11/19).

37. Introduction to a special issue of the academic journal 'Studies in Philosophy', Philosophies of Digital Pedagogy: Lewin, D. & Lundie, D. (2016), 'Philosophies of Digital Pedagogy', *Studies in Philosophy and Education,* vol. 35, no. 235 [Online]. Available at*:* **https://link.springer.com/article/10.1007/s11217-016-9514-7** (Accessed: 26/11/19).

Social justice pedagogy

Addressing injustices in lives and society

Potential impact: Medium

Timescale: Ongoing

Social justice pedagogy is founded on the idea that education can be liberating and can help people address injustices in their own lives and in society. It aims to educate and enable students to become active citizens who understand social inequalities and can contribute to making society more democratic and egalitarian. To achieve that, systems of power, dominance, privilege or oppression may be critically explored with students. They may also be encouraged to engage with processes of activism such as public conversations, dialogue, protests, vigils, community events or voting.

Background

In the 1970s Brazilian educator Paulo Freire proposed a 'pedagogy of the oppressed'. He described how people who were marginalised or exploited should develop their critical powers and ability to engage in dialogue, so that they could identify and start to address the problems or challenges they saw around them in their daily lives and work. Freire believed that teaching and learning are political acts. Social justice pedagogy follows this tradition as it is concerned with injustices in the modern world. For example, it may be argued that injustices arise from the effects of global warming, since an increase in floods, droughts, heatwaves and cyclones leads to poverty and disease that mostly affect those who are already worst off in the world. Another common injustice is that people from economically disadvantaged backgrounds tend to have less access to education and their aspirations remain unfulfilled. Similarly, girls and women across the world are less likely to have opportunities to participate in education, which limits their choices in life and work.

Social justice pedagogy has its foundations in 'critical pedagogy' which is based on the premise of examining how knowledge is produced and by whom, and to question dominant opinions and assumptions. We might question a commonly held perspective on an issue and find that a different perspective emerges when newly discovered factors are considered; for example, assumptions about widespread educational opportunities may be questioned when such opportunities are found to be limited for people from a certain ethnic background. In addition, working with groups or communities whose views had not previously been taken into account may create greater awareness of issues alongside positive actions for change.

Strategies and benefits

Educators committed to social justice do their best to treat all students in a caring and dignified way and to value people's unique experiences and perspectives. They advocate fair distribution of learning resources and a commitment to methods that allow full participation by all. Social justice pedagogy stresses the importance of involving and engaging students at various stages of the curriculum-building education process. For example, if teachers construct a curriculum together with students, the students' voices can be heard, and it is more likely their needs can be met. Learning about who your students are in terms of their respective communities or cultures and embracing what your students already know by implementing it into the curriculum allows teachers to build new knowledge alongside their students.

In higher education and teacher education, exploring curricular theories from the likes of John Dewey (philosopher and educational reformer) or bell hooks (feminist and social activist) can be used to better understand ourselves and each other. Through exploring theories students begin to come to terms with the ways that their own educational experience may have been oppressive, while thinking

through solutions for not repeating such cycles once they step into the classroom.

If a social justice issue is the focus of the class (for example, exploring growing up in a culture of white supremacy), then another specific strategy to encourage student participation is appropriate self-disclosure on the part of the teacher, who sets the scene for a discussion by recounting a relevant personal experience, their reaction to it, and modelling how they were able to reflect on that experience. By being honest about who you are and encouraging students to question everything (including your teaching), makes it more likely that students will be willing to open up about their own experiences, feelings and thinking processes. This leads to greater engagement and contribution on their part, which in turn can enhance understanding. However, this has to be done in a very safe educational environment, for the sake of both teachers and students.

Examples from practice

In an example of a mathematics lesson that made links to social justice pedagogy, a class looked at how neighbourhood resources were related to income. They were asked to find the number of grocery stores within a 2-mile radius of certain schools. They then considered the implications of their findings, e.g. whether more grocery stores could mean it was a wealthier neighbourhood with more available food choices to the populations living there. In an example of practice in the language classroom, social justice can be addressed though discussion of themes such as national stereotypes or language learning opportunities for children around the world.

Apart from highlighting social issues, a social justice approach can also give more power to the learners. In one example, a college teacher in a Communication department told the class that the students would be doing some of the teaching: the students brought their knowledge and lived experience of hip-hop culture, while the teacher supported this by providing relevant academic readings and theory about hip-hop.

Social justice pedagogy may also involve paying attention to how sub-cultures, marginalised groups or under-represented people are portrayed in published learning materials and in the wider context of local and global media. Since published materials play an important part in education, and since materials can come from many sources including the vast resources of the internet, developing learners' media literacy can be considered a vital component of social justice pedagogy. Students can be encouraged to find published pieces or recordings from diverse perspectives, to critique information from various sources, and to produce their own content that explores or reflects their own position. They might explore public dialogue on social media and contribute their views to it. They might also participate in community events and protests or express their views through voting and signing petitions.

Barriers and challenges

Social justice is partly about removing barriers, yet institutional barriers and student resistance may stand in the way of realising a social justice pedagogy. The philosopher Ivan Illich argued that school structures were oppressive and should be replaced by more self-directed, informal education. Schools, colleges and universities can be inflexible, and systems of assessment (especially formal examinations) can act as a barrier preventing people from participating in education.

Issues of social justice can provoke emotional responses ranging from silence to anger and exchanges of views that may offend some participants. Most people want to be fair and just towards others, but sometimes it is difficult to do this in practice, or their unconscious attitudes get in the way. For individuals, the process of thinking about how they came to know what they know, and what they think about what they know, can be very challenging. Specific teacher education may be required, to encourage and prepare teachers to adopt a social justice pedagogy and to deal with how the approach may play out in class.

