ICTE Journal

Volume 9 2020/1

International Journal of Information and Communication Technologies in Education

editorial

CAN A GLOBAL CORONAVIRUS PANDEMIC CHANGE ACCESS TO TEACHING IN SCHOOLS?
Tomas Javorcik 3

articles

USE OF MOBILE APPLICATIONS IN PRIMARY EDUCATION THAT PUPILS CAN USE AT HOME
Natálie Nevřelová 5

ENHANCING COURSE REALISM: INTEGRATING FEDERAL CRIME DATA SETS IN A DATABASE MANAGEMENT COURSE
Daniel Adrian Doss, Balakrishna Gokaraju, Raymond Tesiero, Linda Taylor, David Hughes McElreath, Qiuqi Hong, Xi Wang, Harli Standish, Marcus Hudgins 15

ROBOTIC CONSTRUCTION KITS AT ELEMENTARY SCHOOL EDUCATION
Petr Coufal 27

THE PROCESS OF DEVELOPMENT AND EXPERT VALIDATION OF THE ATTITUDES SURVEY ON TEACHING OF PROGRAMMING IN COMPUTER SCIENCE LESSONS
Tomáš Hornik 39

ICTE Journal

International Journal of Information and Communication Technologies in Education

ISSN 1805-3726

Volume 9, 2020/1 (issued on December 31, 2020)

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http://periodika.osu.cz/ictejournal/

Can a global coronavirus pandemic change access to teaching in schools?

The current pandemic has affected all sectors of human activity. Education was no exception. Virtually all levels of education, except perhaps pre-primary education, have been forced to adopt alternatives. We can already state today that this period pointed out several problems not only of Czech education.

1. Obsolete technology

In many texts that came out before this pandemic, we could read about how well schools are equipped. Unfortunately, this time has shown that this is not exactly what some expected. There are relatively large differences between individual schools. Some schools have shown that although they have the technical means to teach online, their teachers cannot use the technique. The lack of suitable technology was also on the other side of the educational process for pupils and students.

2. The approach of teachers

The constant conservative approach of some teachers, relying on years of proven teaching methods, cannot be applied now. These teachers were then thrown into the endless waters of technology they could not use. Nor can one constantly rely on new teachers, who often get bogged down in the same dormitories as their more experienced colleagues.

3. Inconsistency

There are many approaches to how online learning can be implemented. It is not clear for sure (at least for now) which one is the best. Likewise, it is not possible to dictate to schools and their management how to proceed in online teaching. Unfortunately, during the pandemic, we were able to come across different solutions within one school. The non-uniform system of online teaching then caused pupils to have information on various platforms - often also through printed documents sent by post, email or to their parents' mobile phone.

At the beginning of the pandemic, the situation regarding the digitization of education and online teaching was underestimated. From another point of view, however, we can take the coronavirus as an accelerator of change at all levels of education and at the same time the opportunity to explore the benefits of online teaching and the use of ICT in education in the most realistic conditions.

Tomas Javorcik

Executive Editor

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ICTE Journal

2020, 9(1): 5–14
DOI: 10.2478/ijicte-2020-0001

USE OF MOBILE APPLICATIONS IN PRIMARY EDUCATION THAT PUPILS CAN USE AT HOME

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ABSTRACT

Nowadays, children are constantly surrounded by mobile technologies. Children use them from an early age. Some teachers perceive them negatively, but they can assist in teaching if we use them appropriately. This work presents findings of some possibilities for using mobile technologies, especially the applications in teaching in primary education and the applications usable at home. The applications usable at home can motivate pupils and in these days of quarantine is very needed. The chapter focuses on the educational potential of applications usable at home for support in primary education and how the teacher can evaluate children using these applications. The chapter presents the opportunities that educational applications brings to primary education. The author gives a brief overview of selected applications suitable for primary school children. They then focus on Socrative, Kahoot and Toglic which were used in Primary school in each grade. We will also present a proposal for this research – experiment. We will focus on its possible objectives.

KEYWORDS

Mobile applications, digital technology, primary education, creativity and competences of a child.

1 INTRODUCTION

Nowadays, digital and mobile technologies are part of the everyday life of children in both pre-primary and primary education. Sociologists classify children born after 2000 as the Generation Z. Other experts date Generation Z from 1994 to 2004 and any children born later belong to the youngest Generation Alpha. The term Alpha was coined by Mark McCrindle. He said that last children who will still belong to this generation will be born in 2025.

Joanne G. Sujansky and Jan Ferri-Reed (2009) wrote their book „Keeping the Millennials“ that young people have an ability of multitasking. It means that they are able to work on a computer, watch TV, listen to music and write messages at the same time. It is essential that pupils in pre-primary and primary education know about possibilities of using smartphones and other technologies. It increases their digital literacy. Ulrich Hoppe said that technology creates new conditions for learning and new ways of learning can arise.

Ivan Kalas (2010) said that ICT can also help children do many of things. Information Communication Technology can serve as the environment and tools for the development of a child. We should encourage young children to apply ICT tools for their own purposes in their play.

Most educational experts agree and believe that digital technologies can support pupils competence development. Majority of digital researches have confirmed these discussions and have found that new

technologies impact children's lives significantly. On the other hand, there are studies warning about various risks that need to be considered. Most of these doubts are based predominantly on the misconception that modern technology in education makes pupils passive receivers or lonely computer game players. For using digital technologies in pre-primary and primary education, it is necessary to determine the digital product suitability and adequacy with respect for children's age, select carefully appropriate applications and place them into constructive digital environment/context.

Sylva and Siraj-Blatchford (2006) identified four key areas of learning in Early Childhood Environments (ECE). It is the educational theory section about learning (formal and informal) young children under the age of 8 and it reflects how and in which areas ICT can support them.

They are:

communication and cooperation – they appear naturally in collaborative problem solving – applications based on experiments with programmable toys

creativity – children have to acquire schemes and need playful dispositions to try these schemes in a new context to be creative

sociodramatic play – there is a lot of space to integrate ICT into the playing young children environment

learn to learn – there is evidence that computers help young children think of thinking.

Constructivist teaching approaches and pedagogical research concerned with the application of this theoretical direction to teaching have often been an interest of researches (e.g., Bodner, 1986, pp. 875–876; Held, Pupala, & Osuská, 1994; Renström, Andersson, & Marton, 1990; Žoldošová & Prokop, 2007). They deal with basic questions of science principles of using Augmented Reality in primary education. This trend in research has found continued motivation, both abroad, because children often use only rote memorization as their learning technique without gaining any in-depth understanding of subject's essence (Tóthová, 2014).

Arnheim (2004) argued for the unity of perception and abstract thinking, according to which mental processes do Augmented Reality Applications in Early Childhood Education not only consist of operations with words and numbers, but also imaginary thinking.

2 LIST OF APPLICATIONS USABLE AT THE LOWER SCHOOL LEVEL AND USABLE AT HOME

Now, when the schools are closed, many companies are trying to help parents who have to educate their children at home. Teachers need to adapt their teaching to the current situation. In Czech Republic there are many web sites that are useful and suitable for home exercise. List of them:

www.skolakov.eu – children can practice Math, Czech, English and Science, practicing is on this website using the game

www.matika.in – children can practice Math (the Hejny method, where pupils orient in several mediums)

www.onlinecviceni.cz – children can practice Math and Czech

www.umimecesky.cz – children can practice Czech

www.grammar.in – children can practice Czech, there are many games

www.zlatka.in – children can learn and practice the financial literacy

www.naberanku.cz – children can practice Czech, Math, English, Music

www.e-skola.zolta.cz/vyukove-aplikace-online/ - children can practice languages and Math

www.vyukovematerialy.eu – children can practice writing, reading, Math, Science, Music.

www.mojecestina.cz – children can practice Czech (3 – 5 grade)

www.zssm.cz/dokumenty/online_zdroje.pdf - in this list we have all important websites usable in primary school

www.khanovaskola.cz / www.khanacademy.org – in English – these websites contains a tutorial videos

Subsequent applications were tested in teaching in 2019/2020. We chose some which can be applied suitably at primary school and at home.

Quiver - Quiver App combines physical coloring with state of the art augmented reality technology. The Platonic Solids is a part of the Quiver educational application. We can visualise Platonic bodies by it. Pupils at the first level can get to know formations in three-dimensional space and, for example, look for the geometric shapes which they already know - square, triangle. This application is suitable for mathematics, but by using other printable worksheets, it is also applicable to natural sciences. Therefore we use the STEAM concept.

Socrative – Is an App but can also be used on web site. Students answering formative assessment question in a variety of formats – answering can be by select right answer or write word or sentence or choose yes or no. Teacher immediately sees the child's answers so can evaluate it. The App is separately for teachers and for students. It can be used for any subject.

Kahoot – This App is also usable at home. It is a motivating application where pupils can practise any subject. The quizzes are created by teachers or they can choose from quizzes in the storage and teachers see the results of children then. Children see their classmates doing and it can motivate them to work better. Disadvantages are that there is no possibility to react as the teacher (feedback or rating). It is more like game but game with practicing curriculum.

Toglic – is a website where you will find a tool with which you can easily create interesting teaching activities that you will use in teaching at the 1st and 2nd grade of elementary school. You can create individual activities quickly and you can choose from a set of 15 interesting learning activities. For the children it is intuitive and easy. It can be use for many subjects.

Padlet – is a digital blackboard to create projects that are easy to share with children or parents. Children can upload media here (video, photos, recordings, documents). We use this application for uploading homework during home teaching. Pupils simply upload a file and the teacher can comment and rate it. Other children also see the work from others. It can be used as an application or website.

Seesaw – is the best platform for children to share their learning. Each child has their own portfolio, where they can upload any medium and the teacher can write and evaluate them. Parents also have access to the child's portfolio, so they see the work that pupils do at school. Now in home education, this application is used a lot when submitting work.

Google meet – it is very easy for online education. Anyone can join a meeting on Meet if they have got a link. The call is unlimited and can be attended by up to 250 participants. The teacher can turn off the pupil's microphones and simply record the lesson or share the screen.

3 ACTION RESEARCH

The action research took place at the Elementary school and Kindergarten in Ludgeřovice, where I have been teaching the first level pupils for four years. We use technology mainly for repeating curriculum, and also for pupil motivation. The school has 120 iPads, Dash and Dot robots, Ozobots, Lego Mindstorm, Beebots and Micro:bits that are used by teachers in their classrooms as needed. There is also a class of iPads in education, where we do more advanced work with iPads and robots. From kindergarten and at the first level (1st - 2nd class), we begin to program Bee-bot called "robotic bees", which are very intuitive and simple. Then we follow to program Ozobots (3rd - 4th class), which are programmed by colour combinations or by programming language on a PC or iPad. We use Dash and Dot robots in the 3rd class by using simpler applications and we build codes in the programming language with older pupils in the 4th and 5th classes. With robots we start using iPads from the first class, which pupils have in the classroom 1: 1.

In 2020 we did action research in the 1st class at the first level at Elementary School in Ludgeřovice. There were 23 pupils in the class. Because of quarantine in the Czech Republic we focused on children's work at home with modern technologies. Pupils had experiences with iPads from school and were able to control them.

We determined a research problem:

What is the function of online applications in teaching at home?

Research questions we focus on in this text, are as follows:

Do online applications motivate children in school preparation at home?

How students showed their motivation by online applications?

What parents see as positive about online applications?

Technique of collecting data were depth interviews method with teachers and children and video recordings from online lessons used by Google meet. The conversations were recorded using Google meet. Based on this coding, we identified key categories and these categories we began to descriptively process in detail. By using the qualitative research method – observation and case study - was found following information for several used applications and websites. The case study is here usually presented as a strategy allowing a detailed interpretation of all the factors involved in the case. The keystone is collecting. Almost all known techniques are commonly used in case studies data collection. Questionnaires, interviews with the main actors, all of them are used forms of observation and analysis of key documents. Each research report includes a methodological chapter which: it actually describes what we did during the research and why. The basis of the case investigation must be the collection of real data relating to the research object (case). It is always important that in the case study the researcher strives for a comprehensive understanding the case in its natural environment. The aim is to interpret interaction between the case and the environment. To complete this task requires obtaining large amounts of data from a variety of sources. From this point of view case study is a real research strategy and not a single technique. The researcher uses more information sources and all available data collection methods. The data is based on a systematic comparison and search periodicity segment into a system of categories. The emphasis is on the graphic representation and creation of case relational networks.

Coding

Different words or phrases can be used to create code names. The aim is to make the names comprehensible to research and describe its way of understanding the concrete section. As codes can be used common words, technical terms or so-called vivo codes, which are quotes from statements of respondents that capture the meaning of the section.

Apps used during quarantine:

In the research we observed pupils in the digital environment of certain applications. We observed their behaviour during using applications, whether they were motivated by their work and parent's views on what they think about teaching online.

