Pedagogika, 2018, 68(3), 233–247
http://pages.pedf.cuni.cz/pedagogika/

Preface

Miroslava Černochová, Glynn Kirkham

Introduction

This special monothematic Issue, *Education Futures for the Digital Age: theory and practice*, consists of five papers and three book reviews focussed on current topics about education in the digital age. "The digital age has implications for curriculum, pedagogy and schools' wider role in supporting children's emotional and social life and, indeed, raises questions about the purpose and nature of schools themselves, and how schools' work relates to the wider political, economic and commercial context." (Burnett, 2016:3)

The authors who have contributed to this special monothematic Issue are experienced academic staff from universities in the UK, USA, Australia, and the Czech Republic. In its preparation, we seek to convey to our readers the current situation and to point out where education and training strategies are directed in the context of growing digital technologies for pupils' learning and, in particular, for the development of society.

In this preface, we pose some of the themes and questions that seem to arise from the focus of this issue of *Pedagogika* and to which the contributing authors refer. We are grateful for their splendid contributions which follow and which assist in our understanding of the delights and complexities facing all concerned with ensuring that, through education, our future is secure.

The development and potentialities of digital technology are progressing very quickly. But where are they going? It is not easy to make such a prognosis. Less than a decade ago, in 'The 2010 Horizon Report: K-12 Edition', Johnson et al. published a study on trends in the use of technology in education. They examined "emerging technologies for their potential impact on and use in

DOI: 10.14712/23362189.2018.1225

teaching, learning, and creative expression within the environment of pre-college education" (Johnson et al., 2010: 3). According to this study, *cloud computing and collaborative environments* were expected to be used in education within the next 12 months, *game-based learning and mobiles* within the next two to three years out, and *augmented reality and flexible displays* on the long-term horizon, set at four to five years. What is today's reality in school education?

In countries with highly-developed technologies, we have, in recent years, seen the introduction of the *concept of computational thinking* into the curriculum of schools at all levels (including pre-school education). Greater attention is focussed on the development of algorithmic thinking, the basics of educational programming and educational robotics. Discussions between school managers, parents, and policy-makers in some countries are devoted to prohibiting pupils from using mobile devices while in school. The fact is, however, that even toddlers can manipulate various digital technology (smart phones, tablets, touch devices, etc.). Is it right? Is it all right? How should parents, teachers, and society respond to this? "The implications of digital technologies for children's current and future lives are far-reaching," declared Burnett (2016:3).

Our children and grandchildren are growing up surrounded by digital technologies that serve various purposes: work, entertainment, household management, learning. According to statistics, mobile devices, smartphones, and tablets have already settled in practically majority of households of economically advanced countries; in developing countries, the number of mobile device users is growing rapidly. "There is growing evidence that many children are immersed in a digital landscape from birth." (Marsh, 2016:199) Even young children under the age of five can control some functions of digital devices if their parents or grandparents allow them to use such. According to Marsh (ibid.), "studies indicate that young children use smartphones and tablets to play games, watch catch-up television on tablets and replay their favourite films on YouTube, amongst other things."

According to the OECD, competence in digital technology is essential since it "has revolutionised virtually every aspect of our life and work. Students unable to navigate through a complex digital landscape will no longer be able to participate fully in the economic, social and cultural life around them" (OECD, 2015:3).

But can we effectively use digital technology to enable learning?

Burnett argues that "education in a digital age is not just about ensuring" that "children have digital skills, but supporting them to navigate and negotiate possibilities enabled by technologies" (2016:18). The fact that we can very quickly reach information sources, which (thanks to the multimedia and visual form) are often very clear and understandable, does not, however, mean that you have learned what is to be found there.

The value of access to information through technology is recognised. "Technology is the only way to dramatically expand access to knowledge." (OECD, 2015:4) As Burnett observes, some epistemological and pedagogical questions do arise, "Connectedness and the easy dissemination of ideas, concepts and experiences also have implications for how we understand knowledge." (Burnett, 2016:7)

How does a young generation with digital technology actually learn? Do science teachers, for example, (who have mainly learned otherwise – from printed materials and real-life experiments) teach their pupils how to learn using digital technologies through which pupils perform experiments (in biology, chemistry, physics etc.) using virtual reality (VR)? Using VR, pupils can explore the micro- or macro-world and control devices in ways that have previously been only available to research scientists. What can we do to assist language-learning when we can access automated translations of text or phonograms published in paper form? How can pupils be inspired to conceive ideas, to search for and formulate problems to be solved? We are convinced that there will still be much to come to know and understand, and that the knowledge base should include learning some of what our ancestors knew and understood.