> “ developing learners’ media literacy can be considered a vital component of social justice pedagogy ”

A protest

Resources

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Esports

Learning and teaching through competitive virtual gaming

Potential impact: Medium
Timescale: Ongoing

Esports (e-sports, or electronic sports) are a form of competitive video gaming which is broadcast and played on the Internet. Popular forms of esports involve games such as *Fortnite*, *Call of Duty* and *FIFA*. They tend to be sports simulations, first-person shooter games (i.e. weapon-based combat where the player experiences the action through the eyes of the main character) or real-time strategy games. Other variations of esports include online gaming platforms such as 'Zwift' which enables people to complete a real-life training programme for cycling and running, whilst interacting and competing with others around the world through an online virtual game.

Esports can be played by individuals or teams. It is common for online clubs to set up their own teams of online players that compete in tournaments around the world in different disciplines. The online platform used for large esports tournaments and for those streaming their gaming strategies is the streaming service 'Twitch'[45]. The Twitch platform makes it possible to broadcast gameplay live from anywhere in the world. As such, esports have become popular among both those participating in the gameplay and the spectators watching the game unfold online. There are also ongoing developments regarding the combination of virtual reality and esports which could enhance the immersive and physical experience of sports gaming. Esports has become a global activity and offers both an opportunity for leisure and the possibility for educational activities.

Physical activity and esports

Esports are a relatively new activity in education. Therefore, there is limited knowledge or experience of how they can be applied in a teaching and learning context. Nonetheless, they illustrate one innovative possibility to reach young people and connect them to virtual sporting activities. This might induce growing interest to partake in sports themselves. For example, some sports-based video gamers have become professional riders/drivers or 'athletes' in a real-life context. Esports are classed in some universities as an official sport and scholarships are provided to collegiate esports athletes.

Sports based video games and online games have been used in school subjects such as physical education (PE) to support students' understanding of movement, different rules or techniques of sports and games, and as a teaching aid. An example is the use of 'exergames' (exercise or fitness-based video games such as 'Just Dance' played on consoles such as the Wii Fit), in which example exercises such as dance steps are projected onto a wall or screen and players follow them on a special mat with foot-activated sensors. A study conducted in secondary schools in the UK exploring the use of the dance mat exergame found that whilst students did not significantly increase their physical activity, their reaction times, coordination and mathematics skills improved (Burges Watson et al, 2016[51]).

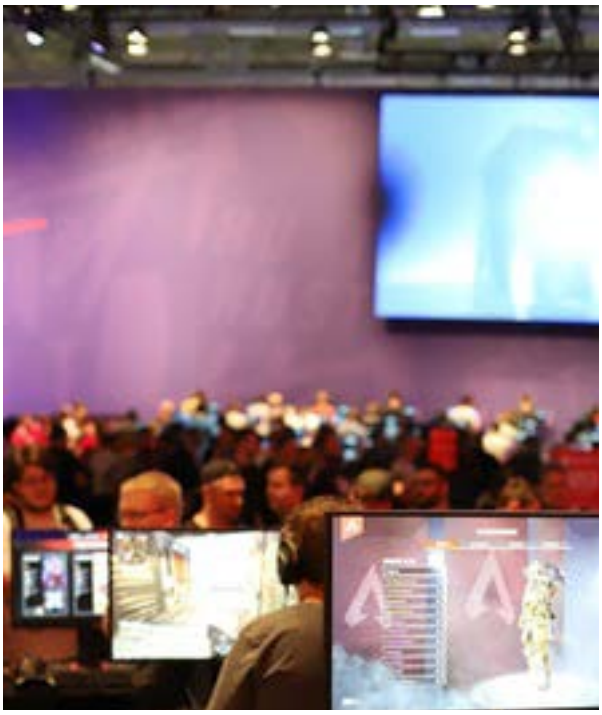
A combination of cognitive, motivational, strategic and mimetic (imitation or mimicry) skills developed through different types of esports can also be a way of enhancing digital literacy. Put differently, those undertaking esports may develop their ability to find, evaluate and compose information in digital environments through playing and watching esports. Furthermore, the North American Scholastic Esports Federation[46] found that creating esports clubs in schools meant that students were actively participating in activities, making friends and socialising with one another. Therefore, esports can not only be a fun activity to support learning in content areas, such as sport and PE, but also a pedagogical basis for supporting digital literacy, socialisation and teamwork.

Online platforms supporting esports – example of Twitch

There is something to be learned from how esports are presented in online platforms such as Twitch. There is much more to this online platform than just streaming video game tutorials. It also acts as a site for amateur online instruction, delivery, the emergence of online communities, socialisation and participation. Game software development is one of the most recent forms of learning which takes place on the platform. Furthermore, 'In Real Life' (IRL) is one of the fastest-growing categories on Twitch[47], [49] which is not linked to a video game at all. It is a space where streamers invite viewers into their everyday lives, creating opportunities for the public to interact with them in real-time situations. For example, some groups host science-themed Question and Answer (Q&A) sessions during esports battles to entertain and educate their viewers. Others teach users how to do computer programming, mathematics or cooking techniques. As such, Twitch has become a site for both formal and informal learning.

In a teaching and learning context, allowing students to create their own videos of gaming strategies or how to perform a skill or movement (e.g. a golf swing) challenges students to think about the structure of the video, the visual representation of content and how they convey their understanding of the activity to others. Esport platforms such as Twitch also allow for recording of group activities. Groups of students could plan, record and disseminate projects for a teacher or instructor to observe, comment on or assess even when they are not physically present. From a teacher or tutor's perspective, and drawing upon the broader principles of 'gamification', Twitch could be used to create and disseminate learning materials using game principles (i.e. having levels, items to collect, problems to solve). Therefore, the platform can be used to create learning resources and engaging learning environments for students at a distance.