Mainly we use applications during our online meetings with kids, which are – Socrative, Kahoot and Toglic. It is because it can be use on the website. Not all students have iPads or smartphones with the possibility of installation application. Pupils practice the already discussed subject with these applications. Parents do not help them, so they are more independent. From the pedagogical point of view, working with these applications after or during online lesson, is motivating.

Pupils worked with one application once a week in each subject. They had not known before which information was supposed to be brought by application. They worked with this application for about 15 minutes, after each start each pupil had a different answers that they could do this test more times. After work with these applications, the teacher sees the student's results and then in the online lesson he knows which subject to practice. After all outputs, the pupils and I discussed about curriculum. This application helps pupils with practice the curriculum and motivate them for next learning. Application Kahoot show them continuous results of other pupils so they were motivated and try it more times.

Show Names Show Answers

Name	Progress (%)	1	2	3	4	5	6	7	8
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	C	A	A	B	B	C	B
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	B
*****	100% ✓	B	B	A	A	B	B	C	A
*****	0%								
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
*****	100% ✓	B	B	A	A	B	B	C	A
Class Total		100%	93%	100%	100%	100%	100%	100%	86%

Figure 1 Results Socrative

CASE STUDY – ELABORATION

The case study for data acquisition was used as a research method. A case study is a focusing on a group of pupils and in the subsequent observation and description of all relevant aspects its behaviour or development. This group of people communicate with each other in the form of group interview. The main method of qualitative research was an unstructured observation. It means the observer minimizes interaction

with pupils. By observing we can see the creativity, motivation, digital literacy and independence through online applications. We used a direct observation - observation of communication among pupils and also an indirect observation - observation of real situations during online education.

Research implementation - data collection was realized during an action research with pupils in the 1st class at the Primary school in Ludgeřovice in Czech republic in 2020, in which 23 pupils participated. By using the online meet, pupils were expected to be more open and to share their views more easily. The teacher was here as a guide, asking questions and encouraging children to answer them. At the beginning of the online meet, the teacher challenged pupils to answer the questions and to share their opinions and remarks. The questions were: „What did you like most when we were using apps (Socrative, Kahoot, Toglic)?“ „Do you think you learned something interesting?“ „What surprised you?“ „What did you not like?“ „Would you like to do it during other online meetings or subjects?“

We used a recording during online meet with pupils and we have test results. The pupils answered and reflected on their work with the application during 15 minutes of the lesson. These records were then transcribed to a written form. The transcript was written as open coding and individual categories were created. (Tab.1) We obtained the main ideas expressed by a specific sentence (concepts), which were categorized in the statement protocol.

We performed observation of the action research at the Elementary school in Ludgeřovice between March – May 2020. The observed pupils were from 1st class. There were 23 children in the research. The aim of the unstructured observation were proceedings of the teaching process via his/her teaching, the teacher began to consciously support the pupil’s digital literacy development through applications on Ipads – during October 2019 - February 2020.

The pupils worked individually. They participated in achieving of the same goal through their activities, but also in fulfiling their own individual goals. Pupils shared their experience with others. They communicated over the images and questions without realizing that this way they were learning. Direct and indirect observations were registred to a written protocol (see Table 2).

By indirect observation we searched for the presence of a phenomenon - its occurrence, in which situations it occurs and how often it occurs. Pupils showed their commitment and motivation by repeating tests and quizzes. They tried it again until they got the right result for all the answers. Also, 100 percent participation in quizzes and tests is a sign that testing is motivated by children. When teacher sent the worksheet and the quiz, the quiz was more successful because the children wanted to talk about it and want to share the results.

During the analysis of pupil’s statements, all statements were included to search for an insight in how to use best the possibilities of the applications (Kahoot, Socrative, Toglic) in the online teaching process. Through using open coding the process of data exploring, comparing, categorizing, coding and conceptualizing was implemented.

Table 1 Statement snippets of pupils

Statements	Codes
I liked when I used PC during lessons.	MF
I liked when the teacher sent me a Kahoot code to practice.	TR
I liked when I see how practice other classmates. I want to be better.	CHP
I learned to work with tablet more.	CHP
I tried tests more times if I have got some mistake.	CHP
I did not learn, I rather played on tablet.	MF
I hope we will use these applications more at school.	MF
If the test was from reading-book I had to read it more time.	TR
It is better than writing.	MF
I liked it.	MF
I have a mobile phone and it is so small for test, my mum prints it for me.	TR

Table 2 List of identified categories, concepts and codes in the protocol.

Interpretative category	Concepts	Codes
Child's performance	The child is improving his / her potential and abilities.	CHP
Teaching methods and formes	Individual work. Working with tablet.	MF
The teacher's role	Teacher as an advisor, an observer. The child gets information in different ways.	TR

We had an online meet with parents. The teacher was here as a guide and asking questions. At the beginning of the online meet, the teacher had questions to them. The questions were: „What is positive when your kid using application during lesson (Socrative, Kahoot, Toglic)?“ „Do you think your kid learned something interesting and new?“

We used a recording during online meet with parents. These records were then transcribed to a written form. The transcript was written as open coding and individual categories were created. (Tab. 3) We obtained the main ideas expressed by a specific sentence (concepts), which were categorized in the statement protocol.

Table 3 Statement snippets of parents

Characters we observed	Statements
How online applications motivate children at home.	My son always sees such online tasks as a reward and enjoys it.
	He enjoys everything, but most work on the tablet. It could be more.
	I like that points are collected in applications, so the child does not give up in the middle but completes the whole test.
Function of online applications in teaching at home.	
	It is good that practicing on the iPad isn't much and it's connected with the curriculum.
	The advantage is that I don't have to sit with my daughter for applications, she manages it herself and the results are immediately visible to her and the teacher.
	These applications are mainly for practicing, children love it and motivate them.
	It is very easy for use these applications.

CONCLUSION

At this time, digital technologies are a desirable tool in education. They are not only an excellent motivational element, but they can also influence several senses of pupils at the same time, and, in that way, instil the curriculum more permanently.

The research aim was to create a model for didactic support to develop digital literacy of children in primary education through online education. The main aim was to find out the impact and benefits of online applications on development of children's digital literacy. The online applications contribution in the area of the children's digital literacy development was significant among the pupils. While children were playing with tablet, a high level of engagement and motivation were observed.

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ICTE Journal

2020, 9(1): 15–26
DOI: 10.2478/ijicte-2020-0002

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ABSTRACT

The purpose of this case study was to gain some insight and understanding regarding the use of real federal data sets within a database management course. This case study examined student perceptions of experiencing the use of real federal crime data sets within a database management course. This case study employed a qualitative approach to examining student perceptions of experiencing realistic data sets in a database management course. Students enrolled in the database course were queried using open-ended, standardized questions. Content analysis was used to identify themes. Four themes emerged: increased complexity and rigor; awareness and understanding of database technical concepts; database awareness and understanding; and awareness and understanding regarding societal crime. The use of federal data sets provided the opportunity to interject some amount of realism within the course learning experience thereby possibly producing graduates of greater knowledge and skill. It appeared that incorporating actual federal data sets enhanced course complexity and difficulty while contributing to a stronger student understanding of challenges associated with implementing realistic data sets.

KEYWORDS

Computer Science, Course Design, Criminal Justice, Database, Database Management, Higher Education, Learning Style, Teaching Style.

1 INTRODUCTION

In the United States, the 1990 Perkins Act defined vocational education as the "organized educational programs offering a sequence of courses which are directly related to the preparation of individuals in paid or unpaid employment in current or emerging occupations requiring other than a baccalaureate or advanced degree" (National Center for Education Statistics, 2020, p. 1). One such occupation involves the vocation of database administration (Foster & Godbole, 2016). Foster and Godbole (2016) indicated that vocational aspects of database administration necessitated knowledge and acumen in the topics of creating, installing, and configuring databases; security; backups and recoveries; tuning; removal; and database management.

Such courses are taught among vocational and certificate programs at higher education institutions (Kamberg, 2018). For instance, Hillsborough Community College, located in Florida, taught a variety of courses pertinent to database concepts as components of its undergraduate certificate program (Hillsborough Community College, 2020). Its curriculum consisted of courses in database design, database administration, and database programming (Hillsborough Community College, 2020). Similarly, Durham Technical Community College in North Carolina taught courses in the field of database programming (Durham Technical Community College, 2020). Courses also were components of programs that led to "Associate degrees, diplomas, and certificates" (Durham Technical Community College, 2020, p. 1). Atlanta Technical College in Georgia offered a vocational certificate program database administration (Atlanta Technical College, 2020). Its curriculum consisted of courses in database management; Oracle databases and administration; and UNIX/Linux operating system (Atlanta Technical College, 2020).

Some people questioned the quality and integrity of vocational studies (Barnett & Ryan, 2005). Concerns also existed regarding "issues in curriculum, assessment, and certification" (Barnett & Ryan, 2005, p. 91). Such notions may be considered from the perspective of database courses. Yue (2013) indicated that a lack of realistic data sets affected the practicality of database course learning environments. Yue (2013) examined the data sets associated with prominent database textbooks. Yue (2013) showed that available textbook databases for supporting database courses were derived from 'toy' projects, were small in scope and size, and were highly simplistic. Yue (2013) also indicated that simplification prepared students neither well nor sufficiently for the complexities of reality among actual workplace settings. Similarly, Jukic and Gray (2008) emphasized that such inferior resources would absolutely fail to adequately prepare students for experiencing the scopes, sizes, and complexities of problems, database issues, and data sets that would be faced when entering a career.

Halawah (2011) pointed out that dynamic educational and learning experiences that had some linkage with the real world, coupled with students being dealt with as achievers and scholars, contributed toward enhanced motivation for learning. Learning experiences should be engaging, and students should be able to relate them to their everyday lives (Caruth, 2016). Additionally, not only should learning experiences have personal relevance, they should also have some influence concerning how students "imagine their future employment" (Heider, 2015, p. 186). Basically, professors should craft learning experiences that provide realism and that may be linked to the real world (Caruth, 2016).

McElreath et al. (2018) showed that the potential of gaining meaningful employment upon the completion of a learning experience catalyzed student motivation. Educational experiences were to be relevant and meaningful for their intended audiences (McElreath et al., 2018). The effectiveness and successfulness of a learning experience were to be demonstrated through skills improvement (McElreath et al., 2018). Proper accrediting of the learning experience should occur to enhance its credibility (McElreath et al., 2018).

Similar notions were reinforced by Arenas (2008) through observations that any educational experience should incorporate facets of "productive work" because it contributed toward the authenticity of the learning experience (p. 377).

Given the chasm between Yue's (2013) and Jukic and Gray's (2008) notions regarding the use of unrealistic, simplistic databases among classroom settings and Arenas's (2008), Caruth's (2016), Halawah's (2011), and McElreath et al.'s (2018) calls for learning and educational experiences to reflect and associate with reality, questions emerge: How does someone improve learning assignments and resources among database classes to reflect the complexities of reality? How can assignments be crafted to foster critical analysis and problem-solving thought with respect to a realistic scenario? Thus, the purpose of this case study was to gain some insight and understanding regarding the use of real federal data sets within a database management course.

2 THE DATABASE COURSE

The database course occurred throughout a 16-week semester. The first eight weeks emphasized theoretical concepts whereas the latter eight weeks focused upon completion of the course project assignment. Typically, as prerequisites, students possessed a year of programming experience as well as completion of a systems analysis and design course. The database course occurred annually during the fall semester at an institution that exhibited accreditation from the Accreditation Board for Engineering and Technology (ABET). During the course, students gained familiarity with Structured Query Language (SQL); learned how to integrate and embed SQL within a host language to support database interaction; learned the fundamental principles of requirements acquisition, database design, and development; implemented testing regimens regarding the gleaned requirements; learned how to normalize a database through third normal form (3NF); and exercised critical thinking skills to solve a variety of problems ranging from integration issues to project scheduling.

3 THE COURSE ASSIGNMENT

The primary assignment consisted of requirement development, database design, database testing, and database implementation. On the surface, the practical aspects of the assignment necessitated the creation of a functioning database that allowed users to query and generate reports for American crime over a period of 54 years of data. The database assignment facilitated the querying of crimes representing incidents of violence, murder and non-negligent homicide; legacy rape; revised rape; robbery; aggravated assault; property crime; burglary; larceny; motor vehicle theft; and cybercrime. It also provided an opportunity to incorporate a straightforward process of analysis, design, development, implementation, and evaluation for constructing the database project. Students were divided into groups, charged with devising a project completion plan, and directed to craft a group learning and activities compact for governing group performance and behavior. Students were also tasked with determining a group leader.

4 DATA SOURCES

The course assignment included a two-fold problem involving the lack of database realism in educational settings and the lack of a database resource for housing integrated crime data sets reflecting crime in both physical reality and the virtual domain. Addressing these shortcomings necessitated the use of two existing products: Uniform Crime Reports (UCR) and Internet Crime Complaint Center (IC3) Annual Reports. Published since 1930, the UCR amalgamated data from approximately 17,000 law enforcement organizations throughout the United States each year (McElreath et al., 2013). Published since 2000, the

IC3 Annual Report detailed "Intellectual Property Rights (IPR) matters, Computer Intrusions (hacking), Economic Espionage (Theft of Trade Secrets), Online Extortion, International Money Laundering, Identity Theft, and a growing list of Internet facilitated crimes" (IC3, 2018, p. 1).