Can we learn anything through digital technologies? How do digital technologies integrate into learning to really have any positive impact on learning? There are somewhat surprising findings presented by Parong and Mayer, who compared "the instructional effectiveness of immersive virtual reality (VR) versus a desktop slideshow as media for teaching scientific knowledge." They predicted that, "… students who learned through immersive VR would report more positive ratings of interest and motivation and would score higher on a post-test covering material in the lesson. … The results," however, "showed that students who viewed the slideshow performed significantly better on the post-test than the VR group, but reported lower motivation, interest, and engagement ratings" (Parong & Mayer, 2018:1).

Computational thinking

Currently, schools are paying much attention to the development of computational thinking of pupils and their teachers. Wing's universally influential 2006 article views computational thinking as yet another literacy. "To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability." (Wing, 2006:33) A number of experts take a similar view. Mohaghegh and McCauley (2016:1524) cite Curzon et al. (2009) "computational thinking is the skill set of the 21st century". According to Linn (2010:vii) "computational thinking is a fundamental analytical skill that everyone, not just computer scientists, can use to help solve problems, design systems, and understand human behaviour. As such, they believe that computational thinking is comparable to the mathematical, linguistic, and logical reasoning that is taught to all children." "Computational thinking for everyone" is now reflected in many curricula. In collaboration with computer science specialists, educators focus on the cognitive and educational dimensions of computational thinking.

It was Seymour Papert who introduced 'computational' thinking as a concept when working with a computer, in his 1980 book, *Mindstorms, Children, Computers, and Powerful Ideas*, where he wrote that, "procedural thinking includes developing, representing, testing, and debugging procedures, and an effective procedure is a detailed step-by-step set of instructions that can be mechanically interpreted and carried out by a specified agent, such as a computer or automated equipment." (Report of a Workshop on the Scope and Nature of Computational Thinking, 2010:11)

Computational thinking should not be confined to use in computer technology. Yadav et al. (2017) clarify and specify the process in detail "Computational thinking might include reformulation of difficult problems by reduction and transformation; approximate solutions; parallel processing; type checking and model checking as generalisations of dimensional analysis; problem abstraction and decomposition; problem representation; modularisation; error prevention, testing, debugging, recovery, and correction; damage containment; simulation; heuristic reasoning; planning, learning, and scheduling in the presence of uncertainty; search strategies; analysis of the computational complexity of algorithms and processes; and balancing computational costs against other design criteria." (Report of a Workshop on the Scope and Nature of Computational Thinking, 2010:3) They see it as a set of problem-solving thought processes derived from computer science "applicable in any domain" (ibid.).

Children's computational thinking may be developed not only in schools during computer science lessons, teaching robotics or STEM subjects, but also through out-of-school activities. Programmable robotic toys for kids (BeeBot, WeDo, Lego MINDstorm, Ozobot, etc.). Software environments (Code.org, CoderDojo, TreeHouse, Codecademy, etc.) can be used to begin learning how to create (simple) computer programs. In some countries, computational thinking may be developed in computer clubs or centres (https://girlswhocode.com/, GDI https://www.girldevelopit.com/, etc.). Some schools including universities, for example, the Media and Education Technology Resource Center at NCSU (https://ced.ncsu.edu/metrc/). At the Smíchovská střední průmyslová škola (Smichov Technical College) in Prague 5 (http://www.ssps.cz/), students have a lot of space and professional support to try out virtual reality, or to "play" video games, to design and to program their own games and to print their own designs, components or components of some models (for example, the Solar System).

