Initiative to Support Basic Digital Skills Development of Romanian Preschool Children

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ABSTRACT
The children of today are born and grow up in a landscape immersed by technology. The research on the jobs of the future shows that 90% of them will need digital skills. Romania, in the context of European Union, ranks on the 28th position out of 28 countries based on the digital skills of its population, even though the IT industry is very well developed. Interventions must be done to improve the level of digital skills of Romanian children. The schools have already included in their curricula ICT (Information and Communication Technology) classes, but we consider that we should also focus on helping preschool children acquire the basic digital skills. It should be done using an integrated approach that refers to interaction with technology and the corresponding content. In this paper we present our initiative on developing interactive products that can be used in kindergarten, a formal education environment, as part of Human-Computer Interaction undergraduate course.

Author Keywords
interaction design, children, user-centered design, serious games, digital skills

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Nowadays, the children are born and grow up surrounded by technology. From the first years of their lives they start interacting with various devices in order to find and play content that entertains them. Statistics show that children of small ages are spending more and more time on the internet [22]. The children of today are the so-called "digital natives" due to their great exposure to technology from their early ages. Still, researches show that it is not enough to be a digital native to cope to the ever changing domain of workforce in the European Union [17]. In the near future the workforce domain will become more and more digital, as 90% of the jobs of the future will be digital [3]. Development of digital skills will be fundamental for the citizens of European Union in order to find a job. Children start learning the basics of interacting with technology from primary school, but when their digital skills are evaluated, studies show that their level does not meet the expectations [11, 12]. Even though the current generations of pupils are digital natives, their digital skills are developed under expectations. It shows that it is not enough to be born digital, there is also a need for developing digital skills. Regarding this aspect the educational institutions have a tremendous role. In this paper we present an initiative that supports the development of digital skills of preschool children in Romania. Our idea is to develop new applications for preschool children using a human (user) centered approach. In the following we present statistics on the digital skills of Romanian population within the context of the European Union. Afterwards we describe the human (user) centered design (UCD) approach used for developing interactive products for preschool children that can be used in the formal educational system and the obtained results. The paper ends with conclusions and further development ideas.

INTERACTIVE APPLICATIONS FOR CHILDREN

Along with the ever growing presence of technology in every aspect of our lives, new terms have been introduced. These new terms suggest the involvement of technology in specific areas of our knowledge or lives, such as *digital skill*, *digital competence*, and *digital literacy*. In the following we present some of the existing definitions of these new terms.

Digital skills and education

According to the European Parliamentary Research Service (EPRS) [15], *digital skills* are defined as a range of basic to highly advanced skills that enable the use of digital technologies (digital knowledge) on one hand, and basic cognitive, emotional or social skills necessary for the use of digital technologies, on the other hand.
The term *digital native* was introduced in 2001, meaning young people who grew up surrounded by and using computers, cell phones and other tools of the digital age [23]. In the same context, the author also defines the *digital immigrants* i.e. people who were born before widespread use of digital technology and who adopted it to some extent later in life. The author also introduces the concept of *digitally wise* - a person that not only knows how to use digital technologies but also has the capacity to critically evaluate them, make ethical choices and more pragmatic decisions. By changing his discourse around *digital natives*, the author confirms that in order to use digital technologies critically and effectively, young people need to acquire digital skills.

Digital competence includes not just digital skills, but a set of skills, knowledge and attitudes concerning the nature and role of information technologies and the opportunities they offer in everyday contexts, as well as the related legal and ethical principles. It also includes critical and reflective attitudes towards the information available and its responsible use [12].

Digital literacy is an umbrella concept for important skill clusters whose names are often used as synonyms: computer literacy, technological literacy, ICT literacy; their content, however, is not exactly the same. *Computer literacy* is the ability to use computers and related technology efficiently, with a range of skills covering levels from elementary use to programming and advanced problem solving [8]. *ICT literacy* refers to a set of user skills that enable active participation in a society where services and cultural offerings are computer-supported and distributed on the internet. *Technological literacy* (previously called *computer literacy*) entails a deeper understanding of digital technology and comprises both user and technical computing skills.

The term digital literacy retains a close connection with other basic literacies (e.g. reading and writing, mathematical competence) that are integral parts of education [13].

