Developing Smart Edutainment for Preschoolers: A Multidisciplinary Approach

Adriana-Mihaela Guran *
adriana@cs.ubbcluj.ro
Faculty of Mathematics and Computer Sicence, Babeş-Bolyai University
Cluj-Napoca, Romania

Grigoreta Sofia Cojocar
grigo@cs.ubbcluj.ro
Faculty of Mathematics and Computer Sicence, Babeş-Bolyai University
Cluj-Napoca, Romania

Laura Silvia Dioşan
lauras@cs.ubbcluj.ro
Faculty of Mathematics and Computer Sicence, Babeş-Bolyai University
Cluj-Napoca, Romania

ABSTRACT

Education has suffered multiple changes due to technological progress. Even though the current generation of preschoolers (aged 3 to 6 years in our country) is called digital native, there is a lack of focus on introducing technology enabled learning tools for them. This paper presents our approach to designing smart learning experiences for a fringe users group, the preschoolers. We present our method proposal for designing edutainment applications for preschoolers, based on a User Centered Design process and how we may integrate Artificial Intelligence to complete and support the capabilities of our little users.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in interaction design*;

KEYWORDS

preschooler, smart edutainment, User Centered Design, emotion, deep learning

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1 INTRODUCTION

We live in a period of digital transformation, with a growing need for self-directed, informal learning. For this reason, we need innovative and powerful new ways of learning that can foster workplace learning, continuously and seamlessly. Smart education aims to get learners participate in their learning process, build their own knowledge, and develop lots of competences for the future society. Smart Learning is the next natural step after the introduction of technology in classrooms. The actual global context dominated by the disastrous consequences of the SARS COVID-19 pandemics showed us once again that other solutions for education support should be provided. For school age children and teenagers the online activities proved to be challenging, but workable [38]. The educational activities for preschoolers have been ignored most of the time, because providing support for educational activities with their mentors is almost impossible from multiple points of view: lack of kindergarten teachers preparation for online teaching, lack of adapted digital resources for children, and lack of physical resources (devices) to support this kind of activities. Although in our country every kindergarten classroom has a computer, it is currently used only for playing multimedia content, not for other activities. Now is the moment to take a step forward, to prepare even very young children for the future context of learning, that will be highly influenced by the digitization progress.

In this paper, we present our approach to design and develop smart edutainment applications that can be integrated with the classical teaching approach for preschoolers. The paper provides a framework of applying User Centered Design to build age appropriate edutainment applications, focusing on the implementation and evaluation aspects that benefit of Artificial Intelligence (AI) advances.

2 SMART EDUCATION AND SMART LEARNING

Smart education, a concept that describes learning in the digital age, has gained increased attention in the last years. The goal of smart education is to foster a workforce that masters 21st-century knowledge and skills to meet the need and challenges of society. Smart learning environments represent a new wave of educational systems, involving an effective and efficient interplay of pedagogy, technology and their fusion towards the improvement of learning processes [33]. As a new educational paradigm, smart learning bases its foundations on smart devices and intelligent technologies [23]. Smart Learning or intelligent education includes new educational contexts in which the importance is focused on the student's use of technology to accomplishing learning goals. It does not depend only on the software and hardware available, but also on how they are articulated in the classes or the online training in conjunction. As identified and heavily studied over the last years, technology can be implemented and used in helping learners learn. Technologies can be used as media or tools for accessing learning content [8] and for evaluation [28] in smart education environments. Experts have highlighted the importance of using technology to improve learning, following the emergence of adaptation and personalization as two

* All authors contributed equally to this research.

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key components of smart learning [11]. A good technological design goes beyond simply using the latest technology in education, to nurturing the required skills for a digital society [20]. A smart learning environment not only enables learners to access digital resources and interact with learning systems in any place and at any time, it also actively provides the necessary learning guidance, hints, supportive tools or learning suggestions in the right place, at the right time and in the right form [11].