The push for all educators to include digital literacy for all comes also from policy. "New curricula introduced in England, Australia, New Zealand and the new ACM CS standards have identified the need to educate for both digital literacy and computer science, and the need to promote both learning areas from the commencement of schooling through to high school, to support youth in participating in an increasingly digital society." (Falkner et al., 2014:3-4)

Researchers have recognised also that children and young people improve their digital literacy out of school mainly because of their hobbies and interests and "often through curiosity and a desire to reproduce or modify particular artefacts" (Wong & Kemp, 2018:309). Very often, their deep interest in digital photography, music, or animation contributes to their digital literacy or computational thinking development. Owing to the rapid development and changes in digital technology, schools find themselves insufficiently prepared. Without support, many cannot be ready to teach pupils to work with the latest technologies. Teachers also differ in the individual readiness and ability in digital technology to teach their pupils with many schools unable to recruit IT and computer science teachers.

Computing / computer science / informatics in curriculum

Why has computational thinking become a current educational preoccupation? The reasons for the focus are (i) educational, it is a specific way of thinking and (ii) economical, the lack of IT professionals needed for a digital society development based on advanced economy and democracy (National Center for Women and Information Technology, 2018).

Although computer science knowledge is seen across the globe (including the UK, USA, Australia and the CR, where the curriculum includes the teaching of computing / computer science / informatics) as essential, there were in the USA less than 17,000 people who graduated with computer science or programming in 2015, including fewer than 3,000 women (Bell, 2018:3). This contrasts with employment demand. "… industries have increased their demand for professionals that have technical experience. The next generation of jobs will be characterised by new standards requiring employees with computational and problem-solving skills in all areas, even if they are not actual technicians." (Balanskat & Engelhardt, 2015, in Slany et al., 2018:105)

To satisfy the demands on potential employees/entrepreneurs suggests a return to Seymour Papert's ideas and vision. It was he in the 1960s, who was convinced that it makes sense for children to learn to program and to implement their ideas in a computer environment, which would contribute to their mathematical, logical and linguistic thinking development.

Although, where available, a variety of SW, mobile applications, programmable toys, robot kits and aids can be used for computational thinking development and computer science teaching, computational thinking can also be developed through activities in which pupils do not have to use a computer. **CS Unplugged** activities designed by Tim Bell and his team from New Zealand and materials **Hello Ruby** created by Linda Liukas from Finland have become very popular among teachers. Additionally, "Many schools are however experimenting with a variety of programs and devices to support programming as part of their computing provision, including: **Raspberry Pi**, the 'low cost credit card sized computer' (https://www.raspberrypi.org/); block-based tools such as **Alice** (Alice.org), **Snap** (http://snap.berkeley.edu/) or **Scratch** (https://scratch.mit.edu/); and game-making programs like **Kodu** (http://www.kodugamelab.com)." (Burnett, 2016:25)

How interested are young people in Computer Science / Informatics or IT professions? The 2006 PISA survey found that on average among OECD countries those planning a career in engineering or computing (see Table

Table 1 Proportion of male and female planning a career in engineering or computing in 2006 in countries where the authors of this special issue of Pedagogika are from (data from OECD, 2012:2).

Country	Female	Male
Czech Republic	5.0 %	20.0 %
Australia	2.5 %	16.0 %
USA	2.5 %	16.0 %
UK	2.0 %	12.0 %
OECD average	5.0 %	18.0 %

Perhaps particular political historical regimes impacted to make the gender differences!

1) were "fewer than 5% of girls, but 18% of boys, expected to be working in engineering and computing as young adults" (OECD, 2012:2).

Gender and computing sciences

Computing does not attract girls or women so much. Stoilescu and Egodawatte (2010) found that, "female students are interested more in the use of computers than in doing programming, whereas male students see computer science mainly as a programming activity." Why are girls not so interested in computing? A survey conducted among 942 students at a Roman Catholic university, St. Francis Xavier University in the USA (CREW, 2001) (see Stoilescu & Egodawatte, 2010:286) concluded that, "marks in mathematics are not significant in determining the future in majoring computer science." How can that determine that girls are still not interested in computer science? Is it a question of poor mathematics' teaching or a requirement of high scores in mathematics for narrowly-focussed computer courses? While it may be the case at that particular university, without further evidence, their claims cannot be universally applied.

The ECU (2015:165) reports that at universities, girls represent less than one-fifth of all students in computer science (17.1%) and in engineering and technology (16.1%) degrees. By contrast, "male students comprised the large majority of students studying engineering and technology (83.9%), computer science (82.9%) and architecture, building and planning (65.0%)." Wong and Kemp show that the results of statistical surveys "prompt us to question the appeal of digital careers for young females today, especially among the digitally skilled" (2018:302).