Being a digital native doesn't empower a child with digital skills, meaning that the early exposure to technology does not positively impact the level of digital competencies, without training [5, 6]. Research shows that not all young people are tech-savvy or have an interest to learn more. An Australian study found that only 15% of the student population are advanced users of ICTs while 45% of all students could be described as rudimentary digital technology users [14]. A study performed in Austria shows that 66% of the Austrians own multiple digital devices which they use often, and 51% of the Austrian workforce spend at least half of their working time on a computer. However, the evaluation of their general computer skills test results showed that 61% of the respondents scored 'bad' or 'very bad', and just 7% received a very good score.

Statistics on Romanian population digital skills

Europe's Digital Progress Report (EDPR) tracks the progress made by Member States in terms of their digitization, combining quantitative evidence from the Digital Economy and Society Index (DESI) with qualitative information on country-specific policies. Romania ranks 28th out of the 28 EU Member States (see Figure 1).

Although Romanians benefit from coverage of fast broadband connections in urban areas, the rate of digitization of the economy, including for public services, and digital skill levels are still low. Only 52% of Romanian citizen use the Internet, comparatively with a percent of 72% in European Union, while 32% of Romanian citizen have never used the Internet. Only 26% of the Romanian employees have basic digital competences. 40% of Romanian people are at risk of poverty and social exclusion, that is why measures to provide digital competences to young generations of users are urgently needed [5].

The PISA (Programme for International Students Assessment) evaluation performed in 2011 showed that Romania has the highest number of persons aged between 16 and 74 years old that do not possess digital competencies (around 61% of the population) [21].

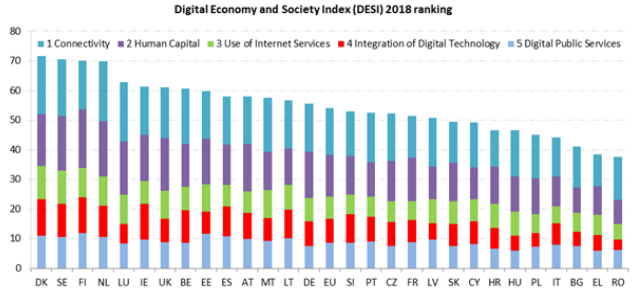

Figure 1: DESI (Digital Economy and Society Index) 2018 ranking [5]

Romanian Internet users engage in a broad range of online activities like reading news online (6%), listening to music, watching movies and playing games online (67%), video calling (45%), participating in social networks (74%). The only category with increased activity in the last year is the category of online video calls. Still, Romanian Internet users are refusing to engage in online transactions, with online shopping and online banking. These online activities register some of the lowest levels in the EU [5]. From here the conclusion that the only digital technologies which are actually used are those for entertainment, the other being reserved for 'specialists' can be drawn. The Ministry of Education aims to increase the digital skills of the new generations and is preparing some initiatives to tackle this issue. Since 2017, both ICT and programming classes have been introduced in middle school. They allow learning simple coding and algorithmic thinking in order to ensure that children are able to search, find and interpret data. A pilot project called 'The Digital Catalogue' has been implemented, allowing parents to digitally track grades and absences in school. Various private companies have launched their own campaigns to improve digital skills. At this point digital skills still seem to be mostly promoted through private sector initiatives, rather than by public policy [5].

The role of educational institutions on improving digital skills

In a world that is increasingly reliant on computers, the integration of technology into school classrooms is on the rise. Children benefit from computers usage in the

classroom by learning basic skills and keyboarding, as well as enjoying programs that enhance their curriculum. Computer skills are also essential for future generations entering the workforce. Most of the statistics on using the computers and other devices refer to people aged from 16 years and above, but the current trends show us that we have to move the focus on even younger children, even toddlers, because technology has already penetrated their environment. It makes no sense in trying to avoid the use of different digital devices by small children. Instead we should focus on providing young children digital content that will support them develop in the right direction. In European Union, the Digital Education Action Plan have been launched with the main goal to help the educational institutions and education systems to better adapt to life and work in increasingly digital societies [5]. Education and training are key ingredients of efforts to develop digital skills. Digital skills development takes place across a full range of education contexts: from formal institutions such as schools, colleges and universities to non-formal provision and training, and various forms of self-directed and informal learning.

State of the art in developing preschool interactive applications

Designing applications for children is a challenging task, as it adds new constraints on the design principles that are applied for the adult users due to the specifics of cognitive and physical development of children. Children under the age of 12 sense and experience, the world differently than adults. Nardini et al [19] found that young children do not combine sense information into one message to be interpreted by the brain. Instead, children keep each of the senses separate and interpret those stimuli independently. The ability to use a mouse and click on the screen is possible for children, but researchers have found that the scale of those abilities are different than adults. While adults may be easily able to click on a small icon on the screen, Hourcade found that children have difficulty with smaller icons [10].