Similar to other asynchronous video platforms such as YouTube, Twitch represents a learning environment in which the content



A group of people playing online games

has been created and has evolved 'from the ground up' (i.e. developed for and adopted by gamers rather than organisations). It has created a space of opportunity for novice through to expert instructors to educate mass, global audiences in real-time over the Internet. This contrasts with the traditional structure whereby professional instructors or companies create content to be streamed. This makes Twitch particularly interesting from a distance- and online-learning point of view because the learning that takes place comes from informal, group guidance as opposed to more directed and structured forms of teaching or training. In addition, Twitch enables interaction and communication between teachers and learners, and among learners through live verbal or written chat. Thus, the video-based learning environment can be beneficial for those looking to improve their problem solving, communication skills and instructional techniques.

Streaming media from platforms such as Twitch may help massive open online course (MOOC) experiences to become more organic and participatory. The ability to provide live video and audio broadcasting, and synchronous and asynchronous chat in online forums, means that the possibility of reaching more students in a distance education setting could be achieved. Content can act as

a source of ‘open education’ where students can interact and engage with the instructor or other learners if they wish, or they can just observe.

Connecting learning content with gaming situations that students find engaging and interesting can be key to ensuring that esports content, teaching and learning are connected. For example, many esports games produce statistics at the end of a period of play, such as time taken, items collected, accuracy percentages, etc. Students could decode the endgame numbers and run probability formulas to increase win rates for certain players. Data from the end of esports games could be used to apply mathematical or statistical equations in order to suggest strategies to improve performance.

Challenges

Concerns for using esports and associated platforms in an educational setting include the lack of real physical activity or development of core physical skills, and the lack of organisational and financial structures for esports to be used pedagogically in schools. The online nature of esports means that students would need access to the Internet to either observe or participate and the skills of teachers to deploy the games into their subject content. Ensuring that esports are used to obtain educational outcomes and not just as a source of entertainment is a challenge for teachers and educators.

A person playing a computer-based game

A person wearing a virtual reality headset and playing a racing game

> “ skills developed through different types of esports can also be a way of enhancing digital literacy ”

Conclusion

There are a variety of different types of esports that are played online. They can be viewed and streamed through online networks such as Twitch. These virtual platforms can have benefits for teaching and learning such as creation of online collaborative communities, enhancement of digital literacy, improvement of reaction times and coordination. If there is a desire to create more meaningful and engaging learning experiences for students, esports could be a way to support education. More specifically, the use of esports can aid students’ exploration of an activity or movement and act as a teaching aid. Further investigation of esports in educational settings is needed to ensure that the use of virtual gaming supports educational outcomes.

Resources

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50. A BBC video looking at why esports is being used in schools and universities: Why esports is being taught in schools and universities' (14 October 2019) BBC video, BBC News, [Online]. Available at: **https://www.bbc.co.uk/news/av/uk-england-london-50049505/why-esports-is-being-taught-in-schools-and-universities** (Accessed: 27/1//19).

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Learning from animations

Watching and interacting with short animations

Potential impact: Medium
Timescale: Ongoing

A picture is worth a thousand words, and an animation is worth a thousand pictures – or is it? The idea behind learning from animations is that some topics are hard to teach through text or static pictures. Such topics include processes showing:

- Movement (e.g. how molecules diffuse through a liquid)
- Dynamics (e.g. how the heart pumps blood)
- Speed (e.g. how light travels through space)
- Procedures (e.g. how to tie a bandage)
- Steps in solving a problem (e.g. how to solve an equation)
- Transformations (e.g. a person blushing).

Animations can reveal processes that are too fast for learners to follow, or too small to see. They can show how an expert tackles a difficult problem through a worked example. They can also show abstractions from the real world, such as an animated weather map showing changes in air pressure, the growth of a city, or how sounds are produced in the human mouth, throat and nose. When learning from animations, students watch short animated movies showing these dynamic processes and may be able to control the animation to pause it, fast-forward or rewind.

Principles of learning from animations

Twenty years of research into learning from animations has shown when they are helpful and how to design successful educational animations. Studies have shown that animations are better than pictures when they are well-designed; they teach processes or skills, and students are in control.

There are three basic principles of how people learn from animations:

- We actively process information, by selecting, organising and integrating those parts of an animation that are relevant to what is being taught
- We respond to different modalities (visual, auditory) in different ways
- Our ability to process information is limited by short term memory (working memory).

What this means is that animations need to be carefully designed to help students process the relevant information (and ignore distracting parts), to link vision and sound, and to make sure that students are not overloaded and have time to reflect on what they have learned.

Some studies have shown that photo-realistic animations can be more effective than cartoon ones. A meta-analysis comparing 26 studies of dynamic versus static visualisations shows a moderate advantage for animations over static pictures[64]. However, there is a greater advantage when the animations are highly realistic.

The value of adding sound to animations is complicated. If the same information is given in the animation and on the soundtrack, a student's attention can be split. But relevant sounds, such as a beating heart, can add realism.

Is a 3-dimensional (3-D) animation better than a 2-D one?[65] It depends on the student. Students with a good spatial ability (who can understand and reason about objects in three dimensions) benefit from 3-D models, but those with poor spatial ability can get mental overload when trying to make sense of the model.

Visualising movement and speed

A teacher who adopts animations in the classroom first needs to choose good examples to show, based on the design principles above. Then, the teacher might show the animation to the class and describe what it is teaching. Next, each student should have an opportunity to watch and interact with the animated sequence, at least three or four times. If the animation shows a process, then the teacher should encourage each student to describe it in words. If it shows the steps in solving a problem, then the students should be given further problems to solve and should be able to refer back to the example solution if needed.