Some studies "have explored creativity as a potential avenue for girls to develop aspirations in computing careers" (Wong & Kemp, 2018:304). Nevertheless, in the UK in 2015, "IT, software and computer services accounted for just under a third (32.2%) of all jobs in the Creative Economy and had the lowest proportion of women working in it at 20.1%"

(DCMS, 2016:20). "Girls with an appetite for digital technology tend to have aspirations in creative arts or designs. In other words, these girls appear to adopt and use digital technology as a part of (or within) their creative interests." (Wong & Kemp, 2018:304) Nevertheless, that computer science is the domain of men remains the dominant societal view even among some young people themselves. Only 10.5% of the boys aged 13-19 surveyed on the basis of their experience "expressed gender-equal views of computing without any acknowledgement, or acceptance, of inequalities between boys and girls" (Wong & Kemp, 2018:308).

Educational robotics

One answer might be through gender-free educational robotics. The rich availability of robotic kits and programmable toys on the market contributes to and influences the introduction of educational robotics and programming in schools. "Young children can become engineers by playing with gears, levers, motors, sensors, and programming loops, as well as storytellers by creating their own meaningful projects that react in response to their environment" (Bers, 2010). According to Rogers and Portsmore (2004) "robotics can also be a gateway for children to learn about applied mathematical concepts, the scientific method of inquiry, and problem-solving." According to Resnick "moreover, robotic manipulatives invite children to participate in social interactions and negotiations while playing to learn and learning to play in a creative context" (Bers et al., 2013:358).

Young people learn to use digital technology out of schools

But is the contemporary school able to provide digital education and the development of information thinking? It turns out that, generally, it is not. In most countries, teaching is the domain of women; many women appear not to care for computer science.Additionally, digital technology is evolving rapidly and much school equipment is obsolete. Many teachers are not getting to know new technologies. Not all schools are able to find an adequate and speedy solution to integrate newer advanced technologies into school work and to train teachers to teach with new technologies. "Many young people constructed narratives about their younger selves in which they were perceived as being good at art or computers, but also felt they had been something of an outsider at school." (Sefton-Green et al., 2014:11)

That learning how to benefit from the opportunities derived from the digital age in which we live is not gained only from school education. Sefton-Green et al. declared that, "School alone will not prepare young people to be successful digital makers, and we need to privilege and support non-formal and informal digital-making experiences if we are to ensure young people benefit from the social, personal and economic values of digital-making." (Sefton-Green et al., 2014:14) Nor is it age-related, "It showed that young people often engage in digital creativity in haphazard ways, and expertise in these fields often bears little relationship to the academic stage the young person has reached within the education system." (Sefton-Green et al., 2014:16)

Early years children and computing

Even very young children are active participants in the use of digital technology. "There is growing evidence that many children are immersed in a digital landscape from birth. Studies indicate that young children use smartphones and tablets to play games, watch catch-up television on tablets and replay their favourite films on YouTube, amongst other things." (Marsh, 2016:199) From research in the UK, involving 2000 parents with children aged 0-5 who had access to the tablet, it was found that "the majority of the small children were able unassisted to swipe the screen (65%), to change photos, to turn the 'page' of an e-book, to trace shapes with their fingers (60%), to drag items across the screen (60%), to open their apps, to draw things (59%), to tap the screen (59%), to open commands, to exits apps and enter other apps, etc. Children could then navigate many apps independently." (Marsh, 2016:204)

The research demonstrated that, "very young children acquire a range of digital literacy skills from a young age in the 'operational' domain, which means that they have the technical skills and expertise to design, produce, disseminate and engage with texts as a reader/viewer. They are more skilled in the area of text reception, design, and production than dissemination, due to the technical skills required to upload texts to websites", nevertheless "children need to develop an understanding of the social and cultural aspects of digital literacy" (Marsh, 2016:205).

Mobile learning

Mobile technology plays an increasingly great role in our life. "Most of the 700 million teenagers everywhere in the world already have their own smartphones, but comparatively few of them have access to PCs, laptops, OLPCs, Chromebooks, or tablets." (Slany et al., 2018:104) The mobile applications user not only downloads apps, but also he or she can program his/her own. "Mobile Computational Thinking, or MCT, is a superset of CT, as mobile platforms (phones and tablets) provide an additional situatedness of computing, where the device changes location and context with its user, and is present for much of the user's interactions in daily life." (Sherman & Martin, 2015:53-54). Mobiles offer so many opportunities to learn whenever and wherever you are.