There is no clear and unified definition of smart learning so far. Multidisciplinary researchers and educational professionals are continuously discussing the concept of smart learning. Still, some crucial components have been discussed in literature. Gwak [17] proposed a concept of smart learning focused on learners and content more than on devices. It is an effective, intelligent, and tailored learning based on advanced IT infrastructure, but the focus stays on learners, not on technology. The technology plays an important role, supporting smart learning, but the focus should not be on the utilization of smart devices solely. Some researchers consider that smart learning, which combines the advantages of social learning and ubiquitous learning, is a learner-centric and service-oriented educational paradigm, rather than one just focused on utilizing devices [23]. There are three dimensions of smart education: educational outcomes, Information and Communication Technology (ICT) and organizational aspects. The most important dimension is related to the educational outcomes, and the attribute "smart" refers to the fact that the learner gets the adaptation advantage [39].

Introducing smart education to preschool children requires an appropriate approach. Considering that the main activity of preschoolers is playing, we should consider as a first option the design of the edutainment applications as games or, at least, they should expose games-related aspects: a character to welcome the children in the game world and to provide support during interaction, a story (or narration) to integrate the content and to provide a goal for the required tasks, and a reward when completing the learning activities. Research shows that games are engaging, they can be effective, and they have a place in learning. The benefits of digital game on learning are now well established [3, 18, 40]. Some of the reported benefits are learner's motivation (to complete learning activities), increasing interest in the subject matter, and generation of positive emotional engagement. Games characteristics include challenging activities, curiosity, rules, choices, fun and social recognition [5].

3 DESIGNING SMART EDUTAINMENT FOR PRESCHOOLERS

Designing edutainment for preschoolers is a challenging task. The constraints on the design are of two types: (1) the goal of building systems that are educative and (2) the final users are very young children, at the beginning of their development process. Thus, designing appropriate systems, that satisfy the educational goals and that can be used by preschoolers, needs adaptation of the software engineering process. The results of an educational process are measured through evaluation and it is recommended to evaluate to knowledge in a manner similar to how the knowledge was introduced.

3.1 Software Engineering Challenges in Designing for Preschoolers

Designing interactive applications for preschoolers is different from designing for adults due to the cognitive and communication skills of the final users. Applying a User Centered Design (UCD) approach [29] in designing for preschoolers needs adaptation in order to include the final users in the design process.

Moreover, building educational applications means that the design process needs the participation of an educational expert to guide the design team on the content, tasks that are to be presented, tasks sequence, and level of complexity. To make the educational applications fun, i.e. build edutainment applications, the entire product should be conceived as a game, thus addressing the main activity of children, playing. Creating a story to incorporate a learning part and a practical part, where the acquired knowledge is used to solve some tasks needs creativity, and in-depth knowledge of children and their interests.

Other challenging design decisions are related to handling errors in task performance, providing appropriate messages, providing support in task performance, and deciding when to move on with the "game" after multiple incorrect answers.

3.2 Software Engineering Challenges in Developing and Assessing Edutainment Applications for Preschoolers

The early age constraint of our final users brings implementation challenges regarding the authentication process. As preschool children cannot read or write, the usual authentication process with username and password is not possible. As an alternative it has been proposed the use of avatars (i.e., representative symbols, different for each child, such as a blue triangle, a yellow square, etc.). Still, it is not certain that children will always correctly choose their avatar.

Implementing interaction with such young children determines the need for new approaches. Preschoolers possess a very limited set of interaction skills, related basically to using the mouse to perform click or object selection. Also, due to the fact that children cannot read or write and they do not possess typing skills either, the usual interaction with input/output based on text is not applicable. The alternative of replacing the textual messages with audio messages each time a widget on the screen has hovered, causes a lot of problems in sound synchronization because children are moving the mouse very fast all over the screen. Task formulation also needs careful attention as it should contain very precise information on how to provide the answer in terms of interaction. For a task like "Find the number of animals on the screen" the children usually answered verbally or pointed with their finger on the correct answer, without selecting the corresponding number on the screen. The task formulation should state very precisely how the application expects the answer to be given, for example "Select with a click the number of animals on the screen".