How to design a good educational animation

Some early research studies showed that animations were no better than textbook pictures, but recent work has focused on the conditions that make animations successful as tools for learning. The main aim is for a student to form an accurate mental model of a dynamic process. Thus, to design a good animation involves the following steps:

1. Analyse the dynamics of what is being taught – what's important to understand and what can be ignored.
2. Choose appropriate graphic elements to show the processes and relationships or properties.
3. Decide how to present the main events or processes.
4. Devise the sequence of events and how that will be presented – from which angle, in what colours, at what speed.
5. Determine when to add pauses if it is a long animation.
6. Choose what will be included, highlighted and zoomed, so the learner can see the crucial information and how the processes work.
7. Consider adding relevant sounds, but not distracting music.
8. Devise an optional spoken narration to explain what's happening.
9. Produce the animation on a software platform that allows the student to stop, start and rewind the animation.
10. Test the animation with students to check that they gain a deep understanding of the concepts and processes.

To be successful, an animation should highlight the relevant parts and zoom into the most important movement. It works best when a longer sequence is split into short chunks, with pauses for reflection. The learner should decide when to start the next section and have control over stopping, starting and moving back in the animation. Learners should be encouraged to explain to themselves what they are learning, perhaps by predicting the next step, and watch the animation three or four times to fully understand what the movement and sequence is trying to explain.

Learning from animations in practice

Khan Academy[63] has produced a huge set of free teaching resources based on animations. Topics include mathematics, science and engineering, computing, arts and humanities, and economics and finance. A typical presentation uses an animated blackboard showing a problem being solved, or a process

unfolding, with a spoken commentary. It sounds boring, but the combination of colour in the animations, being able to stop and scroll back, and a lively narration can make topics such as *Introduction to the Atom*[63a] or *The Krebs Cycle*[63b] engaging and understandable.

'Explainers' are animations that introduce or briefly explain a topic. They are often used by companies to introduce a new product or service, but the same principles can be applied to education. Explainers generally have a strong narrative to tell a clear story, such as how a star is formed. They are short (typically 90 seconds or less), present the key message in the first 30 seconds, generally use a conversational tone and often have a touch of humour. These elements can make the content more appealing to learners who are hard to engage.

Learners with special educational needs can benefit from animations that explain an important idea clearly and succinctly, such as how to stay safe online. Enabling such learners to create animated stories can also be beneficial, when it enables them to express themselves in a different way and portray their emotions.

Animations can also act as a prompt for activities such as creative story writing. The Literacy Shed has hundreds of short videos and animations to prompt children's creative writing. They are organised into themes such as 'adventure', 'anti-bullying', 'fantasy' and 'history'. Most are photo-realistic animations. For example, Mourning Dove[57a] raises themes of love and loss, while The Rocketeer[57b] is set during World War 2 and features a young boy who dreams of flying.

Some issues when using animations

Animations can be ineffective when poorly designed, overloading the learner with too much information. They can be better than static diagrams in revealing movement and speed, with no need for arrows to indicate the direction or rate of flow, but some movements are subtle and not easy to understand. For example, in physics, to fully understand the process of diffusion requires knowing how lots of particles move through liquids and gases, why the speed that particles move at means diffusion is faster in a gas than in a liquid, and how the concentration of particles at the start affects the rate of diffusion. Putting all these elements together is a complex mental task. Thus, some animations can be overwhelming when they try to show multiple processes happening at once, or they can miss out crucial pieces of information.

Another potential issue is that students can mentally switch off and treat the animation just as a video to be watched but not understood. It is therefore a good idea to engage learners in activities through which they can demonstrate their understanding of the animation and apply or practise what they have learnt.

> "The main aim is for a student to form an accurate mental model of a dynamic process"

Understanding the process of diffusion

Conclusion

Animations can help learners understand difficult topics and they are also useful in stimulating their interest and promoting engagement. They can reveal processes that are hard to observe and can make abstract ideas more accessible. Teachers wishing to adopt this approach should be able to find existing animations on the Internet, or they may need to commission new ones or design their own. Learners might also be able to create them. Using proven learning design principles will ensure that the animations are well produced. Following up the viewing of the animation with an activity based on its content will help make learning more effective.

Resources

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56. Beauty of Science has some photorealistic animations to show complex molecules: **http://www.beautyofscience.com/molecular-animations/**

57. The Literacy Shed has collected short videos and animations to prompt creative writing: **https://www.literacyshed.com/**

57a. The Literacy Shed – Mourning Dove: **https://www.literacyshed.com/mourning-dove.html**

57b. The Literacy Shed – The Rocketeer: **https://www.literacyshed.com/the-rocketeer.html**

58. Strokerder.info is a website where you can copy/paste Chinese characters to see how to write them (i.e., see the order of strokes): **http://www.strokeorder.info/**

59. PowToon is a tool for creating simple animations for education or training: **https://www.powtoon.com/home/?**

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Multisensory learning

Using several senses to enhance learning

Potential impact: Medium

Timescale: Ongoing

Human beings have many senses that are used in teaching and learning, including the five most commonly known senses: sight, hearing, touch, taste and smell. Touch, taste and smell have been a natural part of education in many practical disciplines such as food science, agriculture, the pharmaceutical industry and chemical engineering, but have been absent from other disciplines. This is now changing.

Teaching and learning can be enhanced by making use of more than one sense as part of the same experience, for more effective communication, engagement, memorisation and understanding. Multisensory experiences, in which several senses are stimulated, have become more popular in entertainment, tourism and healthcare in recent years. For example, they are often a feature in amusement parks and in 4D (four dimensional) films shown in cinemas. These experiences typically combine an audio-visual experience with physical effects that can include chair vibrations, simulated 'rain', 'wind', leg/back ticklers, temperature changes, smoke and smells. In healthcare, multisensory environments are proving beneficial for people living with dementia – to help them stay active, support communication and trigger good memories and feelings of pleasure. The use of multiple senses for learning – such as the five senses already mentioned and also physical functions such as keeping one's balance – is still relatively new. However, the evidence base thus far shows some promising results.

