ISSN 1648-939X /Print/, ISSN 2669-1140 /Online/

INTEGRATION AND USE OF CONTEMPORARY TECHNOLOGIES IN STEM EDUCATION

Dejan Zemljak, Boris Aberšek
University of Maribor, Slovenia

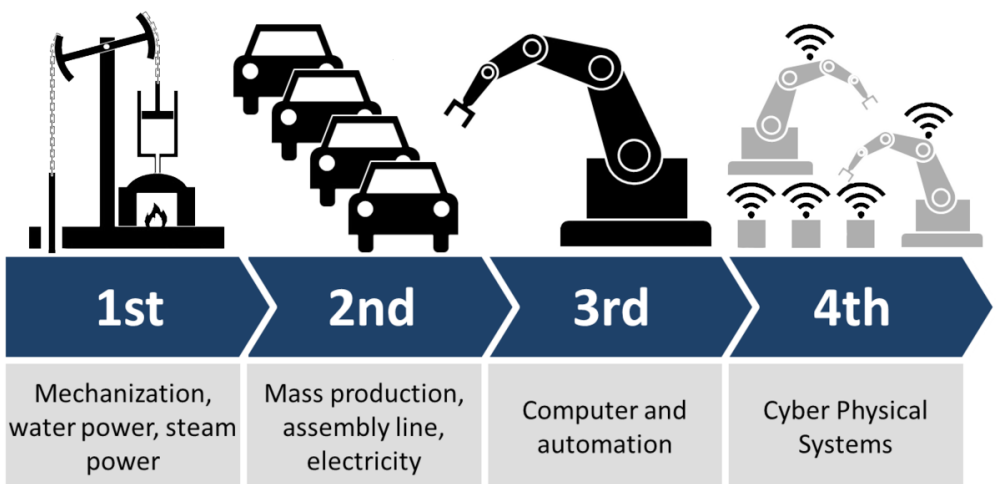
Abstract

Based on the historical development of industry and society, as well as education, we can conclude that in the future we will see continuous progress and development. Accordingly, education should follow, because only in this way will people be able to live a quality life in the future. Given all the progress so far, the question arises what awaits us in the coming years or decades. This article focuses on the question of whether the society is ready for the changes that await, and whether contemporary devices (3D printers, laser cutting machines, etc.) and processing procedures are already included in education, especially in the field of STEM. In order to explore these issues, a short survey was carried out on a sample of 77 STEM teachers in Slovenia. Results show that Slovenian schools are not yet well enough prepared for contemporary technologies, and that these are not included in the lessons for various reasons. Therefore, a strategy (at different levels) should be developed and introduce certain changes, so that education can keep up with the pace of technological progress.
Keywords: *contemporary technologies, STEM education, technological development, changes in education*.

Introduction

Life, as we know it today, as well as the built environment that surrounds us, was created by humans from practically nothing. The industrial development summarized in Figure 1 is particularly remarkable.

Figure 1
Schematic overview of industrial revolutions (Roser, 2017)



The development of education is also remarkable. The beginnings of education can be traced back to the moment when prehistoric man began to make the first simple tools out of stone (Vidmar, 2009). Today, computers and computer-aided technologies are increasingly being integrated into education, and books are increasingly replacing computer applications, showing remarkable progress in this area.

The key question that arises is, where will future developments take us?

Today, smart devices are used in everyday and professional situations in all areas of life. The expression itself stems from the fact that intelligent software tools, connected to machines and devices, are used universally in factory production lines and in our daily lives. Adding to this phenomenon is the technology of cloud computing, which allows access to the desired content and data, as well as to machines and devices, practically from anywhere and at any time (Marr, 2020). Because of all of this, and especially with the emergence of the Internet of Things (IoT), a new industrial revolution called Industry 4.0 is now already underway. Industry 4.0 brings along quite a few changes: traditional production will be replaced by smart production, which will provide higher productivity, more automated jobs, higher product quality, safer working conditions, lower production costs, and shorter travel times of products from production to the market (Kannan, 2020).