5 UNIFORM CRIME REPORT (UCR) DATA

At the time of the assignment, the 2014 year represented the most recent UCR data set. Students obtained both national and state aggregate UCR crime data for the period between 1960 and 2014. Data values represented annual aggregates for the crimes of violence, murder and non-negligent homicide; legacy rape; revised rape; robbery; aggravated assault; property crime; burglary; larceny; and motor vehicle theft. For each individual year, students used both raw aggregate values and a ratio of crime incidents per 100,000 population for each crime category.

6 CYBERCRIME DATA

Students obtained IC3 data sets representing the period between 2001 and 2017. No data sets for cybercrime existed before 2001. Cybercrime categories included various types of fraud; identity theft; harassment; data breach; financial crimes; misrepresentation; malicious software; counterfeiting and copyrights; denial of service; terrorism and hactivism; crimes against minors; ransomware; and gambling. The FBI's IC3 annual reports were the cybercrime data sources. Data values represented annual aggregates. However, unlike the UCR data, the IC3 annual data values were not available in the ratio terms of quantities of incidents per 100,000 population. Students converted the annual aggregates to the necessary per 100,000 population ratio values for each year using annual data from the U.S. Census Bureau. Both forms of crime data were included within the database assignment.

7 DATA INTEGRATION AND STUDENT CHALLENGES

Both the UCR and the IC3 existed as separate, independent entities. The UCR contained crimes that were reported in physical reality but lacked consideration of crimes that were reported in the virtual domain. It contained annual aggregate data for national crimes and corresponding annual aggregate data for each of the states. Aggregate UCR data was presented as either raw values or as incidents per 100,000 population for each year. Further, the UCR was available via the Internet, and anyone could access its contents. Although the IC3 also existed as an independent entity, it contained only crimes that were reported in the virtual domain. Publicly, the IC3 expressed annual cybercrime reports only within a PDF document – thus, no data set existed that could be queried electronically by the public using multiple variables. Students had to seed data within their assignments by transcribing the PDF data within their databases.

8 TECHNICAL CONSTRUCTS

Students selected Python as their language of choice for assignment completion. The Structured Query Language (SQL) was embedded within Python code as the primary database language. It also necessitated use of the MySQL database platform. Normalization of the database occurred through 3NF. Entity-relationship diagrams were used to model the database system. Relational calculus and algebra were used for query design and optimization. The use of MS Excel was disallowed; instead, students had to construct a database system using MySQL, SQL, and Python.

9 LIMITATIONS

This study was limited in that it addressed only a solitary institution of higher education. The perspectives gleaned represented only a single case study regarding the issue of enhancing course realism through the use of actual data sets. Despite its limitations, this case study may be viewed from the lens of transferability.

Ary, Jacobs, Sorensen, and Razavieh (2010) defined transferability as the "degree to which the findings of a qualitative study can be applied or generalized to other contexts or to other groups," (p.501). Although this case study examined a solitary institution, it may have transferability for similar institutions offering analogous database courses. Given (2008, p. 886) indicated that judgments concerning transferability may be made based upon considerations of "context, participants, and research design." Each individual reader may determine whether transferability is appropriate for their respective context and issue (Given, 2008).

10 METHODOLOGY

Terry and Braun (2017) stated that qualitative survey tools were useful for obtaining perspectives and views from respondents for the purpose of querying meaning or representation. Terry and Braun (2017) indicated that qualitative surveys typically consisted of an array of open-ended questions that facilitated free, open responses. The method incorporated an anonymous, end-of-semester qualitative survey to gauge student perceptions of the learning experience using real, large-scale data sets. Students enrolled in the database course were queried using open-ended, standardized questions. Although responses were anonymous, they were assigned a control number for data processing purposes. Over the period of 75 minutes, the qualitative surveys were administered during the last course meeting of the semester. Survey questions were designed with respect to ABET outcomes for accreditation and course experience. Derived from ABET tenets (Vanderbilt University, 2020), the course learning outcomes were as follows:

1. "an ability to apply knowledge of mathematics, science, and engineering" (Vanderbilt University, 2020, p. 1).
2. "knowledge of basic sciences, computer science, and engineering sciences necessary to analyze and design software" (Vanderbilt University, 2020, p. 1).
3. "an ability to identify, formulate, and solve engineering problems" (Vanderbilt University, 2020, p. 1).
4. "a knowledge of contemporary issues" (Vanderbilt University, 2020, p. 1).

The corresponding questions were:

1. How do you believe the use of real data enhanced the level of difficulty or challenge during the course? This question related to the outcome of applying knowledge of mathematics, science, and engineering.
2. How do you believe the use of the real data sets enhanced your understanding of system development and database technology? This question related to the outcome of demonstrating knowledge of basic sciences, computer science, and engineering sciences to analyze and design software.
3. How do you believe the use of real data enhanced the learning of database concepts per the course's goals and objectives? This question related to the outcome of identifying, formulating, and solving engineering problems.
4. How did the real data sets contribute to database course realism? This question related to the outcome of demonstrating a knowledge of contemporary issues.

Data collection occurred via the use of qualitative surveys. The interviewees were provided with a copy of the intended questions before the class session. Each subject was familiarized with the tenets of informed

consent. Implementation of questioning and the conduction of research occurred in conformance with institutional ethics requirements concerning the use of human subjects among research endeavors. Thus, ethical guidelines were integrated throughout the research process invoked herein.

Braun and Clarke (2013) noted that qualitative surveys, when administered by researchers, represented an interview that could occur in written form. Regarding qualitative research endeavors, Given (2008) stated that large sample sizes were inappropriate given the nature of qualitative research. Creswell (2013, p. 157) recommended no more than four to five sources for case studies within a solitary study because it provided "ample opportunity to examine themes." Creswell (2018) indicated that qualitative interviews involved a sample sufficient to generate saturation among respondents. Although the overall course enrollment consisted of 11 students, a total of eight respondents participated in this study. Thus, the quantity of respondents surpassed Creswell's (2013) minimum respondent quantity thereby enhancing trustworthiness and credibility within this study.

Seidman (2013) stated that qualitative inquiry involved establishing the credibility of the respondents and gleaning meaning and understanding of the lived experience. Responses were amalgamated and processed via content analysis. Konczal (2000) indicated that content analysis involved processing data into units that could be analyzed and examined for instances of concept frequency. Content analysis involved analyzing student responses to the aforementioned interview questions. Typically, content analysis was applicable for qualitative studies that described some phenomenon and for which literature was limited (Hsieh & Shannon, 2005). In such cases, predefined categories were unused; instead, categories emerged from the data (Kondracki & Wellman, 2002). Such an approach is termed inductive category development (Mayring, 2000). This study employed inductive category development as the basis for content analysis.

Within the annual reports, the IC3 aggregated data items were presented as either raw values or as incidents per 100,00 population only for the years between 2001 and 2011. After the year 2011, the annual reports lacked any reporting of incidents per 100,000 population thereby necessitating students to mathematically generate the appropriate values. In order to calculate the appropriate per 100,000 population ratios, population data was obtained from the U.S. Census Bureau. The annual quantity of cybercrimes reported was then divided by the population quantity and multiplied by the value of 100,000.

Data processing consisted of content analysis per the guidance of Konczal (2000) via the following process: sample selection, category definition, read and code, data analysis, generate inferences, and draw conclusions with respect to observed patterns. Coding was designed to reflect characteristics of realism, understanding, experience, critical thinking, and learning through which themes within the data were discovered. Responses were parsed three separate times for the following purposes: 1) content determination, 2) effect coding, and 3) themes identification. Each instance of a word or phrase reflecting realism, challenge, and education was counted to determine frequencies. Average quantities were derived by dividing the respective frequency counts by the number of respondents. Frequencies were also divided by these tallies to generate values that reflected the percentage of the overall total for each word or phrase within the content array.

Creswell (2013, p. 63) indicated that trustworthiness represented considerations of the "personal biography" of experience. Trustworthiness was addressed by acknowledging the lived experiences of the instructor, teaching assistants, and the students who experienced the database course. The instructional view represented the teaching and guiding of students; the assistant view represented tutorial and technical course

experiences; and the student view represented the completion of the course and its necessary assignments. All three groups had direct experience with the course and its database assignment.

11 FINDINGS OF THE FIRST QUESTION

The first question queried how respondents believed the use of real data enhanced the level of difficulty or challenge during the course. The dominant theme reflected perceptions of increased complexity and rigor of the course resulting from the use of real data sets. For instance, a respondent indicated, "it challenged each student beyond our comfort zones." Another stated, "The difficulty was enhanced due to the amount of data added." Experience also emerged among the responses. With respect to both the themes of critical thinking and experience, a respondent noted that difficulty increased in the time allotted for the assignment because "we had to do ancillary ratio calculations, make an ERD, normalize, and make software." Regarding awareness and understanding, a respondent expressed that "having so much data" increased the difficulty and challenge of programming.

12 FINDINGS OF THE SECOND QUESTION

The second question queried how respondents believed the use of the real data sets enhanced their understanding of system development and database technology. The dominant theme involved awareness and understanding of database technical concepts. For instance, a respondent indicated, "it also showed the difficulties of merging and integrating two different data sets even though both dealt with crime." Another stated, "I can better understand how to create a database." Critical thinking emerged as the second theme. As an example, a respondent expressed, "we were concerned with keeping our database structurally sound and accurate so we could debate the given data." Experience also emerged as a theme. For instance, a response indicated, "it gave us the opportunity to examine different data sets with the same basic information."

13 FINDINGS OF THE THIRD QUESTION

The third question queried how respondents believed the use of real data enhanced the learning of database concepts per the course's goals and objectives. The dominant theme reflected database awareness and understanding. For instance, a response indicated, "It helped me understand how data can be used to depict large scale statistics. Also, it helped me understand how you can make large sets and implement them in a variety of ways." Critical thinking also emerged as a theme. Beyond the database concepts emphasized in the course, a respondent pointed out, "it taught time management and organizational skills." Regarding the experience theme, a respondent expressed, "we had to do everything talked about in class and that we read about in the book – clean/parse the data, normalize the database, make queries, etc." Another respondent indicated that the assignment provided a "chance to actually work on such technology."

14 FINDINGS OF THE FOURTH QUESTION

The fourth question queried how using real data contributed to course realism. The dominant theme reflected awareness and understanding regarding societal crime. For instance, one respondent stated, "it helps us become more aware of actual attacks that occur every day." Another respondent indicated, "I was better equipped in understanding crime." Experience also emerged with respect to realism. A respondent mentioned that it provided "real life, hands-on experience of the topics we discussed for many weeks." Responses were also reflective of critical thinking. For instance, a response stated, "we had to do secondary calculations to make the category ratios." Another respondent said that data were not "always nice and clean and we sometimes have to fill in the blanks that are missing or find a way to work around them."

Regarding awareness, a respondent stated, it showed the "types of data and crimes that big agencies deal with."

15 CONCLUSIONS

The outcomes may be considered with respect to the ABET criteria and the corresponding research questions. The first criteria involved applied knowledge of mathematics, computer science, and engineering. Students were required to calculate mathematical ratios to perform baseline comparisons of crime data; used normalization techniques to generate 3NF for the constructed database; applied programming skills to generate database queries; and used software testing for quality assurance purposes. The second criteria involved knowledge of basic, computer, and engineering sciences to analyze and design software. Students designed, developed, tested, and implemented a functioning database thereby demonstrating computer science and software engineering skills. The third criteria involved an ability to identify, formulate, and solve engineering problems. Students integrated two separate date sets and generated equalizing ratios for the data. Students crafted source code and corresponding interfaces to facilitate system interaction. Students designed and implemented test cases and scenarios to ensure that requirements were satisfied. Thus, students demonstrated a knowledge of software engineering skills toward solving a variety of problems. The fourth outcome involved knowledge of contemporary issues. The project contributed toward an understanding of crime and virtual crimes and their respective societal impacts. The course improved coding skills to address realistic, practical problems in computer science and software engineering.

Four themes emerged from the first question: increased complexity/rigor of course, realistic experience, awareness and understanding, and critical thinking. Themes representing the second question included database awareness and understanding, critical thinking, and realistic experience. Themes that emerged from the third question included database awareness and understanding, critical thinking, and realistic experience. Three themes were present among responses to the fourth question: realistic database experience; crime awareness and understanding; and critical thinking.

With respect to didactical phenomenology, Treffers and Goffree (1985) advocated four functions that impacted learning:

1. Concept formation facilitating access to principles and concepts;
2. Model formation generating a foundation for learning necessary rules, operations, and procedures whereby critical thinking and relation to other models may occur;
3. Applicability of concepts within reality; and
4. Practice whereby specific skills are exercised during applied scenarios.