Virtual reality. Augmented reality

Thanks to digital technology, learning in recent years has been taking place not only in a real environment but more and more in a virtual environment. In a simulated environment, medical doctors are trained to perform various surgical procedures, pilots learn to control aircraft. Without simulated environments, no astronaut training is now possible. "Virtual reality (VR) is an emerging technology with a variety of potential benefits for many aspects of rehabilitation assessment, treatment, and research. Through its capacity to allow the creation and control of dynamic, three-dimensional, ecologically valid stimulus environments within which behavioural responding can be recorded and measured, VR offers clinical assessment and rehabilitation options that are not available with traditional methods." (Schultheis & Rizzo, 2001:296)

"Virtual reality is a new technology that simulates a three-dimensional virtual world on a computer and enables the generation of visual, audio, and haptic feedback for the full immersion of users." (Mao et al., 2014) With the possibilities of virtual environments, we can also meet in the world of entertainment or 3D cinema. Modern computer games are only playing in a virtual reality; they offer players completely different experiences perceptions of space than they were before; players usually use for such cases special gloves or glasses. However, it turns out that, "an inappropriate use of virtual reality can cause an observer or a regular user to become a state where he/she clearly does not distinguish between the real world and the virtual world, thereby distorting his/her mental perceptions and assessing the real environment in general." Will generations of our children be able to live with the virtual worlds healthily and without risk?

Augmented reality (AR) which combines the real world with objects created by computer technology is another type of technology that already penetrates our life, leisure activities and education. It "allows technology to directly mediate a person's perception of and interaction with the physical world" (Roesner, 2017). This technology represents a great challenge for technological support for the learning process and for use in everyday life, in employment, in transport. According to Michalik, "augmented reality represents part of a new era for computing; freedom from the bounds of the screen" (ISACA 2016). AR can serve doctors and their patients. The statistic portal, *Statistika*, shows that in 2022, the augmented and virtual reality market is expected to reach a market size of 209.2 billion US dollars whereas, in 2018, it is only 27 billion US dollars. However, when used inappropriately, this technology (AR) also poses a great potential risk to humans.

Artificial intelligence in education

Pupils for whom we are currently educating teachers will be living side-by-side with artificial intelligence (AI) objects. "There's tremendous anxiety about workforce issues in AI. And they build on larger, longer concerns about automation and the effect it will have on jobs." (Kirkland, 2018) For such reasons, according to Jennifer Rexford, computer-science chair at Princeton University, it is now necessary to focus on employing AI to adopt novel ways of teaching (see Kirkland, 2018).

Compared to humans, for the AI machine it is still very difficult: "to exhibit creativity and social skills and perceptiveness" (Kirkland, 2018). Machine learning can help us to identify problems that students are struggling or which learning materials are explained non-understandably. Study of machine learning can help us to "personalise the students' learning, so that students can learn at a more efficient pace than they can in today's one-size-fits-all classrooms" (Kirkland, 2018).

In connection with AI, it is becoming more and more important to understand how human being learns. Research in AI contributes immensely to studying learning processes; the results of these studies can enrich pedagogy-psychological and pedagogies in field-disciplines.

Risks in digital technology usage

Inappropriate use of digital technologies can pose significant risks for people, especially for children and young people. Are we able to avoid the risks of using digital technology? Would the solution be that we restrict or even prohibit their use?

One identified problem is *Cyberbullying*. "According to a survey carried out in 2010 in European countries, 6% of children aged 9-16 had been victims of cyberbullying in the preceding year (Livingstone et al., 2011). When the survey was repeated four years later, in 2014, the proportion had risen significantly (to 12%) for the seven countries involved (Mascheroni and Ólafsson, 2014)." (OECD, 2015:44)

Yet another example of negative impact on individuals is *Digital dementia*, a concept introduced in 2007 by research scientists in South Korea, which has one of the highest percentages of digital technology users in the world. It is defined thus: "Digital dementia is the new diagnosis of a disorder caused by the addictive use of digital media." (Woo, 2015)