Error handling is a very sensitive aspect when designing for children. Decisions on how to tackle a situation where a child does not perform the required task correctly, how to provide the error message, how to provide hints for solving the problem, how long to wait until the application goes to the next step in interaction are difficult to take.

Assessing the proposed design is different than working with adult users, because the methods used with adults (interviews, focus-groups, surveys, think aloud protocol) can not be applied without careful adaptation to children. Moreover, the satisfaction assessment of preschoolers is influenced by the fact that children are very willing to satisfy adults.

Considering these, in Section 4 we describe our approach to the design challenges, followed in Section 5 by our solution to address the authentication and satisfaction assessment challenges.

4 A USER CENTERED DESIGN APPROACH TO DESIGN SMART EDUTAINMENT

In order to design smart edutainment for preschoolers, it is very important to know their capacities and limitations. In-depth knowledge of children's development is needed for specific age ranges. There are some guidelines and recommendation for designing interaction for children, but the category of children they refer to is a large age range, namely 0 to 8 years [7, 27]. The differences between children in this age range are considerable, as such, there is a need to deeply know and understand the children who will use an application. The User Centered Design provides the framework for designing appropriate software products. Still, it needs adaptation in order to be used with such young children as final users. Moreover, given the educational role of the designed products, education experts (kindergarten teachers) should be involved in the process. In [13, 14] we have proposed an adaptation of UCD such that it can serve the goal of building edutainment applications for preschoolers. Evaluating the knowledge acquired by the preschoolers using an edutainment application is also a challenging task. Evaluation should use the same approach as the one used for learning (if the new content is introduced using a digital application, then the evaluation should use a digital approach also).

Preschoolers' evaluation is a complex didactic process, that is structurally and functionally integrated into the kindergarten activity. The theory and practice of assessment in education has a wide variety of ways of approaching and understanding the role of evaluative actions. In the kindergarten activity, the evaluation act aims to measure and assess the knowledge and the skills acquired by children during the educational act. Computers have been successfully used to assess older children and adults, and there is much research comparing computer-based testing to traditional paper-and-pencil testing with older students and adults [34, 35]. While for adult users (e.g. faculty students) there are advanced approaches in building adaptive computer-based assessment tools [6, 25, 36, 37], there are only a few attempts in studying the appropriateness of computer-based testing with typically developing preschool children. In [4] it is shown that preschool children can successfully perform computer-based testing. However, the main issue that was discovered was the children's lack of digital skills that brought difficulties in performing the test. In [16] we have proposed an approach, for the development of computer-based assessment tools for preschoolers, also based on a UCD process.

In the following we will describe our adapted user-centered design approach used for building smart education and assessment tools for preschoolers.

Participants. To design successful smart education and computer-aided assessment applications, people with different backgrounds should participate. We consider that people from at least the following domains should be involved: education (i.e., cognitive and developmental psychology), design (i.e., interaction, industrial, UX, game), software engineering, together with preschool children and their parents. As the final users of our intended products are preschoolers, many constraints on the design process occur. Romanian preschoolers are aged 3 to 5/6 years old. By applying UCD, we have the opportunity of building developmentally appropriate applications.

Procedure. The User Centered Design process starts with getting to know the final users and establishing the requirements. In this step, qualitative methods are used to explore and understand the users, the environment and the tasks world. Afterwards, design solutions are conceived and presented to the final users. Based on their feedback, prototypes of the product are built and evaluated. Considering that our final users are a very special group, with limited cognitive and communication skills, we have identified difficulties in involving them in some steps of the design and we have proposed possible solutions. These are described in the following subsections.

Understanding users' needs. When designing educational interactive products, multiple stakeholders are involved: preschool children, which are the primary users, kindergarten teachers that use the products as a support in their everyday activities, parents who get feedback on their children's progress based on the smart edutainment software used for assessment, and generally, the entire society and educational system. The educational system is influenced by the technology penetrating the learning and evaluation process. The society will benefit from our approach in the sense that new generations, with basic digital skills formed from their early childhood, are becoming the new work force.