Principles of designing applications for children have been developed and validated, with no specific insight on preschool children [4, 16]. There are major differences between preschool children and school children determined by the fact that preschool children are pre-literate, the eye-hand coordination is not fully developed and they can not complete tasks without being rewarded. In [24] a study on the improvement of interaction with tangible interfaces of preschool children is presented and design guidelines for touch-screen interfaces are formulated. In Romania, there is a small number of applications targeting preschool children that are available online or sell together with magazines for children on CD support [26]. Auxiliary information about the development of the existing applications, such as: if they are intended for learning goals, if they adhere to the curriculum for kindergarten and the age range they address, are not available. Also, there are no measures and measurement methodologies for the evaluation of preschool children interactive products. As the technology has penetrated the world of preschool children and the institutions that supervise the teaching process in Romania already make interventions for primary school children to improve their digital skills, we have decided to address the problem of digital skills acquirement from a lower level, the preschool children. We are aiming to create digital interactive products that can be used to learn the fundamental digital skills of children while the presented content is related to the rules and constraints of the curriculum for kindergarten.

In the following section we focus on presenting the context of developing prototypes of the applications, the methodology used for their design and development and an overview on the developed products based on the type of the applications, input and output channels, the subject that they address and the initial results of user testing.

CASE STUDY – DESIGNING INTERACTIVE CONTENT FOR FORMAL EDUCATION OF PRESCHOOL CHILDREN

Considering the importance of digital skills for the future development of the children and the statistics on the level of digital skills of the teenagers of today, we have initiated a project that has as main goal to support the development of digital skills of Romanian preschool children. We have focused on creating products that serve three major goals:

- provide support for development of basic digital skills (computer skills): using the mouse, using the keyboard (Enter key, arrow keys, number keys, space bar), perform simple functions using mouse and keyboard (positioning, click or double-click on a certain object, press a specific key), identifying the metaphors used in graphical user interfaces: icons used for actions like start playing a content, going back, going forward in the interaction, identifying ways to exit an application, completing a simple program,
- provide content that can be used in the kindergarten formal educational system (supporting the learning process),
- help the children understand that technology can be used to support the learning process.

In Romania, most of the interactive applications targeting preschool users are available together with magazines for children [26]. The interactive content is provided on CDs and has to be installed on the computer before using it. The content distributed on such CDs is not authorized by educational institutions and there is no information about

how the developed content relates to the cognitive development of preschool children. Professionals in the preschool education domain claim that the first minus of these programs is they need a certain device to be played on and they have minimal specifications of it-thus makes it harder, for both children and grownups, as it is not relevant in the process of learning. Then, the interaction actually does not take place, as the child is not able to perform the activities and perform the tasks all by himself. They do not use suggestive symbols for the content and after completing a level there is no reward for the child in order to stimulate him/her to continue. Some of the applications use terms and terminology about a certain teaching content that are not adapted to the cognitive and emotional development level of the preschool child. As the domain of developing interactive applications for Romanian children is at its beginning, there are no available frameworks for design, development and evaluation.

We have considered that by applying UCD to build interactive applications for children that can be easily used by their teachers we can help both kindergarten teachers and children in the process of developing the basic digital skills of the little users. We knew from the beginning that designing interactive products for preschool children is a challenging task due to the constraint determined by their cognitive and physical development. We assumed that the students attending the Human-Computer Interaction (HCI) optional course from the Faculty of Mathematics and Computer Science of Babeş-Bolyai University would accept this challenge and would be able to fulfill the requirements. The students are enrolled in the third year of study and attend the Computer Science or Mathematics and Computer Science specializations offered by the faculty. Developing applications for preschool children is a very relevant task for the students, as they have experience in designing interactive systems that provide either command-line interaction or graphical user interfaces in different languages (Python, C++, Java, C#) that relies only on text based communication (no use of voice communication and very small use of icons in the designed interfaces). One of the goals of the HCI course is to teach students apply the principles of UCD in the development of interactive products. In order to apply UCD we needed to involve the final users of our products in the design and development stages. To achieve this goal we have contacted kindergarten teachers with the requirement of supporting us in building appropriate products. Although the primary users of our products are the children, we decided that it would be more relevant to consider kindergarten teachers (secondary users) for giving us support in the design and development of the products. Our proposal was accepted with enthusiasm and open-mind and we have started implementing our project in the fall of 2016 and it was continued in 2017. In the following we will describe the development of the project during 2016 and 2017.