Health risks are, however, studied across the world. Statistics from around the world show how fast the number of families and households with digital technology devices available to children is growing, how the percentage of children who have their own smartphone is growing, and how the child's age in which s/he has first contact with digital technology and starts manipulating it decreases. "In response to these increases, organisations, like the American Academy of Pediatrics (AAP), have revised previous policy statements to include specific recommendations for healthcare providers, parents, and educators of children from birth through age 8." (AAP, 2016 cited in Miller et al., 2017) In some countries, like USA, Australia, UK, various associations were founded: National Association for the Education of Young Children (NAEYC), the Fred Rogers Centre, the U.S. Departments of Education and Health and Human Services, the UK Council for Child Internet Safety or the Australian Department of Health etc., in which professionals on early learning and technology provide guidelines to parents what to do with a such small children.

Further risks relate to errors in SW applications. The great interest in developing CT in schools demands that model starting points, mathematical models and programmed applications are correct. He points out the risks of the mistaken implementation of CT. Alfred V. Aho recounted a story—"A number of years ago when I was doing some consulting for NASA, I came to Washington and noticed an article in the Washington Post that said global warming wasn't as bad as scientists feared because the empirical measure of the rate of rise of Earth's oceans wasn't as bad as the computer models had predicted. It turned out to be a software error." (see Report, 2010, p. 36)

It is neither desirable nor our purpose here to identify all the potential problems, barriers, negative impacts of digital technology on healthy development of the younger generation. Some of them (societal risks, social behaviour, legal issues, safety, data protection, ethical etc.) a society or individuals themselves should help to solve. Some of them (teaching methodology, assessment, gender, etc.) should be solved through the collaboration of teachers, parents and the children themselves. For educators, it is still 'work in progress' as the OECD comment notes. "We have not yet become good enough at the kind of pedagogies that make the most of technology; that adding 21st-century technologies to 20th-century teaching practices will just dilute the effectiveness of teaching." (OECD, 2015:3) One of the biggest obstacles for bringing technology and engineering into early childhood education is (according to Bers et al., 2013:356) is "among early childhood educators there is a lack of knowledge and understanding about technology and engineering, and about developmentally appropriate pedagogical approaches to bring" digital technology into the classrooms.

Digital technology is a big and complex issue for school education and for the development of modern society in the digital age. "Technology can amplify great teaching but great technology cannot replace poor teaching." (OECD, 2015:44) Digital technology is a great challenge for all of us, educators, parents, teachers, scientists, policy-makers, because of, Deanna Kuhn's words (cited in Report, 2010:38), "computer science and education communities should use computational thinking" and digital technology in general "not just to teach old things but also to teach new things, both new methods and new ideas, to solve new problems, because that's what the people we will be educating are going to be doing in the future."

What is awaiting readers of this special monothematic issue?

Above we have tried to show some of what is happening actually with regard to digital technologies and education, generally, in the world. We would like readers to adopt a global perspective when viewing the articles included in this themed issue.

We are also aware that education is not just about economics and employment, it is also about the development of the whole child/person. Boy (2013) reminds us an overemphasis on STEM subjects (or digital education) relegates the status of the Arts and the potential for creativity in society. The creativity of our contributing authors is evidenced in the ensuing articles as they present their own varying pursuits for knowledge regarding aspects of digital education in *Education Futures for the Digital Age: theory and practice.*

The article, *Trends in early childhood education practice and professional learning with digital technologies*, by Murcia, Campbell and Aranda (from Australia) offers an overview of the state of early childhood education and digital technology at a fixed point in time reviewing antipodean Australian activity and making some comparison with European. There are some valuable insights and references to good practice as well as suggesting policy approaches concerning the need for high quality and relevant continuing professional development. The importance of collaboration at local, regional, national and international levels (which digital technology enables) is also intimated in this focussed and engaging article.

In the contribution, *Critical Media Literacy for Elementary Students in an After-School Programme,* from one of the states of the USA, Wiseman and Wren explore some of the complexities of developing media literacy and report some of the activities during an after-school programme. The importance of students' openness when they feel secure and unthreatened and how they deal with what the media through technology throws at them on a daily basis. The article contains some of the material that they used in seeking to engage the students in being able to critique what and how the media presents to them, particularly advertisements. Media literacy is not just for the after-school but an essential competence for all in the 21st century. Engaging young people in critical reflection is a moral requirement. The paper would provide a good starting point for teacher professional development on this topic.