The last two functions identified by Treffers and Goffree (1985) involved applicability and practice. Regarding the database course experience, modeling concepts were applied to generate a database system integrating two real federal crime data sets. Students used a combination of the Python programming language and SQL to build the database in conjunction with the models generated during the design and development processes. Practical application facilitated interactive queries of the database system that produced real outcomes. Through applicability and practice, students started developing skills that may be attractive to potential employers. By using realistic data sets to develop such skills, students may be better able to conceptualize and understand employer expectations of new, entry-level hires.

Gorman et al. (1995) indicated that academic class environments typically compartmentalized learning experiences according to insular views of specific topic areas thereby providing an unrealistic perspective of applying course material. However, when experiencing an experimental, multidisciplinary course that integrated various disciplines, students learned that reality defied compartmentalization (Gorman et al., 1995). Similarly, Ktondou and Doukanan (2016) signified that multidisciplinary courses were useful for better investigating realistic cases of some phenomena and solving practical problems. Integrating the federal data sets provided a glimpse of reality for students given the multi-disciplinary approach to the course. Through incorporating two different federal data sets, it appeared that students gained insight regarding the realities of data and real-world issues involving both crime and technology. The students seemingly experienced integration issues whereby they realized that real-world data often necessitated parsing, cleaning, and formatting before data use occurred within a database application. It appeared that the use of real data sets also contributed toward a better student understanding of the dimensions and scopes of data sets that affect organizations.

The potential impact of this study may be considered from the perspectives of student recruiting and retention. Within the United States, enrollment decisions were influenced by elite institutional statuses and reputations whereas international students were influenced by their perceptions of specific majors and programs (Davies & Hammack, 2005). Less influence existed regarding perceptions of the overall institution (Davies & Hammack, 2005). Neumann, Hood, and Neumann (2013) indicated that using real data sets contributed toward enhancements in understanding and gaining meaning regarding course topics with respect to practical application. Neumann et al. (2013, p. 65) suggested that using real data sets contributed toward enhancements of "interest, motivation, and engagement." Using realistic data may improve perceptions of rigor and relevance among both domestic and international students regarding their respective colleges' choice processes. Higher education institutions hoping to attract students may consider this case study as useful when crafting and developing vocational credentials, programs, and courses that are relevant and meaningful from realistic perspectives. Through interjecting reality within course assignments and classroom settings, potential students may be lured toward the institutions or its courses.

The potential impacts of this study may also be considered from the perspectives of implications for policy and implications for practice. Given the potential enhancements in student "interest, motivation, and engagement" (Neumann et al., 2013, p. 65), organizational policy may require the use of realistic data sets when available and necessary. Doing so may bolster the efficacy of student learning throughout the class and program experiences. From the perspective of practice, using realistic data may contribute toward bettering student credentials upon graduation whereby they may be viewed with greater attractiveness by potential employers.

Jukic and Gray (2008) and Yue (2013) indicated that unrealistic data sets were commonly used among database courses. Such unrealistic tools insufficiently prepared students for workplace performance (Jukic & Gray, 2008; Yue, 2013). The use of federal data sets provided the opportunity to interject some amount of realism within the course learning experience thereby possibly producing graduates of greater knowledge and skill. This case study incorporated actual federal crime data sets as a means of interjecting realism within the academic setting. However, many other real data sets are publicly available that may suffice as resources for enhancing course realism and academic challenge. For instance, through the Internet site www.data.gov, faculty may access free and open federal data sets representing a multitude of areas. Examples of the available data set categories include agriculture, climate, consumer, ecosystem, education, energy, finance, health, government, manufacturing, maritime, ocean, public safety, science, and research

data sets. Instructors seeking to enhance the realism of their database courses (or computing courses that require data sets) may find such resources useful for their learning and teaching needs. Thus, future research studies may examine facets of course realism and student challenge from the perspective of using data sets other than crime and cybercrime.

Higher education institutions experienced competition for students (Doss, et al., 2015; Papadimitriou, 2018). Thus, colleges and universities must have some unique selling point to generate competitive advantage and differentiate themselves from other market competitors. Through advertising and marketing the use of real data sets within the course environment, institutions may establish themselves and generate familiarity and notoriety within their respective markets either institutionally or on a per course basis, perhaps. Future studies may examine the various selling points and competitive advantages of higher education institutions, faculty, and courses.

From the instructor's perspective, data sets are useful resources for illustrating different concepts and approaches, analytical methods, and applications toward solving realistic problems (Neumann et al., 2013). Regarding the student viewpoint, data sets are necessary for practicing relevant calculations, gaining experience, and developing reasoning abilities regarding problematic situations (Garfield & Ben-Zvi, 2009). This case study examined only the student perspective of using realistic data sets. Therefore, future research studies may examine the professorial perspective.

Doss et al. (2016) indicated that accreditation was of importance to academic programs and institutions. This case study examined only the perceptions of students representing an internal worldview with respect to the higher education institution. However, external views of the academic setting exist – accrediting bodies. Future studies may examine the perceptions of accrediting personnel regarding the use of real data sets within the vocational education setting.

Actual data sets were deemed as motivational tools that made learning meaningful and relevant while preparing students for reality (Diamond & Sztendur, 2002). Additionally, realistic data sets provided some insight to reality with respect to students who lacked any industry experience (Bradstreet, 1996). Future studies may be considered from such perspectives. After students graduate, enter the workforce, and gain some period of industry experience, future research studies may examine whether course graduates believe that the use of actual data sets truly contributed toward preparing them adequately for entry-level positions.

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ICTE Journal

2020, 9(1): 27–38
DOI: 10.1515/ijicte-2020-0003

ROBOTIC CONSTRUCTION KITS AT ELEMENTARY SCHOOL EDUCATION

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ABSTRACT

The article deals with the topic the development of key competencies of elementary school pupils by the means of a robotic construction kit in project-based learning. Introductory part of the article introduces the key issues and shows the individual working areas: robotic construction kits, project-based learning and key competencies of the pupils, focusing on the problem-solving competency. It also sets research goals, presents pilot research carried out in primary schools and its results. It also describes the main research, its main objectives, methodology, basics, planning and presentation of the first findings. Individual diagrams describe the course of research and the division of control and experimental groups of students in teaching programming using a robotic kit. The diagram shows the division of the method of teaching between the frontal learning and the project-based learning of pupils. This article provides an insight into the issue of teaching robotic kits in elementary schools.

KEYWORDS

Robotic construction kit, key competences of the pupils, project-based learning, research

1 INTRODUCTION

The article represents the introduction into the issues of educational robotic construction kits and systems, project-based learning and key competences of the pupils. It also outlines a plan for the research dealing with the aformentioned topics. The attention is payed to the evaluation of the pilot research with the help of questionnaires, which provided key information for further research survey. It also shows the main research survey as well as the information about its outcomes and results. The motivation and reason for choosing of such a topic is my own long-range interest in robotics and its teaching, mostly at elementary schools.

If the topic of the paper is further examined, it is posssible to divide it into three main parts. The first part is represented by robotic construction kits, the second by project-based learning and the last part consists of key competencies and their development. In the following chapters I deal with the specification of particular key concepts and their description. Current importance of the topic is evident by increasing interest in modern technologies and IT specialists, which has to be taken into consideration in education. Fortunately it is the part of project PRIM (Czech acronym for Support of the development of informational thinking).

2 THEORETICAL BASIS

2.1 Robotic construction kits

In 1920 Karel Čapek in his science fiction play R.U.R. (Rossumov's Universal Robots) used the word robot for the first time. The word originated from the expression robotovat (archaic term for work) and it was recommended to Karel Čapek by his brother, Josef (Coufal, 2016). The first writer who in his stories about robots for the first time mentioned robotics was Isaac Asimov (Coufal, 2016). According to Tocháček and Lapeš the robotics can be defined as "the field about creating of intelligent machines which integrates several scientific and engineering areas" or as "science about robots, their design, production and applications" (Tocháček, Lapeš, 2012). Robots and robotic sets can be divided on the basis of different criteria, stated by e.g. Novák (Novák, 2005) or aformetioned Tocháček and Lapeš (Tocháček, Lapeš, 2011).

The supply of robotic construction kits or educational robots have been increasing every year and thus the schools can choose the best considering their requirements and possibilities. The list of mostly used robotic kits at schools is shown further in the text. Arduino utilizes single-board computers based on microcontrollers ATmega which can be connected to servomotors, display and a large amount of other sensors. From the very beginning Arduino project is an open-source, which has lead to its extended use and popularity. It is used mainly in teaching of programming at high schools and universities. German robotic kit Fishertechnik, using plastic components, resembles Lego set and offers both robotic and non-robotic models in different versions with the usage of controllers. For programming of assembled models the set uses its own programme which enables programming with icons and it is suitable for elementary schools (Coufal, 2016). A very well-known children construction set Lego has already used several versions of controlling robotic unit which is joined to servmotors and sensors. Programming is also possible with iconographic programme. Similiar yet newer construction kit, using plastic structural components, is American set VEX IQ. It enables to plug much more I/O devices to the control unit and furthermore it can be manipulated by provided remote controller. Programming is again suitable even for elementary school pupils. For older, high-school and university students, is the set available in VEX EDR version, using more efficient control unit and metal construction parts. Traditional Czech construction set Merkur uses mostly metal parts and thanks to connection of electronic components and microcontrollers it is possible to build and programme robotic models on one own's choice.

2.2 Project-based learning

As a complex educational method for my research was chosen the project-based learning. The key component of project-based learning is a project. According to the founder of project method Killpatrick it can be stated that "*project is explicitly and clearly designed task that can be presented to a pupil as vitally important by approaching the real activity of the people´s lives*" (Coufalová, 2006). According to Maňák and Švec in project-based learning the person is solving a practical task, defined by its complexity and connection to the well-known reality of life. Project can be realized both in groups and individually. The essential part is always accurate lesson planning of project-based learning that guarantees avoidance of transforming learning into playing and disruption of educational aims (Tomková, Kašová, Dvořáková, 2009). As Tomková, Kašová and Dvořáková stated "*Project-based learning is a complex method enabling pupils touch the reality, experience new social roles, solve problems, interconnect and apply obtained findings from all fields of study during meaningful and useful work. It gives an opportunity for self-realization, motivates them to work individually, to search and discover, to cooperate and communicate. It shows how to think coherently and how to solve the given task systematically."* (Průcha, 2009).

Speaking from experience with project-based learning I can say at first it is more demanding considering the lesson planning, management and conducting the lesson itself. It also takes much more time, which is not such a big problem in after-school activities, but it can be an issue during the lessons at school. The learning method was also used during weekend camp meetings for the members of the robotic after-school clubs. The learning method is popular in the groups of pupils and students. According to the results, stated further in the article, it is a widespread and desired method when teaching programming with the help of robotic construction kits for both the pupils and older students.

2.3 Competencies of the pupils

Current society places heavy demands on the individual, as Zounek states, the school should represent a place for obtaining required competencies "*If the schools are supposed to become places where the pupils will gain the key competecies needed for their lives within the society, then the ICT devices have to necessarily become a common part of all crucial areas of school functioning as well as activities of all participants within the school education."* (Zounek, 2006, s.12)

The Czech National Curriculum Framework for elementary education introcudes particular key competencies. They are defined as follows: "*Key competencies represent a set of knowledge, skills, abilities, attitudes and values important for personal development and employment of each individual in the society. Their selection and conception are based on the values commonly accepted in the society and from generally shared ideas about which competencies of the individuals contribute to their education, satisfied and suscessful life and to strenghtening of the functions of civil society*." (RVP, 2007). It also shows the list of skills the pupil has at the end of elementary education. The pupil:

- "*perceives different problem situations both inside and outside the school, identifies and understands the problem, thinks about discrepancies and their causes, considers and plans the way of solving the problems and uses his or her own judgments and experience*
- *looks up the information sutitable for solving the problem, finds their same, similiar and different features, uses obtained knowledge and skills for discovering of different ways of solution, is not discouraged by possible failure and persistantly serches for the final solving of the problem*
- *looks for a solution on his or her own; chooses the suitable ways of solution; when solving a problem he or she uses logical, mathematical and empirical procedures*
- *practically verifies correctness of problem solutions, applies tried and tested procedures when dealing with similiar or new problem situations, observes own progress during managing the problems*
- *thinks critically, makes deliberate decisions, is able to defend them, understands the responsibilities for his or her own decisions and evaluates results of his or her actions*" (RVP, 2007)

The research deals with the problem solving competency of the pupils, which is defined by Knecht and Klieme as "target-oriented thinking and actions in such situations when the routine procedures are not available for their handling" (Knecht, 2014). In my research, I want to focus on the influence of the robotic kit on problem-solving competencies in primary school students.