As a rule, in parallel with the development of industry, society is also developing. If once humans lived mainly from hunting, and later from agriculture and industry, we can expect that today's information society will grow into a new social form in the near future. A super smart society, where man will be at the center of action. Systems and sensors will detect and analyze different states and conditions around us and adjust our lives in the best possible way. Thus, in the future, human life will become (perhaps even entirely) dependent on cyberspace. However, there are still many obstacles to be overcome, before we reach the so-called Society 5.0 (Society 5.0, 2020).

It seems reasonable to assume that education, too, will change in the future. Computer technology and artificial intelligence are expected to play a significant role in education. It can also be expected that school aids will be interactive in the future; that computers and other smart devices will become an indispensable part of every classroom; and that teachers will become lesson moderators (tutors), who will only guide students to acquire relevant skills and knowledge on their own. In addition, information and knowledge will be available to students immediately (Aberšek, 2018; Zakrajšek, 2016).

It is certainly expected that the content (subject matter) of teaching will change. Given the increasingly changing world, new professions are expected to emerge over time. It is important that students be taught how to negotiate, empathize with and motivate others. Education will need to provide them with skills that will enable them to make a smooth transition from educational institutions to employment. Future schools will not only transmit the specific knowledge required for a specific field, but rather the kind of knowledge that can be used more widely, in several areas. Teamwork skills and communication competencies will need to be strengthened (West, 2015). It is anticipated that a properly trained workforce, equipped with scientific and technological knowledge and possible experience, will increase competitiveness, especially in the field of science and technology. This is why we now have a great responsibility in training people, so that they will be able to adapt to the changes that are inevitable. Unless appropriate action is taken now, there will be many people faced with difficulty in finding a job that requires any kind of specific knowledge. From this point of view, radical changes in science education are inevitable (Cavas, 2019).

It is anticipated that we will need to make changes in a number of areas (Doulík & Škoda, 2009):

- it will be necessary to redefine objectives in science education that reflect the development of technology,
- education will have to be based on the interests of students, their individual experience will have to be respected and used,
- the amount of information to be learned will have to be reduced, and, on the other hand, it will be necessary to devote more time to important topics,
- understanding of basic scientific concepts and rules is expected to become the most important goal in (science) education (thus providing general knowledge and the ability to adapt to different fields and professions) and
- the focus will need to be on developing problem-solving skills.

The implementation of education is also expected to change. Due to new types of employment, parents are expected to be absent less often, so they will be able to dedicate more time to their children and thus teach them certain basic skills, such as reading and writing. Learning time will expand and extend, despite students spending less time in school. The share of general education is expected to increase in the future, while the share of targeted education will decrease. It will also be important to be sufficiently competent in general knowledge, i.e., being able to learn certain professions well and quickly in order to adapt to the situation on the market. It may therefore be predicted that in the future, most people will have several different professions (Gaber et al., 2017).

Research Problem

Schools (education systems) should keep up with all of the changes that have already taken place, as well as with those expected in the future, however, this has not been the case so far. The problem in Slovenia is that education system is still quite traditionally oriented, despite the emergence of innovative approaches to teaching, or the fact that many contemporary technologies and technological processes are now affordable. Everything points to the fact that schools (education systems) are changing rather slowly. On the other hand, there is rapid progress in technology and industry. It would be ideal, of course, to see industry/technology and schools/education systems changing in parallel, but unfortunately, this is not the case. Regrettably, education is not keeping pace with all the rapidly changing trends in technology and industry. Therefore, a key question arises – how to adapt education system to all these changes?

Therefore, in the research we wanted to find out whether the teachers of Slovenian schools are already following all the technological changes and adapting the way of teaching accordingly.

Research Focus

This research attempts to confirm or reject the following hypotheses:

- Hypothesis 1: Teachers in Slovenian schools include contemporary processing technologies in STEM teaching.
- Hypothesis 2: Contemporary schools (education systems) do not keep up with the needs arising from technological change.

- Hypothesis 3: Teachers are willing to accept changes in the way they teach if these changes relate to the inclusion of contemporary technologies in teaching.
- Hypothesis 4: By introducing contemporary methods and technologies to education, we are able to keep up with modern-day industry trends (technological change).

Research Aim

The aim of the research was to determine the current state of affairs in education with regard to introducing contemporary technologies and technological procedures in STEM teaching.