In this context, we consider the kindergarten teachers as the clients of our product and the children as the primary users. When it comes to smart edutainment, the requirements should be extracted from the kindergarten teachers. Still, the final users of the product cannot be ignored. There are several reasons for involving the children in this step:

- the level of kindergarteners' digital skills must be very precisely evaluated, such that their performance during assessment shouldn't be negatively influenced by their lack of digital skills;
- the applications should expose elements from their world (characters they like, tasks that are challenging for them);
- the vocabulary used should be adapted to their communication abilities;
- they should get to know the design team members from the beginning and feel they are important during the process (the children should know that the design team is creating a product tailored to them).

To gather the relevant information qualitative methods, like observation, interviews or focus groups, are recommended [31].

Design Alternatives and Prototyping. Although in UCD the design alternatives and prototyping phases are separated, we consider that when designing for preschoolers the two steps should be performed simultaneously.

In order to be accepted by children, the designed applications should be conceived as games, or at least they should expose games-related elements. As such, the tasks proposed by the smart edutainment tools should be wrapped in a narration. Children should be informed about the final goal of the interaction and the reward they would get after successfully completing the proposed tasks. As during the interaction it is possible that the children will need guidance or supplementary support, a character from the story should be introduced as a support person. It should be always visible during the learning or assessment, such that the children would feel comfortable.

With the information gathered from the previous step, design ideas can be generated. Considering the special characteristics of the final users, there are some constraints that should be taken into consideration if we want to also involve the children in this step. First, they cannot read and their capacity of understanding abstract representations is limited (they are still in Piaget's pre-operative concrete stage [30]. That is why representations familiar to them, like images from the books, should be used to illustrate their navigation through the proposed tasks. When a talented person that can draw the stories on paper is not available, the design team should find alternatives. There are two solutions that can be used in this phase: the development of executable prototypes of the application (which can become expensive) or the use of a *proxy* for the children, the kindergarten teachers. The kindergarten teachers have all the necessary abilities to provide the appropriate feedback: they can understand abstract representations, they can predict children's attitude toward a design and they can also give feedback on the tasks content, complexity, and progress.

In the prototyping phase, executable prototypes of the product are built. In this phase, children should be involved. They act in this step as informants and testers of the product. Now they are able to provide feedback on the following aspects: the ability to interact with the product (if they are able to perform the interaction actions required: select objects, click, double-click, key-press), understanding of tasks (if tasks statements are clear enough), engagement, fun, difficulty of tasks, the time they can stay focused on tasks, and appropriateness of rewards. These aspects cannot be evaluated by other stakeholders. The participation of a kindergarten teacher during this step only brings valuable information on aspects related to tasks' order and complexity.

Evaluation. The evaluation step from the UCD must involve the main stakeholders: preschoolers, kindergarten teachers, and parents. Preschoolers, the real users of the product, should be involved and carefully observed and listened. Play-testing sessions should be organized to observe children interacting with the application. In order to help the children communicate their understanding and thoughts about the experience, peer tutoring sessions will simulate the think-aloud protocol for adults. To gather satisfaction information, post-interviews with the children can be organized. Smileyometers [32] can be adjacently used to gather subjective impression of users. If the children are using other representations to express their emotions during their everyday activities (instead of smiley faces), it is recommended to choose the most familiar representation, in order to reduce confusion. Kindergarten teachers' assessment of the product is essential for the future use of the product. The developed product should be accepted and used to prove its value. That is why, the feedback from multiple education experts should be gathered. This can be done by organizing workshops and focus groups where discussions on the product are explored. Heuristic evaluation can bring relevant information regarding the quality of the product, but, unfortunately, there are no heuristics dedicated to such young children interaction. Some sets of heuristics for e-learning systems have been developed for children aged 10 or above, which comprise navigational aspects, children specific heuristics and learnability heuristics [1]. Applying heuristic evaluation in the context of smart edutainment applications would mean participation of multiple experts, as knowledge about early education, children and navigation is needed. Parents are important stakeholders during the evaluation. They can observe children's progress, improvement of digital skills, and children's attitude towards the interaction experience.