2.4 Current situation of the given issues

The nature of cooperation in groups of elementary school pupils and high school students is examined by Yuen when solving robotic projects at a summer robotic camp. The research study shows how to, with the help of robotics, implement project group solving in education, and introduces the importance of

cooperation in the process of education. The findings of the study will contribute to the usage of robotic projects in education and to the increase in children motivation in STEM area (Yuen, & Timothy, 2014).

The paper of Virmes (2014) is dedicated to educational robotics, its description, division, definition and mostly to the influence on the process of education within the interaction with children. Mutual interaction is divided into four areas. The research was conducted in the year 2006-2011 at different educational facilities. The paper describes educational robots and robotic construction kits. Robotic sets are sorted according to the necessity of programming and controlling with the help of a computer. Goal of the research was to create a theory of children interaction with educational robotics. The research questions focus on observing of the children interaction with educational robotics, deal with the progress of the interaction, sorts of interaction, ways of work with educational robotics and impacts of the interaction. They use Lego Mindstorms NXT robotic set in the research, Topobo construction kit and RUBI social robot. The first research environment was the workshop with robotic set Lego Mindstorms NXT for a group of pupils aged 10-14, together with their teachers at a special school. All the children suffered from different kinds of learning disorders, attention deficit hyperactivity disorders (ADHD), autism spectrum disorders or speech disorders. The second environment was a workshop for kindergarten children aged 4-5, using Topobo construction kit. The third research environment used RUBI social robot in a pre-school educational centre for the children at the age from 15 to 23 months during everyday activities. Paper further presents the results of axial coding in four basic areas of the children interaction with educational robots as well as selective coding which showed different types of used educational robots. As the result it is possible to find the establishment and description of the theory of children interaction with educational robotics.

In another study Slangen asks what the pupils aged 10-12 can learn when using robots, working on the assumption that robotics is a parts of technological literacy. The study includes cognitive and conceptual analysis leading to creating the referential framework for establishing knowledge in robotics. From the point of view of difficulties four perspectives were distinguished: psychological, technological, functional and system controlling. The results are discussed concidering technological literacy of the pupils and learning possibilities in primary education (Slangen, 2011). As stated by Shih (2013) Lego NXT robotic construction kit has been used more and more often in different courses for creating of multimedia education materials. The topic of the research is the understanding of the factors influencing teachers' intentions to use Lego NXT robotic kit at an elementary school. Using TAM model (Technology Acceptance Model) the study gathered data from 17 elementary school teachers in Kaohsiung and Pingtung regions in Taiwan. SEM (Structural Equation Modelling) method helped testing of the hypotheses. Somyürek (2015) deals with the learning of construction skills of the pupils in his study. The published paper explaines the integration of robotics into education. Within the study 66 pupils aged 8-14 participated in experimental research. They used Lego Mindstorms robotic kits. The aim of the study was to analyse construction learning skills of the pupils. Based on the findings they can be divided into four parts: active learning, authentic learning, multiple perspectives and collaborative learning. The study was perceived in a positive way mainly because of following three reasons: exploring and finding of the solution, using of imagination, freedom in production. Also Kvenild (2017) focuses on the development of programming and digital skills in STEM area, for using of robotic construction sets and for expansion of curriculum when mentioning pre-school children to the elementary school ninth-graders.

3 RESEARCH AND RESEARCH AIMS

The aim of research paper is to find out the influence of the robotic construction kits used in project-based learning of programming on the development of pupils' competencies. From the long-term personal experience I suppose that working with robotic kits and systems influences the pupils and it causes changes in their competencies. I further focus on production of educational and methodical materials for different robotic kits and systems used in teaching of programming at elementary schools in the Czech Republic.

3.1 Aims of the reseach

- Analysis of the development of pupils' competencies mostly in areas of technical and algorithmic thinking in programming of robotic constructrion kits.
- Analysis of the influence of project-based learning of programming with the help of robotic sets on the development of competencies of the pupil.
- Establishment of the conditions of robotic kits and systems available at elementary schools and mapping of used teaching forms and methods.
- Writing of the list of existed researches in the area of using of robotic construction kits at elemenetary schools focusing on the key competencies of the pupils both in the Czech Republick and in the world.

3.2 Research questions

- What is the influence of education with robots or robotic construction kit on the development of key competencies of the pupils?
- How is the problem-solving competency influenced by education with robots of robotic construction kits?
- Is project-based learning suitable for all lessons in teaching of programming using robotic construction kits?

In the individual subparts of the research study we defined secondary research questions, focusing on the way and methods of teaching robotics, used robots or robotic sets and other key competencies of the pupils.

4 ORIGINAL RESEARCH

Original research dealt with findings and mapping of the situation considering used robotic construction kits and systems at elementary schools. It also focused on used forms and methods of education with the help of robotic sets. Original research included six secondary aims.

Regarding established aims the method of quantitative research was chosen to be the method in original research, including a questionnaire survey. Selected method is suitable for obtaining of the information from more significant amount of respondents.

4.1 Research sample and research method

When selecting the reserarch sample I proceeded with respect to the established aims, I chose elementary schools in the Czech Republic where the teachers used robotic construction kits in their lessons. This information was found on the websites of given schools, from the lists of robotic competitions members organized in the Czech Republic, e.g. First Lego League, Robosoutěž, Robotiáda etc. In total more than 150 schools were approached.

Answers from the respondents were aquired with the help of semi-structured questionnaire, available in two different versions – paper and electronic. Electronic version of my questionnaire was created in Google Forms application, where the application itself contributed to processing the results of questionnaire survey. The questionnaire was divided into four subparts according to research survey areas of interest. Semi-structured questionnaire enables obtaining the set of structured responses as well as answers to open-ended questions. The questionnaire, including the link to the form, was sent via email to all selected schools.

4.2 Results of the original research

The results of the original research were thoroughly statistically processed and evaluated in detail. Based on the given results, it is obvious, the most commonly used robotic construction kit at elementary schools is Lego Mindstorms, representing 74,2 %, followed by Fishertechnik set on the second place and then other robotic and construction kits Merkur, VEX IQ and Micro:bit.

From the obtained data is apparent most pupils work in groups containing 2-3 members, and such a size of working groups is preferred by the children themselves. In most cases (78,12 %) the lessons are led as all-group lesson, beginning with frontal method, adding project-based learning later during the lesson. Most of the respondents have already experienced at least some types of project-based learning. When dealing with their own projects, pupils prefer working in their own pace, having enough time to complete the task, even if they had to stay longer after the end of the lesson.

5 PILOT RESEARCH

Pilot research used obtained findings from original research and from data based on literary review. In practical part the survey worked with created methodical and teaching materials for using robotic kits.

5.1 Purpose of the study

Before the practical part of the dissertation an analysis of literary review data was realized. It focused both on Czech and foreign studies in the field in question. Already in this stage of the study was obvious the lack of large number of relevant published researches. Considering the development and increasing interest in using of robotic construction kits in elementary school education the pupils and their key competencies are being much more influenced. The research should clarify what influence have used robotic sets and project-learning method of teaching on the pupils and their key competencies. Thus its contribution can be seen in an appropriate determination and using of suitable robotic construction kits in education, preferably leading to contributive influence on pupils and their competencies.

5.2 Research sample and research methods

Research pilot testing sample was represented by a group of 18 pupils, attending the sixth grade of elementary school, in IKT subject (Czech abbreviation for Information and communication technologies). Regarding the school options and equipment the group is divided into two sub-groups which attend the lesson separately. The whole group was divided into halves, each of them including nine pupils. The first group was determined to be the control one, the second group was the experimental.

First group (FG) = Control group (CG)

Second group (SG) = Experimental group (EG)

The given class is taught IKT subject only once each week. The classroom is equipped with standard desktop computers. Pupils worked in groups, each of them including three children. The room offered enough space around every workplace, enabling driving the robotic models.

For the pilot testing was chosen combined research represented by pedagogical experiment with the help of non-standardized semi-structured questionnaire using self-evaluation questions. The scheme of pilot research can be seen in Figure 1, showing division of the pupils into two groups and the first testing with the help of a pretest. Another step was teaching of the individual pupils, when the control group was taught by a frontal method, experimental group by a project-based method. Considering the task, the pilot research is represented by explaining the theoretical basis of programming of the robot movement and by solving a complex task including a robot movement in the marked space. After the lesson there followed a posttest, in the same form as the pretest. The tests took into consideration obtaining new skills and knowledge in robot construction, robot programming, problem solving and mutual communication of the pupils in the team. It further included pupil's self-evaluation.

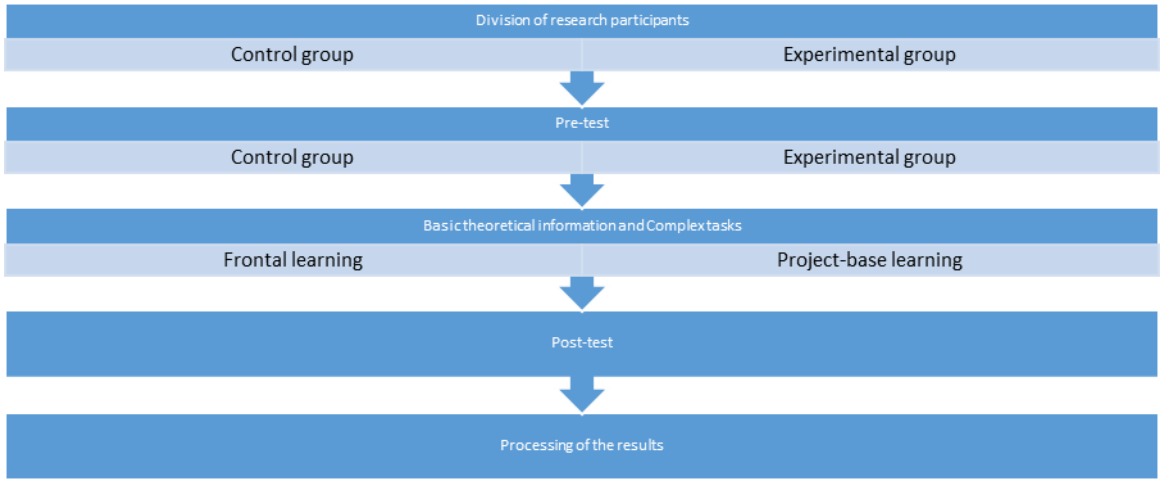


Figure 1 Pilot research scheme *(created by the author)*

Time schedule of the pilot research was split into lessons in 6 follow-up weeks, which was not a lot of time, considering one lesson a week. On the grounds of short time for pilot testing, lessons were focused on the basic controlling and programming of the robot movement, using the uncomplicated construction.

5.3 Results of the pilot testing

Pilot research was conducted on the basis of created teaching materials, under the tutelage of experienced teacher in two groups of pupils, attending the sixth grade of elementary school. In the lessons Lego Mindstorms robotic set was used.

For processing of the results was used Excel application, enabling the author to clearly arrange the findings using of visualization and schemes. The procedures of descriptive statistics were applied. Based on the findings it can be stated that the frontal method of teaching of the theoretical key knowledge about robot movement was more helpful for the pupils in comparison to project-based learning of theoretical basis. On the other hand solving of the complex task in which the robot was supposed to drive through the given space, the project-based method was assessed as much more convenient. Concerning the self-evaluation, pupils considered positively including of communicative competencies and using of problem-solving competencies. Pupils were choosing their agreement level with given statements on the Likert scale. From obtained answers it was possible to assess responses on main research questions. To confirm these results it will be convenient to use the results also from the main research, which will follow. At the moment, however, can be stated that the pupils' development of problem-solving key competence is being influenced by project-based education using the robotic construction kits.

Here occurs the question: What kinds of data influenced the results of the pilot testing? Above all it was the short period of time specified for pilot research, then created teaching materials, teacher's personality and his/her lesson planning, sufficient motivation of the pupils to the work at the end of school year, personal experience of the pupils with robotic construction kits and programming itself. Last, but not least the results were affected by the division of the pupils into separate working groups.

6 MAIN RESEARCH

Main research, reflecting the findings and correcting possible shortcomings in the pilot testing, was launched this spring on a larger scale and scheme. The main research takes significantly longer with more pupils and more teachers in order to reduce the influence of the teacher's personality to a minimum. Another expected change is to insert a test between the individual parts of the lesson (theoretical background information and solving a complex task) in order to determine the level at the beginning of the second part of the lesson.