Research Methodology

General Background

The research focused on the current situation in the field of introducing contemporary technologies (especially contemporary processing technologies) to Slovenian schools. The research was performed at the end of the 2018/2019 school year - from May to June. The questionnaire was offered to teachers at 20 randomly selected primary schools in Slovenia. The decision of whether or not to answer the questions in the questionnaire was up to the individual teachers.

Instrument

The questionnaire contained questions about how many years teachers have been teaching and which STEM subjects they teach. In the questionnaire teachers had to agree whether they use the mentioned didactic aids in the lessons. The following aids were selected: hand tools for processing materials, various materials processing machines, computer for presentation purposes, e-textbooks, computer aided technologies, drawing and modeling programs and computer applications.

Teachers also had to answer the question of what modern technologies they use in teaching. The following answers were possible: CNC milling machine, 3D printer, 3D scanner, engraving (laser) machine, modern materials (such as smart materials), nano technology, other (where suggestions could be written) and none of the above (if the teacher does not use any of the mentioned technology).

Teachers, who participated in the research, had to choose the reasons why they incorporate modern technologies into teaching. They were able to choose from the following reasons: this makes it easier to present the learning content, students are more motivated, students are more attracted to this way of teaching, students understand the presented content better with this way of teaching, we reach higher taxonomic levels, this way of teaching is more fun and modern technology is increasingly embedded in our daily lives.

Participants

Randomly selected primary school teachers from Slovenian schools provided answers to the online survey. Since the focus was mainly on technologies, devices and machines for material processing, the survey could only be completed by STEM teachers, whereas teachers of other subjects were asked only about their attitude towards contemporary technologies in education. 77 teachers from Slovenian schools provided complete replies to the survey. The participation of teachers in the research was voluntary and completely anonymous (no personal data was collected). Before the research began, they were informed about their role in the research.

Data Analysis

The data were collected using an online questionnaire platform. Randomly selected teachers from Slovenian schools answered the questionnaire. The analysis of the results was performed with a computer program, where percentage values, average values and standard deviations for individual survey questions were calculated (where possible). The results are schematically presented in the form of diagrams.

Research Results

As shown in Table 1, teachers in Slovenian schools believe that practical work in the classroom should not be neglected. The majority of teachers believe that students need to learn to work with hand tools. They also find the use of a computer important, however, it should be noted that computer skills decline as the complexity of content and programs rises. The assumption is also confirmed by the statistical analysis shown in Table 1.

Table 1
The use of didactic aids in teaching

Item	**%**	***SD***
Hand tools for processing materials	100	0
Various materials processing machines	100	0
Computer for presentation purposes	97	0.18
e-textbooks	50	0.5
Computer aided technologies	41	0.5
Drawing and modeling programs	81	0.4
Computer applications	48	0.5

The answers to the question of which contemporary technologies teachers use in the classroom were as follows: 65% of teachers do not include contemporary technologies in the classroom, 26% of teachers use a 3D printer in class, 7% of teachers use an engraving laser machine, 7% of teachers present and use smart materials in their classes, and only 5% of teachers use a CNC milling machine.

Table 2
Integration of the mentioned technologies in teaching

Item	%
CNC milling machine	5
3D printer	26
3D scanner	0
Engraving (laser) machine	7
Modern materials (such as smart materials)	7
Nano technology	0
Other	7
None of the above	65

Table 2 shows that almost half of the teachers do not include the mentioned contemporary technologies in their lessons. Of the remaining listed technologies, most teachers include 3D printing, while other technologies are used less.

In the survey, teachers were also asked whether they felt that the current curriculum should be changed to include content on contemporary processing devices. 68% of respondents agreed, while 32% of respondents were not in favor of such changes.

In addition, teachers were asked why they think it is important to incorporate contemporary technologies into teaching. The results are shown in Table 3. Most teachers believe that contemporary technologies need to be incorporated into lessons because they are increasingly present in our everyday lives. 50% of teachers believe that contemporary technologies help them present the content more easily. A good half of them think that students are more motivated when modern technologies are used in their classes. 50% believe that in this way, students understand the presented content better.