Engaging multiple senses

All the senses are currently receiving more attention in education. This is partly due to advancements in technology-supported learning environments. Another reason is growth in research on special needs among learners who have sensory preferences or who respond well to combined use of senses, for example learners who have severe reading difficulties. Indeed, research involving learners with additional needs (e.g. autism and developmental dyslexia) has suggested that multisensory learning can produce benefits in terms of learning gains and an increase in learner focus. Dyslexic author and champion Ben Foss, founder of the non-profit organisation HeadStrong Nation which provides support for dyslexic children, says that "There are three types of reading: ear reading, eye reading and finger reading (Braille)."[70] By 'ear reading', he means the use of audio books and text-to-speech applications, which can provide an alternative means of engaging with literacy, different from the usual 'eye reading' of words on a page or screen.

Other examples of using auditory input in learning include the use of:

- Music, singing and rhymes
- Audio tones
- Clapping
- Chanting and dialogue.

For example, certain styles of music could be used to learn about a period of history, in combination with pictures of how people dressed, or trying out the sorts of food that they might have eaten in that time period (using taste and smell). Indeed, taste and smell responses can be very evocative and can add meaning to words. They can encourage ideas that can be used in storytelling. Imagination can be a powerful tool, particularly when bringing in a multisensory dimension – learners can think about or discuss how something would feel, sound, smell or taste, which might broaden their perspectives and improve vocabulary. The sense of smell can also be used to help memorise information and it is being explored in current efforts to create multisensory human-computer interfaces for learning environments.

Foss's mention of Braille references tactile forms of learning, where learners can process information by being able to feel what they are doing through touch. This could include the use of different textures or materials (e.g. sand or modelling clay) for example to make letters or write a name. Using finger paints or objects such as letter tiles, dominoes and coins can all help convey knowledge and understanding in a different way from written letters and numbers.

Touch is an important part of a kinaesthetic approach to multi-sensory learning. However, it is not always essential to have something tangible to hold onto. Kinaesthetic skills also involve motion. Motion can include activities in sports and physical education, walking, dance and also finer movements such as 'air writing', where a learner draws a letter in the air with their finger, whilst simultaneously pronouncing that same letter out loud. Indeed, 'air writing' is a technique that is part of the Orton-Gillingham approach to multi-sensory teaching, which arose from Dr Samuel Orton and Dr Anna Gillingham's work with learners who had additional needs in the 1930s. Orton and Gillingham devised a programme aimed at teaching literacy to those who had problems with reading, writing and spelling. The Orton-Gillingham methodology has now been formalised into the Institute for Multi-Sensory Education (IMSE), which provides training and support for educators wanting to develop their teaching skills in this area.

Multisensory learning is also emphasised in current designs for game-based learning, where several senses (sight and hearing, as well as movement) may be used to teach concepts in mathematics in ways that make learning more enjoyable as well as more effective. In one futuristic example, the Magika room for children shows how projected digital images on a wall and floor can be combined with a range of smart toys, lights and various artefacts to engage multiple senses; teachers can control the room, design game-based learning activities to take place there and can customise them to the needs of individual children.

Considerations in multisensory learning

The reasons why multisensory learning seems to be beneficial lies with learner engagement and more natural processing of multisensory signals by the brain, which is typical in everyday life. However, research by Ernst in 2008 suggested it might not be well developed until middle childhood (around 8 years old, or older[75]) and so it might not be suitable for younger learners. Furthermore, teaching based on movement may not be suitable for children with dyspraxia, defined as difficulty in conducting smooth and coordinated physical movement.

It is important that readers do not confuse multisensory learning with 'learning styles' which have now been widely discredited by learning scientists and educators. Learning styles classify individuals as having a distinct way of learning, whereas multisensory learning is about involving different senses in the learning experience to improve learning outcomes. In addition, whilst someone may seem to be strong in one area or have a sensory preference (e.g. "I'm a visual learner"), it is important to ensure they develop using different modalities and approaches, to enable them to strengthen any perceived 'weaker' areas and for them to develop compensatory strategies.

> "taste and smell responses can be very evocative and can add meaning to words"

Conclusion

Researchers believe that the next generation of rich media services in health, well-being and tourism as well as in education and training will be multisensory. Listening to a teacher and using the visual channel (i.e. our eyes and visual approaches such as looking at books and watching videos) used to be the primary means of perception for learning. We seem to be moving away from mainly verbal and visual perceptions being considered in learning, and instead there are attempts to consider more broadly how other senses can be incorporated into the learning experience. Evidence shows that stimulation of other sensory channels (and combinations of channels) during learning can prove beneficial, resulting in learning gains and deeper understanding, as well as greater enjoyment. This is particularly the case for learners with additional needs.

Using touch and visual sense in learning

Senses that are underused in education

Multisensory game-based learning

Resources

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Offline networked learning

Networked learning beyond the Internet

Potential impact: High
Timescale: Long (10–15 years)

Networked learning via digital networks promotes connections between learners, between learners and tutors, and between a learning community and its resources. However, there are circumstances where using the Internet for networked learning is not possible: this may be due to lack of access, a desire for autonomy, a need for privacy, or for playful/creative reasons such as creating an art installation that only works when you are nearby. There are many places where Internet access is not available and phone networks are limited or too expensive to use. This includes many rural areas, developing countries, and spaces where access to the Internet may be purposely limited, for example in prisons.

In such situations there are learners and teachers who have or can be given access to smartphones, tablets or laptops without a connection to the Internet. Enabling them to use the power of these devices and take advantage of networked learning without the Internet has been made possible by low cost, low power network hubs like Raspberry Pis. This approach is called 'offline networked learning'. It is most practical when supporting very local networking: enabling people in the same room, or close by, to have conversations and share resources through digital tools. It is important that educators consider not only the technical opportunities and constraints of this approach, but also its pedagogical implications. Learners' and teachers' competencies, capabilities, motivations and social support networks may enable or hinder effective teaching and learning using this approach.