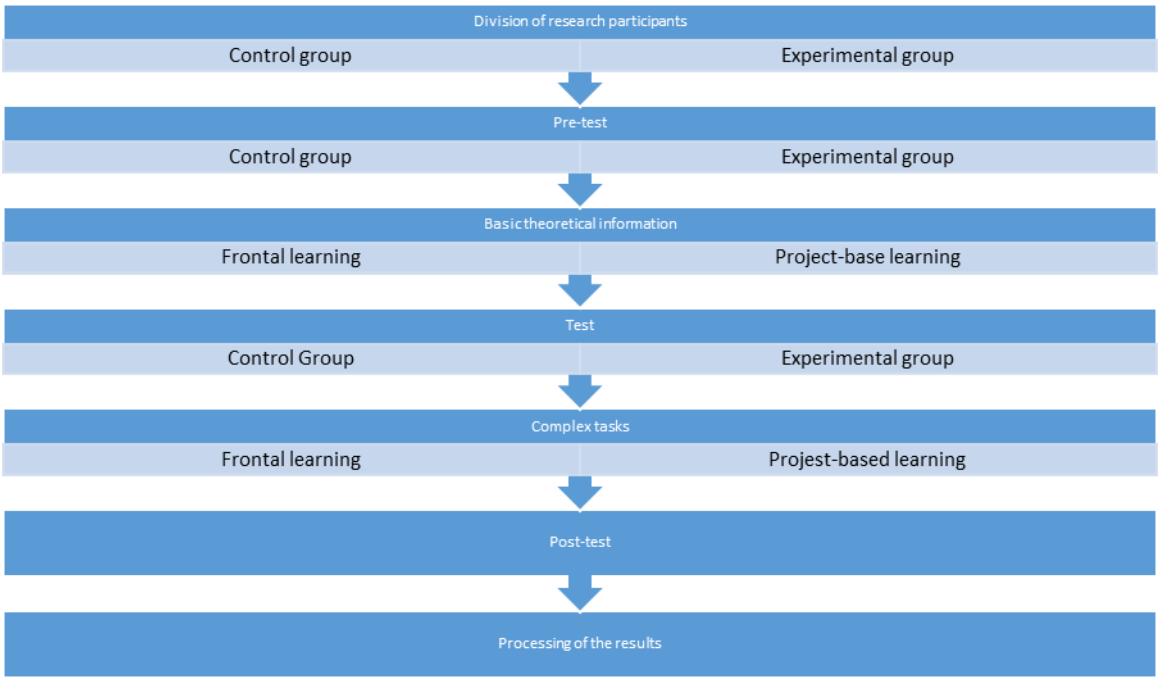
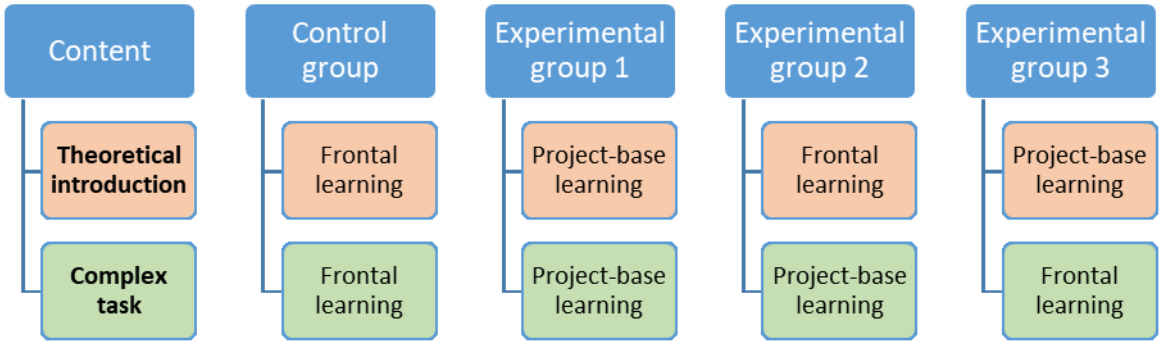


Figure 2 Main research scheme *(created by the author)*

6.1 Extention of main research

I would like to further extent the main research and continue in dealing with other influences on pupils and education when using the robotic sets. In the first stage I would like to increase the number of involved



groups to three experimental groups and one control group. According to the scheme in Figure 3 it is possible to see alternation of given teaching methods.

Figure 3 Scheme of group division *(created by the author)*

Another anticipated extension is connected with the comparison of common education at elementary schools to learning in after-class groups focusing on robotics. This could bring interesting results from the point of view of comparing the influence of pupil's interest in robotics on his or her performance and progress.

This could be followed by a comparison of construction robotic kits during lessons at schools and their influence on the pupils and their progress. Here occurs the possibility of dealing with similiar robotic kits, most importantly commonly used Lego Mindstorms, Fischertechnik construction kit and newer, VEX IQ robotic set. These robotic construction kits are considerably similiar to each other, and necessity of their comparison during the lessons could help the school facilities to decide if to buy them or not.

CONCLUSION

In the article I discussed and introduced theoretical knowledge as the topic of my research paper, specifically robotic construction kits used in elementary school education, project-based learning and key competencies of the pupils. The development of these competencies represents the basis for the practical part of the research paper. The article further shows findings and contribution of the original research, focusing on the situation in employment of robotic sets as well as the teaching forms and methods. All of it was followed by characterization of the pilot research and introducing of the primary results. I also presented a scheme and extension of main research, which is currently limited in schools. Extension of the number of experimental groups and their division and development of types of teaching. Change in the extension of the main research scheme. The results of the main research will provide clear answers to the research questions. The conclusions will be beneficial for the practical teaching of programming using robotic kits in elementary schools.

ACKNOWLEDGEMENTS

This article has been supported by the Specific research project of the Faculty of Education of the University of Hradec Králové 2020.

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ICTE Journal

2020, 9(1): 39–44
DOI: 10.1515/ijicte-2020-0004

THE PROCESS OF DEVELOPMENT AND EXPERT VALIDATION OF THE ATTITUDES SURVEY ON TEACHING OF PROGRAMMING IN COMPUTER SCIENCE LESSONS

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ABSTRACT

Current global trend of shifting teaching the introductory programming and algorithmization topics into the primary and lower secondary education sphere brings along a wide array of different programming languages, development environments, textbooks, courses and other educational materials. Even though curricular documents, such as Framework Education Programmes, ensure the type of content and the width of discussed topic, the selection of specific educational tools utilized in lessons can significantly influence pupils' attitudes toward the topic of programming and thus subsequently also the progress of the lessons. Present attitudes surveys regarding the topic of programming were identified in course of the literature review and after undergoing comparative analysis they serve as the foundation for creation of a new attitudes survey suitable for secondary school pupils. This paper describes the process of selection, modification and creation of items for a new questionnaire as well as the process of internal validity evaluation based on the input from the panel of experts composed of selected methodological specialists, university lecturers and teachers of informatics with long-time experience with teaching the topic of programming. Pilot testing on selected elementary school is going to commence at the beginning of school year 2020/2021. Based on the results the items will be modified for the last time before final data collection scheduled till the end of the school year.

KEYWORDS

Programming, education at elementary schools, educational programming languages, attitudes survey, attitudes questionnaire, creation of questionnaire, validation process.

1 INTRODUCTION

Establishment of teaching of introductory programming on elementary schools is no longer just a current trend, but with regard to educational curricular documents worldwide (Národní ústav pro vzdělávání, 2018; Štátny pedagogický ústav, 2014; The White House, 2016; Kemp, 2014, p.6) we can state it has become a standard and an integral part of Computer Science subject. By means of various specialized educational tools, such as traditional robotic toy Bee-Bot, it is possible to build the most basic foundations already in the course of pre-primary education (Pekárová, 2008). When addressing the subject from the Czech point of view, terms *Computer Science* and *Informatics* can be used interchangeably, since at the Czech elementary schools the most common designation is still *Informatics* even though the content is mostly overlapping with globally preferred Computer Science. Programming is one of the fundamental topics of

Computer Science and can span anything from a month up to the whole school year, depending on a given school policy and a level of importance the school puts on it.

At the secondary elementary school for pupils at the age of 11 to 15, which is Czech equivalent to ISCED 2, the options that are available for a teacher for this topic are vast. Essentially there are:

- online interactive courses (Hour of Code, Code Combat, Code Monster, Khan Academy, etc.);
- various educational children specific programming languages and their environments, which usually contain only limited introductory tutorial and then depend on the work and ideas of pupils or teachers (Scratch, Snap!, Swift Playgrounds, Kodu Game Lab, Alice, LOGO,...);
- textbooks and other educational materials utilizing aforementioned languages (where from the point of view of Czech education system currently the most relevant sources are results of nationwide project PRIM (Czech acronym for Support of the Development of Informational Thinking), which are freely the official website imysleni.cz);
- robotic educational tools (such as LEGO Mindstorms, LEGO WeDo, Ozobot, mBot, etc.), however, there are always further expenses necessary for the acquisition of selected robotic kit;
- professional full-fledged programming languages and their environments (e.g. JavaScript, Python, Java, Visual Basic, C#, etc.), which are largely not suitable to be employed at elementary schools as a part of programming lessons intended for general population.

Further information can be found in a university textbook *Programming didactics* (Hornik, Musílek, Milková, 2019), which was created within the framework of project PRIM as an introduction to specific selected programming courses, languages, and environments for students of pedagogical faculties with a major in Computer Science.

Curricular documents currently in effect for Czech teachers are Framework Education Programmes that came into effect in 2017 (NÚV). The specification of mandatory content for the subject Informatics is extremely vague and reduced compared to the other subjects, thus leaving the IT teachers almost completely open choice regarding the content of the lessons and selection of general areas of interest. The topic of programming is in this concept not mandatory and it is not included at all in school educational programmes of many schools. However, the current revision proposal of the Framework Education Programme in the Field of Computer Science and ICT does include the topic and defines corresponding framework of expected results (NÚV, 2018, p. 11 and 12). Thus it is possible to claim that when the proposal of curricular revision is accepted, minimal mandatory content of the lessons for the topic of programming will be same at all elementary schools and the nature of the topic itself dictates that all the educational resources are conceptually very similar – see e.g. the comparison conducted by Krejsa in his diploma thesis focused on teaching the foundations of programming in Scratch (2014, p. 35 and 36).

With regard to the fact that such a complex topic originally used to be taught at as a part of upper secondary education and at universities (ISCED 3 and higher), which are all selective schools, it is necessary to take into consideration complications caused by character of elementary schools, which are intended for general population. When the content of the lessons is factically similar it is worth considering their form, since attractiveness of selected materials from the pupils' point of view and user friendliness of the selected language and its environment can have positive influence on pupils' attitudes which further influence their behavior during lessons. The topic can be negatively accepted especially among the weaker pupils and

consequently there is a high risk of disruptive behavior. Such a behavior resulting of these attitudes even from a single pupil has negative impact on the rest of the class and even though there are proven methods for effective classroom management (see e.g. Cangelosi, 2006), it still hinders the progress and depth to which the given topic can be introduced in the course of a lesson. Hence it is necessary to focus not only on the pupils' performance, but also their attitudes towards the topic.

Attitude is in Pedagogical dictionary (Průcha, Mareš and Walterová, 2003, p. 171) defined as "evaluative relationship maintained by an individual towards the surrounding world, other subjects, even oneself. It includes a disposition to behave or react in a given relatively stable way." Nevertheless, Albarracin et al. (2018) state that the definition of attitude must be sufficiently exhaustive while remaining universal and taking into consideration modern trends. In their research they claim that "what has been consistent in the multiple conceptualizations of the attitude construct is that evaluation is the key component" (p. 4), based on which they consequently simplify the whole definition to equation of attitude with evaluation.

2 RESEARCH DESIGN AND RESEARCH QUESTIONS

Basic tool for data gathering is questionnaire survey. Research design is based on two questionnaires with introductory programming lessons in-between, where the impact of the lessons on pupils' attitudes is measured by comparing results obtained in pre-test with the post-test answers. In order to be able to compare the attitudinal shift before and after the lessons, pupils are given a random code that they write in both pre-test and post-test questionnaires.

The introductory part of the questionnaire consists of only five questions that are gathering general information about the pupil, namely aforementioned random code, sex, age, class and school. In the post-test questionnaire there is a sixth question that identifies specific materials and languages used in the course of lessons. Even though attitudes can be influenced by a vast range of variables (e.g. personal interests, family environment, amount of free time, parents' professions, etc.) the goal of this questionnaire is not an attempt to detect and record all these influences, but an evaluation of the impact of undergone Informatics lessons in course of which the topic of programming has been presented. This impact is determined by examination and comparison of answers obtained before and after the programming lessons regardless the aforementioned personal variables of individual pupils.

The primary focus of the survey is to evaluate pupils' attitudes towards their programming lessons, i.e. answer the question whether the specific lessons in specific programming environment and language with given coursebook or tasks with their IT teacher was received positively or not and if not, indicate possible reasons. This is achieved by comparison of attitudes obtained from the questionnaire given to the pupils before their programming lessons with the answers from the second questionnaire after the lessons. Secondary research questions are focused on mapping the situation of pupils' attitudes towards the teaching of programming, specifically on evaluation of the influence of sex and age on the attitudes; on comparison of pupils' attitudes towards the topic of programming and the subject of Informatics in general; and on identification of specific aspects of the lessons that could significantly influence the attitudes of pupils towards the topic.