With respect to the last question of the survey, one teacher suggested (under the option "Other") that contemporary technologies are included in the lessons because remarkable progress has been made in this field.

Table 3
Reasons for integrating modern technologies into teaching

Item	%
This makes it easier to present the learning content.	69
Students are more motivated.	69
Students are more attracted to this way of teaching.	53
Students understand the presented content better with this way of teaching.	50
We reach higher taxonomic levels.	28
This way of teaching is more fun.	40
Modern technology is increasingly embedded in our daily lives.	81

Discussion

As can be seen from Table 1, teachers in Slovenian schools believe that practical work in the field of STEM should not be neglected. All of them believe that students need to learn to work with hand tools. They also find computer skills important, however, it

should be noted that computer skills decline as the complexity of content and programs rises. Such results were expected. “Technique and Technology” is a specific subject in Slovenian schools, in which students need to be taught motor skills and working with tools. Physical skills (manual work) should therefore not be excluded from lessons, but rather, preserved, despite the growing presence of contemporary technologies.

The first hypothesis stated that teachers in Slovenian schools include contemporary technologies in their lessons. Results (shown in Table 2) show that 65% of the teachers do not incorporate the mentioned contemporary technologies into teaching. Since the share of teachers who do not include contemporary technology in teaching is higher than the share of those who include it in teaching, the first hypothesis was rejected. One of the main reasons is the number of teaching hours. Since the vast majority of teachers focus on practical work, and the number of lessons is relatively small, this means that they simply run out of time to teach students manual work with tools and at the same time work with contemporary technologies and technological procedures. Perhaps the reason for non-inclusion is also that teachers are less professionally trained in working with contemporary technologies or do not feel confident enough using them. Another reason is the equipment in the classrooms. Not all teachers have the appropriate equipment and technology (devices and/or machines) available and consequently cannot teach students to work with them even though they want to. It would therefore be reasonable to draw up a plan (at the state level) on how to provide funds for acquiring contemporary technologies, as well as a plan for educating and further inspiring teachers to include these technologies in teaching.

Some of the most basic technologies that would be suitable for students include 3D printing, engraving and cutting laser machines, 3D scanners, etc. Based on the results shown in Table 2, the second hypothesis, which stated that contemporary schools, i.e., the education system, do not follow the needs of technological change, was confirmed. More than half of the teachers included in the survey do not involve contemporary technologies in their lessons. The remaining share most commonly use 3D printers and engraving laser machines. One of the main reasons is the lack of financial resources: many schools do not have the financial means to buy contemporary devices or machines, as a result, teachers cannot use them, and students do not learn about them. This problem could be solved by way of collaboration, especially on a local level, whereby schools from the same local area could collaborate with one another. They could buy contemporary devices and machines together, which would represent a smaller financial investment for each individual school. It would also make sense for a school and a local company to work together. In order to learn about contemporary technologies and technological procedures, students could occasionally visit a nearby company, where they would be taught to work with contemporary technologies and also test themselves at work (of course, to a limited extent and under supervision).

Based on all of the above, it has been found that contemporary technological devices are not an integrated part of school life. They are not included in the lessons for a number of reasons. On the other hand, this research has also shown that teachers are willing to accept and incorporate contemporary technologies into their lessons. The results showed that teachers would agree to changes or adaptations to the curriculum, if such changes referred to contemporary technologies being included in the curriculum, (this confirms Hypothesis 3). Results shown in Table 3 point to the fact that the main reason for including contemporary technologies and technological processes in the classroom is the fact that they are increasingly embedded in our daily lives.

The fourth hypothesis stated that introducing contemporary methods and technologies into teaching or education is a means of following the trends of contemporary industry or technological change. This hypothesis was confirmed, as it was demonstrated that the inclusion of contemporary technologies in the classroom leads to a better understanding and knowledge of the field, which the students will be able to apply in the future. Contemporary processing procedures, smart materials, artificial intelligence, etc., are inevitably becoming a part of our lives. Students need to be taught about contemporary technological processes and devices. At the same time, of course, manual work and motor skills, which students acquire by working in a school workshop with hand tools, should not be neglected.