Ensuring good learning

There are several facets to good learning. These include undertaking dialogue with peers and tutors to support understanding, engaging in collaborative activities, sharing resources, visualising aspects of learning, and reflection on what has been learnt. Offline networked learning can support conversation, collaboration, resource sharing, visualisation and consolidation, thus enhancing the process of learning as well as the outcomes.

For example, the MAZI project[85] developed a web-based set of tools running on a Raspberry Pi computer, battery powered and portable, that has enabled 'a webserver in your pocket'. This set of tools has been used in rural Zambia to enable teachers to come together from different village schools to access digital teaching resources, share their own materials with other teachers during training workshops, and take selected materials back to their own schools. It has also been used to enable indigenous communities in Guyana to upload, share and discuss videos they have created that record their traditional knowledge, creating knowledge repositories to empower communities and inform policy-making.

Battery powered Raspberry Pi: community story sharing in a remote village in Guyana

MAZI toolkit enabling teachers to share resources via smartphones in rural Zambia

The Personal Inquiry project enabled school students walking together in groups across a town to gather data about urban pollution and load it into a netbook running an offline web server. The students could see pollution data from different places as they were input. Later they could download the collected data sets to analyse on their own computers. This approach has been developed further in collaboration with the UK Field Studies Council to enable species observation in different habitats[81]. Students can collect species samples along a river and can work together making sense of species diversity in live conditions, thereby enabling a more agile approach to fieldwork.

The World Bank funded iBox project in Ghana[88] enables up to 100 learners at once to connect with one another via WiFi in schools in underserved areas. Students can access a learning environment that supports the science curriculum and provides video lessons, exercises and assessment. New digital tools are being developed, including a virtual microscope, 3D artefacts for manipulation, and a fully immersive lab, which will provide virtual equivalents to teaching and learning resources not otherwise available in these schools.

Spaces for offline networked learning

As all these examples illustrate, networked offline learning is applicable in many different contexts. Mark Brown[80] describes a digital learning ecology consisting of four elements: formal and informal learning contexts, and physical versus virtual learning. Learners frequently move between these four facets of the digital ecology. Offline networked learning could be positioned in any of the quadrants. It can be used in school and out of school, in class and out of class, in formal and informal settings, supporting physical (face-to-face) and virtual learning.

In a higher education context, the Spaces for Knowledge Generation project explored ways in which learning spaces can be technology-enhanced. It found that students move in nomadic but purposeful ways across a learning landscape of which the university is only a part. Students are typically already enmeshed in a continuum across work, home, and places where they study, and the problem for the university is to replicate and indeed advance these open and flexible communities on campus. This is best done by providing multiple, welcoming, aesthetic and reconfigurable spaces for learning.

Supporting slow learning

Networked offline learning brings people together in meaningful collaboration and sharing activities that can create opportunities for a slower, more deliberate learning experience than is typical on the Internet. Kahneman describes two systems of thinking: System 1 thinking refers to subconscious and automatic processes, as well as emotional responses and those that rely on biases or intuition, whereas System 2 thinking is defined as 'slow', more concerted and conscious thinking. The concept of 'slow learning' (or 'slow education'[86]), which is a reaction to the frenzied fast pace of learning generated by the Internet, gives space and time to System 2 thinking. Slow learning[83] is about deep connection to knowledge, and it emphasises the quality of the educational engagement

between teacher and learner. This engagement enables students to think independently, and to learn through curiosity, passion and interest rather than through fear of the examination hall. It is important because many within the education sector feel that we have gone too far down the road of standardisation, measured by outcomes. This not only affects students' mental health, but prepares them poorly as independent thinkers, able to deal with the challenges of 21st century societies. Slow learning in the context of teachers' professional development is focused on the need to provide space and time for teachers to work together and engage in the slow and complex thinking needed to find more effective ways of educating learners, particularly those who are 'hard-to-reach'.

Challenges

Adopting offline networked learning brings a number of challenges. Pedagogically, learners and teachers may not have the digital skills needed to engage effectively with this approach and can struggle if not provided with enough support. Learning designs for activities have to take into account that only resources on the local hub can be accessed and have to be pre-loaded, there cannot be links out to other places on the internet. Offline networking means that work carried out and recorded on a local hub is not necessarily easy to share more widely. Running an independent, offline networked system may require that greater local technical competency is in place to support and maintain services rather than when using Internet based services. Offline networking can also expect students to 'bring their own devices'. Some students may be excluded if they do not have their own smartphone or tablet, or there may be resistance by institutions, teachers or families to students using their own devices in schools and learning spaces.

Conclusion

Offline networked learning can provide the benefits of networked learning for educators and students who either cannot or choose not to learn online. Collaboration, reflection, and learning over extended timeframes can be supported using smartphones or other network-capable personal devices, via low-cost hubs like Raspberry Pis, particularly in very localised learning environments. Careful learning design is required to take account of the challenges as well as benefits. Offline networked learning requires technical and digital skills capacity and sufficient competencies to enable a successful initiative. Given the barriers to access to the Internet for a large percentage of the global population for the foreseeable future, and the value of enhancing learning via digital networks, it is likely that this approach will flourish and mature over the next decade, and it can enhance the concept of slow learning. As we look to the future we can consider how to best design and support both online and offline networked learning, and enable teachers to help students navigate across the four quadrants of the digital ecology.

> "There are many places where Internet access is not available and phone networks are limited or too expensive to use"

Resources

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81. Offline system developed to enable species observation in field locations: Collins, T. (2015) 'Enhancing outdoor learning through participatory design and development: a case study of embedding mobile learning at a field study centre', *International Journal of Mobile Human Computer Interaction (IJMHCI)*, vol. 7(1), pp. 42–58, [Online]. Available at: **https://bit.ly/35qJxv0** (Accessed: 27/11/19).