Experience on developing preschool children interactive applications in 2016

In 2016, there was a total number of 105 students who were split into 26 teams, each team having three to five members. Each team had to choose a subject and a range of age for their application. In order to provide useful and usable products the students were required to apply a user centered approach. The development of the project has started with an initial meeting between the client (one kindergarten teacher) and the students. During this meeting the client has briefly described her job, and the main challenges she encountered while trying to organize the learning activities with children from kindergarten using interactive content (applications on the computer). First of all, she mentioned her difficulties in using the interactive content that is distributed mainly on CDs that contain multiple technical specifications. She also specified the need to have access to interactive content that aligns to The National Curriculum for preschool level in the chain of the Romanian Educational System, elaborated by The National Ministry of Education [18], meaning a content that can be reliable in teaching. She explained the necessity of teaching children through computer applications and developing digital skills through running compulsory subjects, according to the main domains of curriculum. The students' next step was to document on the subject and to understand the requirements. In this sense, the students had to study the curriculum for kindergarten and Bloom's taxonomy of educational objectives [2]. After this research step, each team had the chance to meet the client again, and gather the requirements for their project using a qualitative research method (structure/semi-structured interview, observation). The client has described the stages of the teaching activities in kindergarten and she mentioned that the applications should cover one or all of the mentioned stages (focus capturing, recall moment, presentation of new content, and fixation game). Afterwards, the teams had to think of a solution for the client's problem (choose the domain of their application and the age range of children their solution addressed). The teams presented the domain from curricula they have chosen and the kindergarten teacher either approved it or proposed new approaches to it. Then, she provided information on the content that must be presented and examples of tasks the children should be able to perform after the presentation of the subject. The teams also had to build alternative designs for their ideas, and then to build an executable prototype that was evaluated with the client. Based on the feedback from the kindergarten teacher, consisting in recommendations for: the content presented, the tasks proposed for the fixation games, the complexity of the interface, the feedback provided for the proposed exercises, and the rewards for the children, the teams continued with the solution implementation followed by another evaluation session for the final product. The proposed solutions have taken the form of games, designed to support the learning goals of the

curriculum. Each team had to also specify the range of age of the children their application addressed and the domains from curricula covered by it.

In Table 1 are shown the curriculum domains covered by the applications developed by the students and the number of applications for each domain, in the two iterations of our project (year 2016 and year 2017). The choices of domains were spread between the following curriculum domains: Aesthetics and Creativity, Human and Society, Language and Communication, Science, and Psychomotor, in an integrated manner. The proposed solutions cover all the above mentioned domains. Most of the solutions were focused on the Mathematics and Science (see Table 1) and we can justify the choice by the fact that the students are more familiar with this domain, but there were also surprising approaches to domains such as Human and Society, and Aesthetics and Creativity.

One characteristic of the proposed solutions is that they were not restricted to a single domain, such that they can be used in different learning contexts. During the development of their solutions, students encountered multiple challenges that they haven't faced during faculty before. First of all, the existence of a real client for their project (that does not have technical knowledge, with different background and vocabulary) was at the same time intimidating and challenging. The need to identify the requirements from real clients was also challenging, because during their studies, students are used to solve problems stated by very clear requirements. The requirement to follow UCD guidelines, and as a consequence applying qualitative research methods was a difficult step in project development, knowing that during their (technical) training, the communication skills of Mathematics and Computer Science students are not very often elicited. Most of the students did not followed the recommendation to apply observation in the real environment of their client, such that many changes have been suggested after prototypes evaluation.

The evaluation of the proposed applications was performed using direct observation, as the literature states that it is the most effective when trying to identify the opinion of users on the products they are exposed to [1, 20, 25]. The observation sessions have been designed as play-testing, where the preschool children have been asked to explore the created products. The problems found during the evaluation sessions were related to identifying ways to start the interaction, going back to a previous context and confusion (sometimes the children did not understand the goal of the application). The main suggestion for improving the understanding of the application (goal, tasks, navigation) was to introduce a character (an assistant) that guides the children through the tasks and content of the application. In order to avoid confusion regarding the entrance point (how to start the interaction), the character provided enough explanations and the play icon (button) was strategically placed in the same place all through the application. Students participating in the evaluation sessions have mentioned that they were impressed by the enthusiasm and willingness to explore of their little clients and this was very rewarding and made them feel motivated to improve their products. From the client's (kindergarten teacher) point of view, all the developed applications can be used in different activities organized with kindergarten children as following: a great amount of information can be integrated during a lesson (at the beginning, on-going or at the end of a lesson as evaluation of a certain content). There is a small number of applications (6) that can be used as a lesson itself approaching subjects as emotions, the garden, seasons, animals from our country, learning musical instruments, and learning about Europe.