Conclusions and Implications

It has been confirmed that Slovenian schools do not follow the trends of technology development. As the results of this research have shown, teachers in Slovenia often do not have the appropriate equipment (for example, contemporary processing devices and machines), so they rarely or never teach students about these contents. Among the reasons for the lack of such equipment, most teachers pointed out that the school does not have sufficient funds to purchase these devices. Therefore, reforms should be prepared, and changes should be gradually introduced in education. These changes do not only refer to increasing funds and acquiring technology, but also to educating teachers: if teachers do not know how to work with technology, then its involvement in lessons does not make sense. It has been found that teachers are willing to further educate themselves for this purpose. In this respect, a comprehensive procurement and education system should be established. One of the possible solutions is definitely collaboration between a school and companies in its local area, and/or collaboration between several schools. In this way, financial investments in purchasing technology and educating teachers would be optimized, and students would gain new knowledge. Moreover, this would be a way for education to keep up with the pace of technological change, and thus begin to reduce the gap between knowledge and technological progress in students. More time and effort should be devoted to this topic, and possible guidelines for addressing these issues should be prepared collaboratively. It can be concluded that much remains to be done in this field, and that matters need to be addressed systematically with respect to the various specific areas within this field.

References

Aberšek, B. (2018). *Problem-based learning and proprioception.* Cambridge Scholars Publishing.

Cavas, B. (2019). Industry 4.0 and science education. *Journal of Baltic Science Education*, *18*(5), 652-653. https://dx.doi.org/10.33225/jbse/19.18.652

Doulík, P., & Škoda, J. (2009). Challenges of contemporary Science education. *Problems of Education in the 21st Century*, *11*, 28-36. http://www.scientiasocialis.lt/pec/node/files/pdf/Doulik_Vol.11.pdf

Gaber, S., Marjanovič Umek, L., & Tašner, V. (2017). *Zastavki problematik prihodnosti sodobnih družb in šole, Prihodnost šole v družbah dela brez dela* [The problem of the future of modern societies and schools, the future of school in the societies of work without work]. Pedagoška fakulteta Univerze v Ljubljani.

Kannan, A. (2020). *Smart vs. traditional manufacturing: A "Never-Before-Seen" comparison*. https://www.hakunamatata.in/our-resources/blog/smart-manufacturing-vs-traditional-manufacturing/

Marr, B. (2020). *What is industry 4.0? Here's a super easy explanation for anyone.* Forbes Media LLC. https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#b5b7ad59788a

Roser, C. (2017). *Industry 4.0.* https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#b5b7ad59788a

Society 5.0. (2020). https://www8.cao.go.jp/cstp/english/society5_0/index.html

Vidmar, T. (2009). *Vzgoja in izobraževanje v antiki in srednjem veku* [Education in antiquand medieval times]. Znanstvena založba Filozofske fakultete Univerze v Ljubljani.

West, D. (2015). Kaj se zgodi, če nam roboti ukradejo službe? Vpliv tehnologij na zaposlovanje in javne politike [What happens if robots steal our jobs? Impact of technologies on employment and public policies] In Gaber s. & Tašner, V. (Eds.), *Prihodnost šole v družbah dela brez dela* [The future of schools in work-free societies, the future of school in societis without work] (1st ed., pp. 149–184). Pedagoška fakulteta Univerze v Ljubljani.

Zakrajšek, S. (2016). *Nujne spremembe v osnovni šoli zaradi sodobnih tehnologij* [Urgent changes in elementary school due to modern technologies]. Biteks.

Received 22 May 2020; Accepted 29 June 2020

Cite as: Zemljak, D., & Aberšek, B. (2020). Integration and use of contemporary technologies in STEM education. *Gamtamokslinis ugdymas / Natural Science Education, 17*(1), 44-52.

Dejan Zemljak
MSc, Assistant, Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška cesta 160, 2000 Maribor, Slovenia.
E-mail: dejan.zemljak1@um.si
Website: https://www.researchgate.net/profile/Dejan_Zemljak

Boris Aberšek
PhD., Professor, Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška cesta 160, 2000 Maribor, Slovenia.
E-mail: boris.abersek@um.si
Website: https://www.researchgate.net/profile/Boris_Abersek