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Online laboratories

Laboratory access for all

Potential impact: High
Timescale: Ongoing

Laboratories are an important part of any science, technology, engineering and mathematics (STEM) discipline. They enable students to apply the theory they have learnt in order to practise and help them develop important skills. However, there are circumstances in which using a physical laboratory is not possible or not appropriate, for example when students are unable to come to a lab or when they need to engage with dangerous activities. In these cases, online laboratories provide a viable alternative.

Starting in the early 1980s, there has been a concerted effort to understand the role of practical activities and science investigation in the study of STEM and accreditation of STEM graduates. This has implications both for distance teaching and conventional universities. The online lab offers rich opportunities and possibilities to learners in terms of access to equipment and data from anywhere with a reliable web connection, and it can also provide access to teachers, which could be more cost-effective for students than having to travel to a physical lab. These approaches are becoming mainstream in higher education for science and engineering in many countries around the world.

What is an online laboratory?

An online laboratory is an interactive environment for creating and conducting experiments. The lab could be accessed through the web, or as a program running on a computer either in the classroom or at home. The aim is for a student to experience the procedures of carrying out an experiment, including the consequences of making mistakes, and to get results. Some online laboratories provide real data, such as specimens on pre-prepared microscope slides that can be inspected at different magnifications and illuminations. Others take the student on a virtual field trip, for example to collect and analyse geological samples. Designers of online labs can highlight the important elements of an experiment and provide multimedia guides to help with each step. Students can quickly repeat experiments and compare results.

Online labs can also allow students to interact with real experimental equipment. In this case the labs are usually termed ‘remote labs’. These will normally have an interface to the equipment and cameras to give views of the experiments. The advantages are that students can access and interact with (sometimes expensive) equipment at a distance and time of their choosing and safely explore scientific topics such as radiation.

Benefits of online laboratories

Benefits of online labs include flexibility of access, cost reduction, and provision of instant feedback. Comparisons of virtual and real experiments carried out by students show similar learning processes and outcomes. However, the practical skills involved with manipulating laboratory equipment will not be similar for all learners.

Learning in remote labs can provide students with authentic experiences. The labs can provide students with hands-on investigation and opportunities for direct observation. Students control the equipment and collect data over the internet. They can undertake experiments remotely, including in environments that would otherwise be too expensive, dangerous, difficult or time consuming to access. For example, the Radioactivity iLab enables students to measure radiation from a sample of strontium-90. The Faulkes Telescope Project is a network of

telescopes around the world that can be controlled remotely from the classroom or home. Go-Lab[93] is a portal with online labs for use in schools; its remote labs include a Geiger counter to measure radioactivity, a chemical lab to synthesise the compound methyl orange and a wind tunnel with model vehicles.

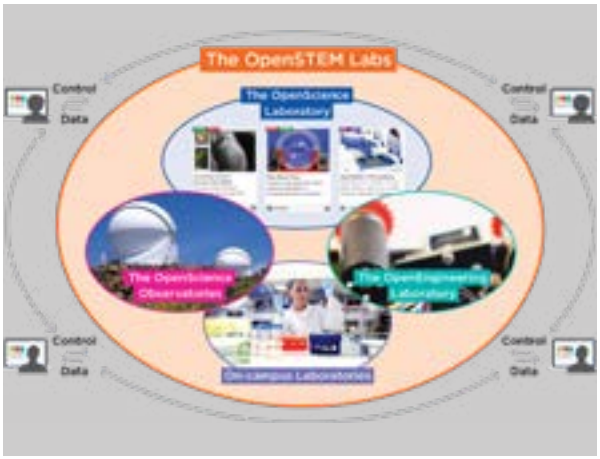
Examples of online labs

Starting in the 1990s there were experiments in The Open University's (OU) distance teaching of science using simulations, virtual field trips and remote laboratories. The latest developments in online science learning began in 2013 when the OU developed the OpenScience Laboratory (now part of OpenSTEM Labs). The Open University's OpenSTEM Labs are a good example of online laboratories offering a full range of experiences of practical work online. Examples include:

- Interactive screen experiments
- Simulations of experiments, data collection and interpretation for citizen science activities
- Remote access to analytical instruments
- Remote control of robots
- Virtual reality field trips
- Live labcasts that connect students and lecturers via live web streaming.

OpenSTEM labs allow students to carry out experiments online, as well as enabling remote access to scientific apparatus and to real instruments/equipment that can be robotically controlled. Another feature of the labs is access to tools used for 'citizen science' experiments such as iSpot and Treezilla. The OpenSTEM labs now combine the OpenScience Lab, the OpenScience Observatories (OSO) and the OpenEngineering Lab (OEL). OSO offers access to two remotely operated optical telescopes based in Tenerife, and a radio telescope based at the OU's main campus in Milton Keynes.

OEL provides practical lab-based teaching at a distance covering engineering, electronics, control, materials and robotics.



The OpenSTEM lab

One example of tools provided in the OpenSTEM Labs is the Virtual Microscope. The Virtual Microscope was first introduced at The Open University to assist with the teaching of Geology as early as 1993. In one experiment it was used to link students and specimens through the nQuire platform, which is an established inquiry-based learning platform. This pilot experience enabled students to interact with virtual microscope slides of moon rocks to explore their minerals, features and textures. In this way, they could start to understand how these rocks came to form part of the Moon's surface and were recovered by the Apollo astronauts. One of the main pedagogical advantages of the Virtual Microscope has been the simultaneous viewing and manipulation of the same slide by multiple users. Such activity cannot be achieved with a physical microscope. Using the Virtual Microscope in this way can offer a more collaborative experience for distance learning students.