5 INTEGRATING AI IN THE SMART EDUTAINMENT DEVELOPMENT PROCESS

Our previous experience in designing and assessing edutainment applications has focused on adapting the UCD process to the characteristics of the final users, the preschoolers. We have identified the stakeholders that need to be involved in the design: preschoolers, their parents, educational experts, and interaction designers. During our research we have performed case studies on the three different age ranges that are encountered during the kindergarten in Romania: small group (children aged 3 to 4 years), middle group (children aged 4 to 5 years) and big group (children aged 5 to 6 years) [13]. The subjects of the edutainment applications were taken from the National Curricula for kindergarten: the autumn, the tree through all seasons, fairy tales heroes, the human body, fruits, insects, discovering the cosmic space, sailing on the sea, recycling, the five senses, etc. Each design team has interacted with groups of 3-5 preschoolers during the design, implementation and assessment phase. As evaluation methods we have used observation, smileyometers, post-interviews (with the children in the big group), and peer tutoring. To evaluate the appropriateness of our work from the educational experts' perspective, we have applied heuristic evaluation with the kindergarten teachers [15]. During the development of smart edutainment we have identified challenges related to delivering the learning material as a game, using age appropriate interaction skills, and using instructions that are very clear for the children.

Evaluation of preschool children's progress is an important aspect of children education, as it guides the approach of kindergarten teachers in the future. Research shows that evaluation should be consistent to the way the content has been introduced. As a consequence, we have started designing computer aided assessment tools for preschoolers. In this case, new challenges have been encountered related to the following aspects [16] :

- authentication - when performing evaluation, it is very important to know exactly who is interacting with the software system in a given moment;
- emotions assessment - natural and easy to perform when the evaluation is performed by an adult who can support the children during evaluation. In an automated assessment situation, it is important that the assessment software accommodate to children' emotions, by providing appropriate support and feedback .

For these situations the advances in Machine Learning can provide relevant information, as we will show in the following.

5.1 Automatic Children Authentication

For the authentication aspect, we tried to used machine learning algorithms to establish the child's identity during the interaction. For an input image, the face was detected and bounding boxes were extracted from the original image. Afterwards, a detector based on a special Convolution Neural Network (CNN), a ResNet architecture [19] was used. Each bounding box was then transformed so that the eyes and lips were always in the same place in each image. This transformation (known as alignment) was able of reducing the number of examples that were required for the learning step and facilitated the face comparisons performed in the next step. The alignment transformation was performed by the face landmark estimator [22], an ensemble of regression trees. Next step was to take each detected and aligned image patch and to encode it into a smaller generic representation to better differentiate the persons. After the encoding was obtained, the representations were saved for all the persons in order to form the dataset of "known" users. In the last step of the face classification, using the embedding, a k-Nearest Neighbour (k-NN) model with votes was applied [2].

The proposed authentication approach was validated by considering two datasets. The first dataset contained images of adults and kids from "Labeled faces in the wild" (LFW) [21]. From 1600 persons, the persons that had more than 5 images have been considered obtaining a sample of 4910 images from 276 different persons. Many groups were not well represented in LFW dataset. For example, there were very few children, no babies, very few people over the age of 80, and a relatively small proportion of women. In addition, many ethnicities had very minor representation or none at all.

The second dataset used for validation, called UBB dataset, contained images provided by a kindergarten teacher. Ten children (5 girls and 5 boys) were considered and 5 images per child were recorded on average. The dataset contained cropped photos of only their faces. In addition, some photos captured the children from the side. The total number of images gathered was 50.

Two scenarios have been investigated. In the first one, the face alignment step of the above presented approach was skipped, while in the second one all the stages are performed. The numerical experiments indicate a recognition accuracy improvement from 90% (without alignment) to 95% (with alignment) in the case of LFW dataset and from 30% (without alignment) to 65% (with alignment) in the case of UBB dataset. Given the different sizes of the datasets (kids vs adults), the obtained results are distant from one another when evaluating the scenarios: without alignment *vs.* with alignment. For the first scenario (without alignment) for the kids dataset the recognition accuracy is very small. This small percentage was obtained because the dataset contained a great number of children pictures's that were not looking straight forward to the camera. We believe that even though this is a very small dataset it is a relevant one for small children, because they are always moving and turning around. Therefore, having most of the pictures with children facing the camera would not be fair. For the second scenario (with the alignment step), we can easily see a great improvement for children's face identification. For the UBB dataset, the accuracy almost doubled. When talking about adults, there was also an improvement. When comparing our results with the state-of-the-art methods, the proposed approach reached an accuracy close to the state-of-the-art in the case of adults. For children case, such a comparison was not possible.