Back to Australia, and in the paper, *Unplugged Programming: The future of teaching computational thinking?*, Aranda and Ferguson suggest ways in which computational thinking can be enhanced and even taught without the costs of hardware and software. Unplugged Programming has some of the answers to the development of thinking skills and learning different ways of solving problems both through the use of the mind and machines but also the body. Computational thinking is one way (but not the only way) of thinking about how to construct and deconstruct the world in which we live and as such becomes a valuable tool for all who can employ it as and where necessary. That the development of this epistemological approach can be enacted where funds are limited is a bonus both for individuals and for the education system.

In his article, *Learning with Mobiles in the Digital Age*, Traxler, a UK proselytiser and activist for mobile learning who has put his beliefs and principles into action and experience in a significant number of situations and countries, writes with managed passion. Despite his passion, he presents in this article a clear, balanced and objective account of the development of the most prevalent, available and yet under-explored digital hardware and its application to learning and for learners. He asks difficult questions about the nature and purpose of education, where we are and why we are where we are and underlying issues of power and knowledge in the digitalised age. This is a strong, epistemological paper which could be used at many levels to initiate further professional discussion and learning not only relating to digital education but also to the fields of pedagogy and andragogy in general.

Digital technology has brought forward many innovative ways of visualising the world and the Czech Republic has made its contribution in some fields. Contributors to this edition on digital education from the Czech Republic, Jeřábek and Rambousek, focus their article, *Educational Functions of Augmented Reality*, on the unique potential of augmented reality, what it is and how best it might be deployed, employed and have an impact on learners and learning. The two bring a paper which challenges the status quo and affords the opportunity for teachers at all levels to consider the value of yet another innovation. There is no doubt in their minds that used appropriately (and that is a skill required of the teacher) augmented reality can add a new dimension to learning for all.

One overriding principle emerging from all of the papers presented is of "collaboration" as a significant theme. If we are collectively to gain from the rise and rise of digital technology we need to share our knowledge, ideas and hardware and software. We need to keep our eyes, ears and minds open to making critical, professional decisions based on the best evidence available to us and to assess and share our assessments, our hopes and fears and our findings with one another, as these papers have done. In such a way, as educators we grow individually and collectively strengthening our profession and making the best use of both digital and non-digital technologies in the learning process.

Resources

Bers, M. U. (2010). The TangibleK Robotics Program: Applied computational thinking for young children. *Early Childhood Research and Practice*, 12(2).

Bers, M. U., Seddighin, S., & Sullivan, A. (2013). Ready for robotics: Bringing together the T and E of STEM in early childhood teacher education. *Journal of Technology and Teacher Education*, *21*(3), 355-377.

Bill, A. M. (2018) *Exploring computational thinking concepts, practices, and dispositions in K-12 computer science and engineering.* Thesis. Master of Science. Nashville, Tennessee.

Boy, G. A. (2013). From STEM to STEAM: toward a human-centred education, creativity & learning thinking. In *ECCE ,13 Proceedings of the 31st European Conference on Cognitive Ergonomics.* Article No. 3. Toulouse, France, August 26-28, 2013. ACM New York, 2013.

Burnett, C. (2016). *The digital age and its implications for learning and teaching in the primary school.* A report for the Cambridge Primary Review Trust. CPRT, Research Survey 7 (new series).

CREW. Collaborative Research Experience for Women (2001). Project from Xavier University granted by the Computing Research Association (CRA). Retrieved from http://cerebro.cs.xu.edu/crew2001

Curzon, P., Black, J., Meagher, L. R., & McOwan, P. (2009). cs4fn. org: Enthusing students about Computer Science. Proceedings of Informatics Education Europe IV, 2009, 73-80. In Mohaghegh, M., & McCauley, M. (2016). Computational Thinking: The Skill Set of the 21st Century. *International Journal of Computer Science and Information Technologies, 7*(3), 2016, 1524-1530.

DCMS (2016). *Creative industries: Focus on employment.* Department for Culture, Media and Sport.

ECU (2015). *Equality in higher education: Statistical report 2015 Part 2: Students.* London: Equality Challenge Unit.

Falkner, K., Vivian, R., & Falkner, N. (2014). The Australian Digital Technologies Curriculum: Challenge and opportunity. In *Proceedings of the Sixteenth Australasian Computing Education Conference (ACE2014)*, Auckland, New Zealand.