Experience on developing preschool children interactive applications in 2017

Encouraged by the success of the first iteration in the implementation of our project, we have decided to continue our work and to refine the way the requirements are addressed to the students. We have observed that by letting them choose the domain and the age range, a lot of time was spent on deciding what to do, a lot of feedback was needed to confirm that they have made the right choice and that their products are developed in the expected direction. In 2017 the kindergarten teacher has proposed a list of subjects and has clearly specified from the beginning the age range for each subject. The subjects were formulated very shortly, like: "The Bicycle", "Water and its circuit in nature", "The toy-how is made", "Recycling", " The Human Body" , "Seasons", "The tree through the four seasons", "Fairy tales heroes", "The cosmic space", "Materials and Substances", "Clothing", "Dinosaurus", "Primary and secondary colours", "Spring" ,"Summer", "Autumn", "Winter", "Fruits", "Insects", "Professions/Jobs", "The five senses", "Environment", "The car-how is made", "Means of transportation on land", "Means of transportation on water", "Means of transportation through air", etc. A number of 113 students grouped in 27 teams of 3 to 5 members have participated into our project implementation. The user centered design has followed the requirements analysis step, where students have used at their choice qualitative methods like interviews, focus groups, and observation to gather details about the current state of the tasks. During these meetings with the client, the students have gained supplementary information about the subject, as the targeted age range and the domains from curricula they have to cover. The next step was to build alternative designs and to decide on building an executable prototype. In this step, the students have gathered feedback from the kindergarten teacher regarding the information that have to be presented to the children, the type and complexity of tasks the children should perform after consuming the presented content (knowledge), their order, the feedback the children should

receive based on their actions and the complexity of the interface (colours, sounds, layout of objects on the screen), and interaction with the children (navigation, feedback, control). After the evaluation with the kindergarten teacher, the students have made the required changes and a new evaluation session with the children was organized. The prototypes were evaluated with the children by direct observation and interviews (the goal was to discover the attitude of the children towards the products). As Table 3 shows, in 2017 the students have chosen to develop web applications in order to address the requirement to avoid complex installation steps needed before product use. Regarding the interaction style, students have developed direct manipulation and point and click interfaces. The information (knowledge) has been presented by audio messages, and sometimes written messages have been provided (in situation where children should answer using numbers), with an increase use of the mixed channels in 2017 (see Table 4).

Curriculum Domain	**Number of applications developed in each domain**	
	2016	**2017**
Science (Mathematics and Natural Science)	22	16
Language and Communication	1	3
Human and Society	1	5
Aesthetics and Creativity	2	3

Table 1. Curriculum domains addresses by the applications

Age range	**Number of applications for the age range**	
	2016	**2017**
3-4 years	none	7
4-5 years	(Elements for) 20	9
5-6/7 years	26	11

Table 2. Age ranges addressed by the applications

Application type	**Number of applications of type**	
	2016	**2017**
Desktop	19	11
Web	6	15
Mobile	1	1

Table 3. Applications types

Interaction style	**Number of applications using the interaction style**	
	2016	**2017**
Voice messages	24	26
Iconic	26	27
Written messages	2	1 (for text messages and with audio translation if needed)
Mixed	7	26

Table 4. Interaction styles provided by the applications

The client of the products have remarked a visible improvement on the quality of the delivered products and we can explain this by the requirements that were clearly stated from the very initial steps of the projects, such that students had more time to focus on designing their products and identifying the most appropriate interaction styles for every aspect of the applications (teaching, knowledge fixation, exercises).

CONCLUSIONS

In this paper we have presented our initiative of developing interactive applications for preschool (kindergarten) children that can be used in the formal educational system from Romania. The arguments to start this project are the statistics on digital skills of Romanian children (and adults), the trend of digitization for most jobs of the future, and the fact that the current habits on using technology of Romanian people do not provide the context for developing the digital skills. The challenges in implementing our initiative were related to the lack of experience in designing software applications for preschool children, the small number of applications for Romanian preschool children that could serve as example, and the absence of an evaluation framework for this kind of application with a

double purpose: learning and fun. In the future we intend to perform heuristic evaluation with kindergarten teachers to gather information about the appropriateness of the developed applications in the formal education system and to measure the effectiveness of using the developed products in the educational process comparatively to the classic approach

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