5.2 Automatic Emotion Recognition

We have also used Machine Learning to identify preschoolers' emotions while interacting with edutainment applications. Our goal is to automatically assess children's satisfaction while interacting with the edutainment applications. The current approaches for automatic emotion recognition from face expressions involve two steps: face detection and emotion recognition. If for face detection, the accuracy of the existing approaches has passed the threshold of 99% and an average precision of 91.4% [9], for emotion recognition the recent approaches achieved only around 75% accuracy for classifying facial emotions from real-world images [24], [26]. One of the difficulties encountered is the lack of datasets with children faces that can be used for training and validation.

Datasets with children faces are difficult to construct as image acquisition requires parental consent, and finding and recording children is a time and effort-consuming task. In this context, there are just a few available datasets and they are not evenly distributed in relation to emotions. The predominant emotions in these datasets are neutral, sad and happy.

For emotion recognition, we have used deep learning methods, with different network's architectures. Details about the network's architecture, training, validation and results can be found in [12]. One approach followed the traditional supervised machine learning pipeline: first handcrafted features were extracted and then an emotion classifier was construct on them for learning. Other approaches involved deep learning methods, i.e. a Convolutional Neural Network (CNN) that learned to both extract features from images and construct an emotion classifier [10]. As our final aim was to obtain a classifier for children' emotions and because the children images were too few, we have approached a transfer learning pipeline (an emotion classifier was trained by extracting knowledge from an adult source setting and then, we applied it to a different target setting - children images only or children and adults images mixed together). We have observed that an emotion classifier trained on adult images is able to well generalise on other adult images, but when it is tested on images with children, its accuracy decreases (e.g. one approach reached 81% accuracy for images with adults, but only 52% accuracy for images with children). As opposed to adults, children do not have a strong distinctive facial expression for every emotion, and, also, the emotion labeling process is very subjective in the case of children. Both elements can influence emotion recognition. In one approach the emotion classifier was trained using only images of children. It obtained the best accuracy on an existing benchmark dataset called CAFE with the accuracy of 68%, and the results obtained on the UBB dataset have almost the same accuracy. From all the approaches that were investigated, the best children' emotion recognition results (with the accuracy of 81%) were obtained when the classifier was trained and tested on a mixed dataset (containing images of both adults and children). From these results we can draw the conclusion that AI could be used as a supporting tool for usability evaluation with children.

The proposed method could be used for developing and assessing smart edutainment for children aged 3 to 6 years from other countries too. Adaptation might be necessary for both the face detection step and the emotion recognition step.

6 CONCLUSIONS AND FURTHER WORK

In this paper we have presented a method proposal to develop smart edutainment for Romanian preschoolers. We have discussed the challenges in every design step and the stakeholders that should be involved to gather the relevant information. For some aspects like authentication or usability evaluation (which are difficult to perform with preschoolers) we have tried to integrate Artificial Intelligence. In the future we intend to validate our approach through multiple case studies, to improve the validation with the kindergarten teachers and to design and develop adaptive edutainment systems.

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REFERENCES

[1] Asmaa Alsumait and Asma Al-Osaimi. 2009. Usability Heuristics Evaluation for Child e-Learning Applications. In *Proceedings of the 11th International Conference on Information Integration and Web-based Applications &Amp; Services* (Kuala Lumpur, Malaysia) *(iiWAS '09)*. ACM, New York, NY, USA, 425–430. https://doi.org/10.1145/1806338.1806417

[2] Naomi S Altman. 1992. An introduction to kernel and nearest-neighbor nonparametric regression. *The American Statistician* 46, 3 (1992), 175–185.