ISACA (2016). Risks and rewards of adding augmented reality to connected devices. As the internet of things gets real, businesses get ready. *ISACA 2016, IT Risk/Reward Barometer*. Retrieved from http://www.isaca.org

Johnson, L., Smith, R., Levine, A., & Haywood, K. (2010). *2010 Horizon Report: K-12 Edition*. Austin, Texas: The New Media Consortium.

Kirkland, R. (2018). *The role of education in AI (and vice versa).* Retrieved from https://www.mckinsey.com

Linn, M. C. (2010) Preface. In *Report of a Workshop on The Scope and Nature of Computational Thinking.* National Academy of Sciences.

Mao, Y., Chen, P., Li, L., & Huang, D. (2014). Virtual reality training improves balance function. *Neural Regeneration Research*, *9*(17), 1628-1634.

Marsh, J. (2016). The digital literacy skills and competences of children of pre-school age. *Media Education, Studie and Research*, *7*(2), 197-214.

Miller, J. L., Paciga, K. A., Danby, S., Beaudoin-Ryan, L., & Kaldor, T. (2017). Looking beyond swiping and tapping: Review of design and methodologies for researching young children's use of digital technologies. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, *11*(3), article 6.

Mohaghegh, M., McCauley, M. (2016). Computational Thinking: The skill set of the 21st century. *International Journal of Computer Science and Information Technologies*, *7*(3), 1524-1530.

National Center for Women and Information Technology. Retrieved from https://www.ncwit.org

OECD (2012). What kinds of careers do boys and girls expect for themselves? *PISA in Focus, 14*.

OECD (2015) *Students, Computers and Learning: Making the Connection*. PISA, OECD Publishing.

Papert, S. (1980). *Mindstorms: children, computers and powerful ideas.* New York, NY: Basic Books.

Parong, J., & Mayer, R. E. (2018). Learning science in immersive virtual reality. *Journal of Educational Psychology. January*. (Online).

Report of a Workshop on The Scope and Nature of Computational Thinking (2010). National Academy of Sciences.

Roesner, F. (2017). *Who is thinking about security and privacy for augmented reality?* Retrieved from www.technologyreview.com

Rogers, C., & Portsmore, M. (2004). Bringing engineering to elementary school. Journal of STEM Education, 5(3-4), 17-28. In Bers, M. U. (2010). The TangibleK Robotics Program: Applied computational thinking for young children. *Early Childhood Research and Practice*, *12*(2)

Sefton-Green, J., & Brown, L. (2014). *Mapping learner progression into digital creativity. Catalysts & Disconnects. A state of the art review*. Nominet Trust. Retrieved from https://socialtechtrust.org

Sherman, M., & Martin, F. (2015). *The assessment of mobile computational thinking*. Consortium for Computing Sciences in Colleges, 2015.

Schultheis, M. T., & Rizzo, A. (2001). The application of virtual reality technology in rehabilitation. *Rehabilitation Psychology*, *46*(3), 296-311.

Slany, W., Kirshan, K. L., Mueller, M., Schindler, C., & Spieler, B. (2018). Rock Bottom, the World, the Sky: Catrobat, an Extremely Large-scale and Long-term Visual Coding Project Relying Purely on Smartphones. In: *Constructionism 2018. Constructionism, Computational Thinking and Educational Innovation: conference proceedings.* Vilnius, Lithuania.

Stoilescu, D., & Egodawatte, G. (2010). Gender differences in the use of computers, programming, and peer interactions in computer science classrooms. *Computer Science Education, 20* (4), 283–300.

Wing, J. M. (2006). Computational thinking. *Commun. ACM 49*(3), 33–35.

Wong, B., & Kemp, P. E. J. (2018). Technical boys and creative girls: the career aspirations of digitally skilled youths. *Cambridge Journal of Education, 48*(3), 301-316.

Woo, M. Y. S. (2015). *Living with Technology. An investigation into young adults' challenge to prevent digital dementia*. PhD thesis.

Yadav, A., Stephenson, C., & Hong, H. (2017). Computational thinking for teacher education. contributed article. *Communications of the ACM*, *60*(4), 55-62. Retrieved from https://cacm.acm.org