3 RESEARCH METHODS

Based on the literature review (Hornik, 2019) all the questionnaires published until 2019 focused on the topic of attitudes towards the teaching of programming were researched and analyzed. Every questionnaire in the conducted review used four or five-point Likert scales as their only method of attitudes evaluation, with the exception of attitudes evaluation tool created for the purpose of evaluation of programming lessons on high schools by Klement et al. (2012), which was based solely on dichotomous yes/no questions. Most of the items in our new questionnaire survey is based on existing surveys (see table 1) and as such they also utilize five-point Likert scale.

Table 1 Attitudes Questionnaires Focused on Programming Selected in the course of Literature Review

Author(s)	Publication year	Name of the research/questionnaire	Number of Attitudes Items	Respondents Sample size
Phillips & Brooks	2017	Impact on Attitudes and Self-Efficacy with CS	4	**8040** elementary and high school pupils
Asad, Tibi, & Raiyn	2016	Attitudes toward Learning Programming through Visual Interactive Environments	**29**	**24** elementary school pupils
Du, Wimmer & Rada	2016	Attitudes towards computer programming and knowledge of programming	**4**	**116** university students
Klement, Klement & Lavrinčík	2012	Metody realizace a hodnocení výuky základů programování	**12** (for students) **16** (for teachers)	**321** grammar school students and **12** teachers
Korkmaz & Altun	2014	Attitude Scale of Computer Programming Learning (ASCOPL)	**20**	**496** university students in first phase and **262** in the second
Tew, Dorn & Schneider	2012	Computing Attitudes Survey	**10**	**447** university students
Baser	2013	Programming Attitude Scale	**35**	**179** university students
Wiebe, Williams, Yang & Miller	2003	Computer Science Attitude Survey	**57**	**162** university students

Prior the new questionnaire initial evaluation by a panel of experts the possibility of employment of the semantic differential instead of the Likert scale was considered in order to simplify understanding of the items and to ensure pupils' answers unambiguity. Only two of the eight experts in their assessment mentioned that the use of Likert scale can be problematic and in both cases only in relation to a single item (see chapter 5) and subsequently the idea was abandoned. The selection of items regarding the attitudes was done in three consecutive steps described in detail in chapter 4.

Even though attitudes questionnaires usually contain same question in more than one phrasing (potentially supplemented by their negative formulation) in order to ensure that the respondent understands it and the concordance in answers supports internal reliability, there are substantial drawbacks to this approach especially when dealing with young respondents. Křeménková and Novotný (2016) state that in their study among 7th grade pupils apparently recurring items lead to frustration, anger and significant slowdown in finishing the questionnaire. Other problems discernible in the pupils' answers were focusing too much on detailed/literal accuracy of the question, inability to answer too general questions and a lack of understanding complex words combined with fear to ask for their explanation. Křeménková and Novotný (2016, p. 88) conclude that *"it is appropriate to apply some principles for questionnaire items when creating assessment tools for children and adolescents. These principles include use of 1) simple, specific and unambiguous questions/items that minimize the risk of multiple possible interpretations, 2) items with low demands on abstraction and generalization, 3) fewer semantically identical or similar items, and 4) minimal use of foreign terms. The verification of clarity of understanding the items by respondents shows also as necessary."*

The author of this paper has the same experience from previous research on secondary school pupils (Hornik, 2016) and from his four years of experience as a teacher on secondary elementary school. As such, the questionnaire is trying to avoid multiple occurrences of the same items and general ambiguity. However, in order to avoid random answers from pupils who do not read the items at all, we found inspiration in item 19 from Computing Attitudes Survey (Tew, Dorn & Schneider, 2012) and we added simplified version of it: *"This item verifies whether you are reading the questions. In order to prove it please select from the given options precisely the option four, which is I Agree."* If any of the pupils selects anything else (including option 5 – I completely agree), their whole questionnaire is discarded as biased data, without any information content, obtained by random clicking of the pupil.

4 THE PROCESS OF PRIMARY ITEMS SELECTION

The process of new questionnaire survey focused on pupils' attitudes towards programming was executed in three steps. In the first step, questions that appeared in more than one of these questionnaires were selected automatically. In the second step, the questions that appeared always just in a single questionnaire were evaluated and if considered meaningful for the purpose of this study and especially for the target audience (secondary school pupils), they were also selected. Because there is no validated and reliability tested attitudes questionnaire in the area of programming that could be used on secondary school pupils, the Computer Science Attitude Survey by Wiebe et al. (2003) was also included in this step as a possible base ground for question modifications. Even though the questionnaire is officially intended for the subject of Computer Science/Informatics, it was actually deployed as a part of a study exploring the benefits of pair programming (Williams et al., 2002) and its items are not only focused mostly on the topic of programming, but they are also simple enough to be used with secondary school pupils.

Selected questions that meaningfully complete our questionnaire, were modified according to a generally acknowledged process used e.g. by Baser (2013, p. 251) or Tew et al. (2012). The modification process consisted of elementary changes that focused generally oriented questions into more specific topic (word *"courses"* was replaced by word *"lessons,"* phrase *"computer science"* was replaced by *"programming,"* etc.) and if the question was too ambiguous and could be asked in a simpler and shorter way it was rephrased as such, even though there could be a slight informational loss or shift (e.g. *"Errors generated by computers are random, and when they happen there's not much I can do to understand why."* that appeared in the Computing Attitudes Survey by Tew et al. (2012) was shortened and rephrased to *"When the computer generates an error during programming, I don't know why and I don't understand it."*).

For the third step the overall composition of the questionnaire was considered while focusing on the research questions and data applicability. New items were created to fulfill the missing information concerning the pupils' attitudes toward the programming lessons and their content, including the specific programming language and its development environment.

4.1 Selection of Items from Established Questionnaires

Since five out of eight established questionnaires are focused on university students, most of the items were not suitable for secondary school pupils and thus the first selection step was concluded with only five items. The specific phrasing of questionnaire items was never exactly the same and the questions were compared based on their semantic content. The most repeated questions were about pupils' desire to continue learning about programming (Klement et al., 2012; Korkmaz & Altun, 2014; Tew et al., 2012; Baser, 2013) and to join a programming course (Du et al., 2016; Korkmaz & Altun, 2014; Baser, 2013). Remaining three

questions appeared always in only two questionnaires. Following repeated questions were whether pupils consider the lessons difficult (Klement et al., 2012; Korkmaz & Altun, 2014), whether the pupils believe they can learn the topic (Phillips & Brooks, 2017; Korkmaz & Altun, 2014) and whether they enjoy solving challenging programming problems (Asad et al., 2016; Tew et al., 2012).

In the second step, questions were selected from individual questionnaires based on their suitability for secondary school pupils. All the criteria introduced by Křeménková and Novotný (2016) were observed in course of this selection process and only thirty-five items were considered satisfactory from the questionnaires focusing strictly on the topic of programming with additional forty-six questions from more general subject oriented Computer Science Attitude Survey (Wiebe et al., 2003). All the selected questions were further analyzed and questions that were too similar and thus could be confusing for pupils (even though their semantic content was different) as well as questions that were considered outside the scope of this research were omitted, leaving twenty-seven questions in the second step.

4.2 Addition of Completely new Items

The last step consisted of assessing missing information and subsequent creation of entirely new items. These items were necessary since none of the questionnaires was focused on pupils' evaluation of the selected programming language and its environment as well as the specifics of a given primary source of information (which could have been an online course, a textbook or a teacher). The new set of questions is focused on the pupils' impressions regarding not the general topic, but their specific lessons, because even the best language and the nicest development environment can be ruined by e.g. poor choice of tasks or incomprehensible explanations of new programming topics (and vice versa).

The impact of how the pupils perceive the connection of the topic with the real world is undeniable (see Arthur et al. (2018), which was focused on the same question in the area of mathematics) and an item about this perception regarding the general Computer Science was already among the questionnaires (Tew et al., 2012). However, an extra question had to be created anew for the particular topic of programming: *"The topic of programming is strongly connected with the everyday world around us."* which was based on the experts assessments changed to *"Programs are used in everyday life all around us, not only on PCs, laptops and mobile phones."* This is also the only new question that does not focus on details regarding the lessons pupils experienced.

Remaining new questions can be divided into two categories, namely questions evaluating pupils' attitudes toward the programming language and its environment and the questions aimed at their perception towards the source of information and tasks (be it their teacher, an online course or a textbook). The specification of the source of information is part of the introductory questions in the post-test. Questions focused strictly on the programming language and its environment were:

- *The work in the programming environment was without any problem.*
- *When I was looking for something in the programming environment, I usually found it immediately or very fast.*
- *I liked the look of the programming environment (the placement of everything, the look of buttons, etc.)*
- *I liked the pictures (e.g. backgrounds and sprites) in the programming environment.*
- *If I could, I would use completely different pictures for backgrounds, character sprites and things.*
- *I think it is possible to create anything I could think of in this programming language.*

These questions should identified possible sources of frustration and other problems that could be hindering the pupils' progress and attitudes, regardless the quality of given explanations or practice tasks, which is the aim of the second set of new questions:

- *Usually I understood explanations how everything works without any problems.*
- *There was always enough simple examples for a new topic.*
- *Textbook/materials were always easy to understand.*
- *In every task I always knew what is the goal.*
- *In some new topics I would like more tasks to try the new things.*
- *Usually I had enough time for my work.*
- *I very often needed help from my teacher.*
- *I was totally OK with the way my teacher handled the lessons.*

Even though the personality of teachers and their teaching styles have very strong influence on the pupils' attitudes toward the subject (Blazar and Kraft, 2017; Hashim et al. 2014), this questionnaire identifies possible problems related to the teacher in a single question. If there are such problems, they are not connected specifically with the topic of programming and if a teacher wants to identify and rectify them, there are other tools, as for example the Teacher Self-Assessment Tool (Teacher Leadership, 2017).

Five questions repeated in several questionnaires combined with twenty seven questions appearing in single questionnaires further complemented by additional fifteen new questions leads to the total number of forty-seven questions. Such amount of questions would make this questionnaire the second longest of them all, with only Computer Science Attitude Survey by Wiebe, Williams, Yang & Miller (2003) being longer with its fifty-seven questions. Even though the questions are based only on Likert scales, the questionnaire should be suitable for children in the age of 11 to 15, whereas especially the younger pupils wouldn't be able to cope with this extent. Preliminary selected forty-seven questions are meant to be reduced in the course of their evaluation by the panel of experts (see chapter 5) and during the pilot testing in selected focus groups (which is planned for September / October, 2020).

4.3 Preliminary Organization of Items Into Categories

Four of the eight questionnaires that emerged from the original literature review, utilize categories for organization of questions by their subject matter, although with the exception of Wiebe et al. (2003) and Baser (2013), the categories are always completely different (see table 2).

Table 2 Categories of Items Identified in Other Authors' Surveys

Questionnaire and its author(s)	Categories of questions
The Attitude Scale of Computer Programming Learning by Korkmaz & Altun (2014)	- Willingness - Negativity - Necessity
Attitudes toward Learning Programming through Visual Interactive Environments by Asad, Tibi, & Raiyn (2016)	- Motivation category - Competition category - Challenge category
Computer Science Attitude Survey by Wiebe, Williams, Yang & Miller (2003)	- Confidence in learning computer science and programming - Attitude toward success in computer science - Computer science as a male domain - Usefulness of computer science and programming - Effective motivation in computer science and programming
Programming Attitude Scale by Baser (2013)	- Confidence in learning computer programming - Usefulness of computer programming - Attitudes toward success in computer programming - Effective motivation in computer programming

Since none of the existing divisions of questions is suitable for the goals of the new questionnaire and do not fit the research questions, six new categories were identified based on our selected questions. The new questionnaire does not only focus on general attitudes (categories 1 and 2) and pupils inner motivation (category 5), but more importantly analyzes what could cause the pupils' attitudes shift in the course of school Computer Science lessons focused on the topic of programming (categories 3 and 4).

Despite the attempts of projects such as Hour of Code to equalize gender in programming (Du, 2019), women are still minority in this area of expertise. Study on one of the major programmers' forum Stack Overflow showed that as of 2018 only 6,3% of their users were females (Griffin, 2018). Four items were selected from Computer Science Attitude Survey by Wiebe et al. (2003) regarding the issue of gender perception (category 6) because of that. Categories 3 and 4 are only in post-test questionnaire.