In another example of an online lab, from OpenSTEM, Drysdale and Braithwaite describe how students can interact with an electronics test bench, in their 'Internet of Things' approach:

"For our teaching apparatus, such as in electronics, we adopt an approach that mimics the reconfigurable nature of an electronics test bench. In addition to the standard test and measurement equipment such as a power supply, multimeter, function generator and oscilloscope, a student would expect to see any additional specialist equipment, circuit boards, and test items, as well as reconfigure their locations and settings as you go, as determined by your experimental agenda. Thus, we provide a number of windows that can be moved and sized as desired by the student. This allows them to retain their autonomy in working through an experiment, by letting them choose which view they would prefer at any given time." (Drysdale and Braithwaite, p6)[97].

Screenshot of the web interface for an electronics activity

Challenges when using online labs

Building simulations (e.g. for the Virtual Microscope) is recognised as a difficult problem. The production of simulation software has always been a highly specialised application area and such software is often initially produced with external research funding. The web has facilitated the cross-platform capability for the Virtual Microscope application. Teachers and learners have sometimes expressed a concern that some of the aspects of practical work (such as vivid memories of the sights and smells of experiments in the laboratory) are missing from the online lab experience.

Conclusion

The potential of online labs is clear, and the number of projects and platforms are increasing. However, as with all examples of technologies introduced to teaching and learning situations, there is a need to ensure that the learning designs for lab-based practical activities make the best use of such potential.

> "They can undertake experiments remotely, including in environments that would otherwise be too expensive, dangerous, difficult or time consuming to access"

Resources

90. The Open University's OpenSTEM Labs: **http://stem.open.ac.uk/study/openstem-labs**

91. WebLabDuesto – an initiative of the University of Deusto aiming to increase experiential learning through remote laboratories. Software is available under an Open Source license and equipment can be duplicated: **http://weblab.deusto.es/website/**

92. LiLa – an acronym for the "Library of Labs", this is an initiative of eight universities and three enterprises, for the mutual exchange of and access to virtual laboratories and remote experiments: **https://www.lila-project.org/**

93. Labster – A company with many projects ongoing in Europe and USA with colleges and Universities. **https://www.labster.com/**

94. Go-Lab - a federation of online labs which enable enquiry learning: **https://support.golabz.eu/about**

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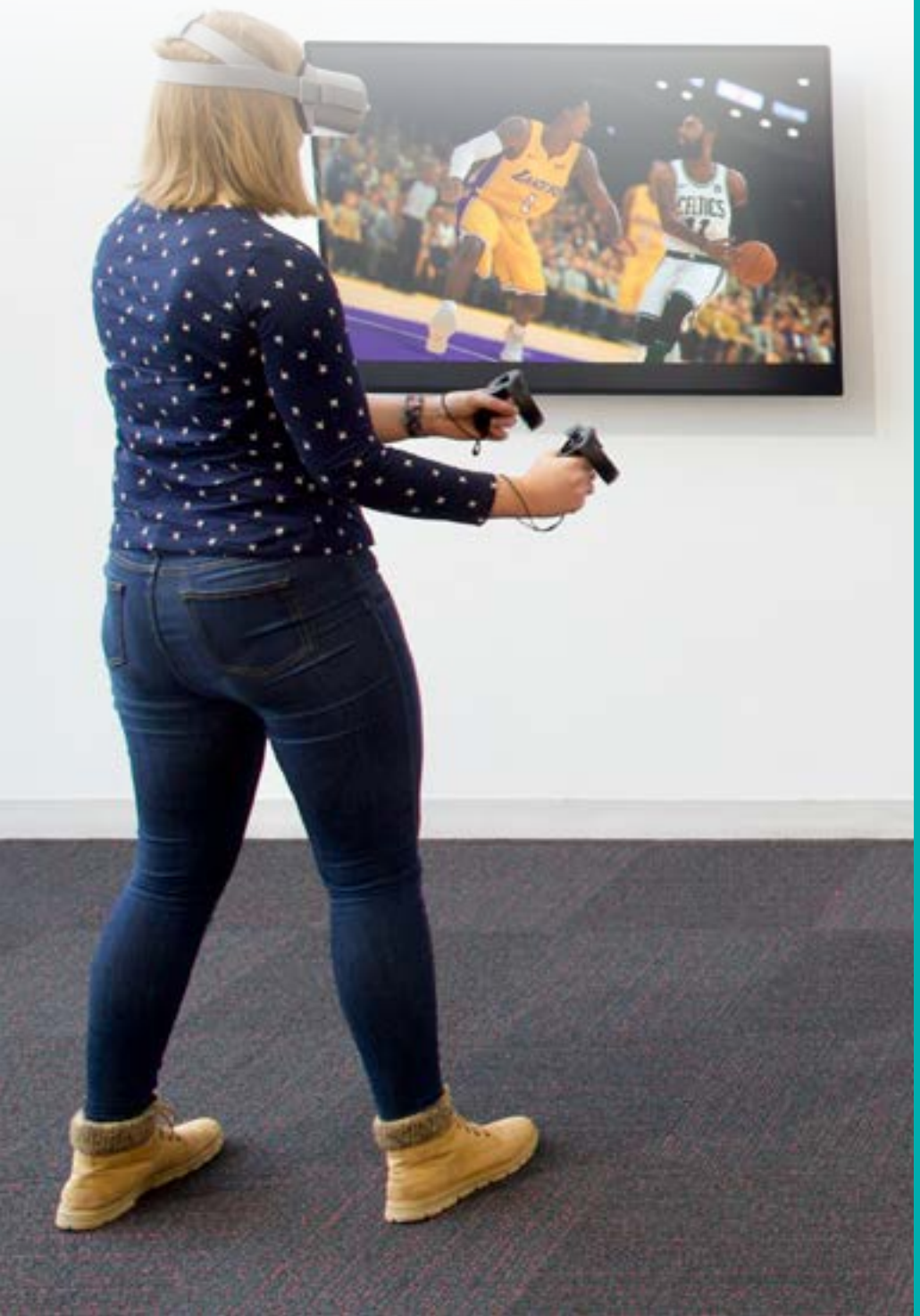

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