1. The attitudes toward the Computer Science as a subject in general
2. The attitudes toward the topic of programming in general
3. The attitudes toward the specific programming language and environment
4. The attitudes toward the specific source of information (course/textbook/teacher)
5. Subjective personal aspects of the pupil
6. Gender prejudices with regard to the topic of programming

5 ASSESSMENT BY THE PANEL OF EXPERTS

Preliminary version of the whole questionnaire was sent to the panel of eight experts for evaluation of its internal validity and assessment of the exact phrasing of the questions. The panel of experts consisted of specialists focused on methodology testing and computer science didactics, as well as teachers with long term experience in teaching the topic of programming at elementary and high schools. The experts were approached before the beginning of school year 2020/2021. They were given the questionnaire in both Czech and English language mutation accompanied by six queries that should be considered for each of the questionnaire questions:

1. *Is general phrasing of the statement properly characterizing the point of the question, in other words, is the question clear?*
2. *Is the specific word choice suitable for secondary school pupils?*
3. *Does the statement ascertain thematically relevant information connected with programming?*
4. *Can the use of Likert scale with this statement be confusing for children?*
5. *Is the statement classified in the suitable category?*
6. *Should the statement remain or be completely discarded?*

The divisions of questions that are present in the preliminary version for experts' evaluation are omitted in the questionnaires for pupils. All the statements that were not accompanied by any kind of commentary from the experts were considered as without objections. One of the goals of the questionnaire modification was overall reduction of the survey, because two experts' assessments described the survey as far too long,

which could increase the probability of implausible answers. Such a distortion can be caused by a wide variety of reasons, ranging from misunderstanding, inattention, boredom, fear up to deliberate prank-like reactions (Kohoutek & Mareš, 2012, p. 6). If the opportunity arose to reduce the length, it was in most cases taken. Following minute modifications in formulations and major changes were conducted based on the experts' assessments:

- Items *"The topic of programming interests me."* and *"From all the Computer Science topics, programming is the most interesting for me."* were labeled as duplicates with only difference in the level of stress put on the intensity of interest. Both items were merged and averaged to *"Programming is one of the most interesting Computer Science topics for me."*
- Similarly duplicate were items *"The work in the programming environment was without any problem."* and *"When I was looking for something in the programming environment, I usually found it immediately or very fast."* The core of both items is to determine how user friendly is the programming environment for pupils. Items were also merged and the second item was used as an example in brackets: *"The work in the programming environment was without any problem for me (e.g. when I was looking for something, I found it very quickly)."*
- It was pointed out that specific examples of subjects in brackets can strongly influence the pupils' answers in item *"Computer Science is useful in other subjects (e.g. biology, arts and crafts, foreign languages)."* Since it is also an item that can be modified to target behavioral aspect of attitudes, which were originally underrepresented, the item was changed to *"The things I learn in Computer Science I also use in other subjects."*
- The problem of pupils responding to questions from block B (see chapter 6) even before the programming lessons was brought to attention. Because the questionnaire did not incorporate an explanation of what programming is, the answers could have been unintentionally misdirective. Programming is a fundamental term and as such it is very difficult to define it accurately in a few sentences. At the beginning of the questionnaire an explanation taken from the Czech translation of a Python textbook was included: *"Computer Programming is the art of making a computer do what you want it to do. At the very simplest level it consists of issuing a sequence of commands to a computer to achieve an objective."* (Gauld, 2005) Instructions for teachers will also warn teachers they have to draw pupils' attention to the elementary explanation.
- Item *"I want to attend an after-school programming course."* was identified as misleading, because a positive answer could be limited by factual hindrances (e.g. there is no such course at the local school or its nearby surroundings or the pupils could be limited by the amount of their free time or their family financial situation). Two experts recommended simply use conditional mood *"I would like to attend an after-school programming course."*
- Two of the experts described the item *"I'm sure I can learn programming."* as difficult to answer on Likert scale. The intensity was lowered by rephrasing to *"I believe I can learn programming."* but the item was kept since it is a relevant indicator of so called self-efficacy (which is confidence of individuals in their own abilities) that has fundamental influence on acquisition of new knowledge, performance and behavior (Smetáčková a Vozková, 2016). This item will be pointed out in teachers' instruction manual and there will be an example for pupils of how to work with Likert scales.

- Item *"Everybody should learn how to program because it teaches you how to think."* was highlighted as unsuitable combination of two questions – should everybody learn to program and does programming teaches how to think? The answer to the second question was implied as a fact based on the formulation of the item. This problem was addressed by two experts who suggested a simple modification to *"People learn how to think logically by learning programming."* which was accepted and incorporated into the survey.
- Phrases *mostly, in most cases, usually* and *very often* were described as far too general, because every pupil has different notion of it and it would be better to not use them at all. These phrases were replaced by unified *usually.* However, it was decided to keep the word in all the items, because regardless the exact understanding of the word *usually*, it lowers their absoluteness, see e.g. *"I usually had enough time for my work."* compared to *"I had enough time for my work."* (where in the second case there seem to be implied *always*).
- Formulation "*I think it is possible to create anything I could imagine in this programming language."* did not include any examples and word *anything* is far too general and practically unrealistic at the same time. Based on the remarks of two experts the item was modified to *"In this programming language I can try programming without any restrictions."* The goal of this item is to find out whether pupils perceive the limitations while working in online courses such as Hour of Code.
- Based on the advice of two experts and despite the effort to lower the number of items, one item was added into the first part of the questionnaire regarding the subject Informatics *"The things we learn in Computer Science are interesting for me."* This item complements the information about the importance of the subject and thus allows to ascertain if the interest correlates with the subjective perception of the subjects' importance.
- Item *"The topic of programming is strongly connected with the everyday world around us."* was expanded to *"Programs are used in ordinary life every day, not only on PCs, laptops and mobile phones."* The point of the item is to find out whether pupils realize that programs are controlling even items and processes impacting every aspect of human life (e.g. traffic lights, cars, appliances,...)
- Item *"A big problem in learning programming is being able to memorize all the information I need to know."* was labeled by three experts as confusing and they all recommended to omit it. The questionnaire is intended for secondary school pupils, where the most common environment is based on visual blocks and pupils don't have to remember specific formulations of e.g. cycles or conditions such as *if...elif...else*. If the target respondents were high schools or technically oriented schools that utilize text based programming, rephrasing the item would be important. Here the item was removed.
- Item *"Generally I was not worried about attempting to solve computer programming problems."* which was intended for establishing if the pupils weren't afraid to try different approaches or to do major changes in their programs was deemed incomprehensible by two experts. Since the reformulation with further explanation would be too long and there already is an item about pupils' fears or worries, the item was eliminated altogether.
- Category of items preliminary labeled as *Subjective personal aspects of the pupil concerning the topic of programming* was based on the recommendation of three experts divided into two parts – one that can be answered even in pre-test and the other is only in the post-test.

- *Men and women* in the first gender oriented item were replaced by boys and girls. In order to not insinuate the prejudice that boys are better than girls at programming, genders were swapped in the item to *"Boys are as good as girls at programming."*
- Out of the four initial gender oriented items *"Women are certainly logical enough to do well in programming."* was eliminated. Remaining three gender oriented items were moved from their own category to category B that was renamed to *The attitudes and prejudices toward the topic of programming in general* and the separate category of gender prejudices was removed.
- Items *"I liked the pictures (e.g. backgrounds and sprites) in the programming environment."* and "*If I could, I would use completely different pictures for backgrounds, characters sprites and other things."* were pointed out by one expert as contradictory to the intention of the survey universality. Due to the prevalent gamification of the topic it is reasonable to expect that standard lessons (and thus not specialized programming oriented extracurricular courses and clubs) will utilize some form of visual block language or other graphical elements (such as Logo, which is a text based language focused on controlling turtles drawing geometrical patterns). Both items remained unchanged.

One of the experts raised a question whether to include also the answers from pupils with special educational needs, because the handicap of some pupils can significantly influence their answers. Pupils with individual study plans and other specific educational needs are still pupils of the school, teachers must work with them in regular lessons and the pupils have to be familiarized with the topic to a certain extent. Because these pupils are inseparable part of the school, exclude them would bias the data. Addition of an extra question to the introductory part of the questionnaire regarding the special needs was considered, but since it would confuse pupils without it, it was not included.

Two experts further pointed out the issue of setting the topic of programming in context of other topics that should be covered in the school year. Framework Education Programmes do not set the order of topics and because programming is often strongly gamified, it is potentially very entertaining and there is a high chance of employment of the topic at the beginning of the school year with the intention to motivate pupils. In that case it is impossible for pupils to compare programming with other topics and all items related to this issue lack the information value. For the purpose of the survey itself, optimal delivering of the topic is at the end of a school year. If it is not possible and the teachers want to discuss the topic earlier, it is recommended to outline all the topics for the school year briefly beforehand, which gives pupils at least limited perspective and enables substantially more objective answers.

Four experts independently strongly stressed the necessity of pilot testing, which was already arranged and at the time of the writing of this paper at the beginning of school year 2020/2021 it is in progress.

6 CURRENT VERSION OF THE SURVEY BEFORE PILOT TESTING

Based on the experts' evaluation five items were completely removed, one was added and twelve items were rephrased or otherwise modified. The scale of the questionnaire was thus decreased from original forty-seven items to forty-three items in the post-test. Pre-test is significantly shorter with only nineteen items. The author of this paper majored with honors in English language and the whole set of questions with regard to the correctness of their translations was checked by two more English language teachers and one Czech language teacher. Complete questionnaire in English version is in table 3.

Table 3 Unabridged Version of the Questionnaire Before Pilot Testing

A.) **The attitudes toward the Computer Science as a subject in general**

1. I like Computer Science.
2. Computer Science is an important subject.
3. The things we learn in Computer Science are interesting for me.
4. The things I learn in Computer Science I also use in other subjects.
5. I can see the things, I learn in Computer Science, being used in everyday life all around me.

B.) **The attitudes and prejudices toward the topic of programming in general**

6. Programming will be important for my future life.
7. Programming is one of the most interesting Computer Science topics for me.
8. I would like to attend an after-school programming course.
9. I worry that mistakes I make when writing a program may damage my computer.
10. People learn how to think logically by learning programming.
11. Programs are used in ordinary life every day, not only on PC, laptops and mobile phones.
12. Boys are as good as girls at programming.
13. It makes sense that there are more men than women in programming.
14. Women who enjoy programming are a bit peculiar.

C.) **The attitudes toward the specific programming language / environment** (only post-test)

15. The work in the programming environment was without any problem for me (e.g. when I was looking for something, I found it very quickly).
16. I liked the look of the programming environment (the placement of everything, the look of buttons, etc.)
17. I liked the pictures (e.g. backgrounds and sprites) in the programming environment.
18. If I could, I would use completely different pictures for backgrounds, character sprites and other things.
19. In this programming language I can try programming without any restrictions.
20. When the computer generates an error during programming, I don't know why and I don't understand it.

D.) **The attitudes toward the specific course/textbook/teacher** (only post-test)

21. I enjoyed the programming lessons.
22. Programming lessons were the worst Computer Science lessons.
23. Programming lessons were difficult for me.
24. Completing the lessons changed my opinion towards programming for the better.
25. I want to continue learning programming in our computer science/informatics lessons.
26. Even though I work hard, for some reason programming is unusually hard for me.
27. Usually I understood explanations how everything works without any problems.
28. There was always enough simple examples for a new topic.
29. Textbook/materials were always easy to understand.
30. In every task I always knew what is the goal.
31. In some new topics I would like more tasks to try the new things.
32. I usually had enough time for my work.
33. When working, I usually needed someone's help.
34. I was totally OK with the way my teacher handled the lessons.

E1.) **Subjective personal aspects of the pupil concerning the topic of programming**

35. I am afraid of programming lessons.
36. Programming is boring.
37. I believe I can learn programming.
38. I can get good grades in programming.

E2.) **Subjective personal aspects of the pupil concerning the topic of programming** (only in post-test)

39. I like to solve difficult programming problems that are challenging for me.
40. It would be really great to have an opportunity to take part in a programming competition.
41. When I am stuck, I do not spend more than five minutes before giving up or asking someone for help.
42. I do as little work in programming lessons as possible.

43. This item verifies whether you are reading the questions. In order to prove it please select from the given options precisely the option four, which is I Agree. *(This item is going to be inserted randomly somewhere in the second half of the questionnaire.)*

7 CONCLUSION

Modified version of the questionnaire is currently undergoing pilot testing in a selected group of pupils as the first topic in Computer Science lessons at the beginning of the new school year (September/October 2020) and their remarks are going to be considered for the last stage of questionnaire modification. As a part of the pilot testing, validity will be also evaluated by the measures of criterion group subjects, i.e. *"those who have been proved to possess the construct."* (Maurer, 1983 in Simonson & Maushak, 2001) As a part of this method pupils who are very keen and very negative are identified and their answers should account for both positive and negative extremes within the pilot group. The influence of individual items on overall reliability of the survey is going to be verified by Cronbach's alpha reliability test score.

Final version of the survey should not only bring a large amount of data usable for modification of existing educational materials and resources, but it should also enable an objective comparison of different programming languages and courses on pupils' attitudes. This should facilitate more effective choice of suitable educational tools for the teachers.

8 ACKNOWLEDGMENTS

The article has been supported by Specific Research Project of Faculty of Education, University of Hradec Kralove, 2020. The author would like to express gratitude to all the experts who were involved in the survey assessment as well as linguistic experts who verified the translation of the survey for its potential international use.

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