[3] L. Annetta. 2008. Video games in education: why they should be used and how they are being used. *Theory Into Practice* 47 (2008), 229–239.

[4] S. K. Barnes. 2010. Using Computer-based Testing with Young Children. Nera Conference Proceedings.

[5] D. Charsky. 2010. From Edutainment to Serious Games: A Change in the Use of Game Characteristics,. *In Games and Culture* 5, 2 (2010), 177–198.

[6] K. Chrysafiadi, C. Troussas, and M. Virvou. 2018. A Framework for Creating Automated Online Adaptive Tests Using Multiple-Criteria Decision Analysis. In *2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*. IEEE, Japan, 226–231.

[7] L. Crescenzi and M. Grane. 2016. An Analysis of the Interaction Design of the Best Educational Apps for Children Aged Zero to Eight. *Comunicar* 46, 3-4 (2016), 77–85.

[8] John Daniel. 2012. Making sense of MOOCs: Musings in a maze of myth, paradox and possibility. *Journal of interactive Media in education* 2012, 3 (2012), Art.18. http://jime.open.ac.uk/articles/10.5334/2012-18/#

[9] Jiankang Deng, Jia Guo, Debing Zhang, Yafeng Deng, Xiangju Lu, and Song Shi. 2019. Lightweight face recognition challenge. In *Proceedings of the IEEE International Conference on Computer Vision Workshops*. IEEE, Korea(South), 0–0.

[10] Ian Goodfellow, Yoshua Bengio, and Aaron Courville. 2016. *Deep learning*. MIT press.

[11] B. Gros. 2016. The design of smart educational environments. *Smart Learn* 3 (2016), 15. https://doi.org/10.1186/s40561-016-0039-x

[12] Adriana Mihaela Guran, Grigoreta Sofia Cojocar, and Laura Silvia Dioşan. 2020. A Step Towards Preschoolers' Satisfaction Assessment Support by Facial Expression Emotions Identification. In *24th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems*. to be published.

[13] Adriana Mihaela Guran, Grigoreta Sofia Cojocar, and Anamaria Moldovan. 2018. Initiative to Support Basic Digital Skills Development of Romanian Preschool Children. In *15th International Conference on Human Computer Interaction, RoCHI 2018, Cluj-Napoca, Romania, September 3-4, 2018*, Adrian Sabou and Philippe A. Palanque (Eds.). Matrix Rom, 147–154.

[14] Adriana Mihaela Guran, Grigoreta Sofia Cojocar, and Anamaria Moldovan. 2019. Applying UCD for Designing Learning Experiences for Romanian Preschoolers. A Case Study. In *Human-Computer Interaction - INTERACT 2019 - 17th IFIP TC 13 International Conference, Paphos, Cyprus, September 2-6, 2019, Proceedings, Part IV (Lecture Notes in Computer Science, Vol. 11749)*, David Lamas, Fernando Loizides, Lennart E. Nacke, Helen Petrie, Marco Winckler, and Panayiotis Zaphiris (Eds.). Springer, 589–594. https://doi.org/10.1007/978-3-030-29390-1_43

[15] Adriana Mihaela Guran, Grigoreta Sofia Cojocar, and Anamaria Moldovan. 2019. Co-Design of Edutainment Applications with Preschoolers. Is it feasible?. In *16th International Conference on Human-Computer Interaction, RoCHI https://www.overleaf.com/project/5ec3b37d431fc000017fc56f 2019, Bucharest, Romania, October 17-18, 2019*, Alin Moldoveanu and Alan J. Dix (Eds.). Matrix Rom, 92–97.

[16] Adriana Mihaela Guran, Grigoreta Sofia Cojocar, and Anamaria Moldovan. 2020. A User Centered Approach in Designing Computer Aided Assessment Applications for Preschoolers. In *Proceedings of the 15th International Conference on Evaluation of Novel Approaches to Software Engineering, ENASE 2020, Prague, Czech Republic, May 5-6, 2020*, Raian Ali, Hermann Kaindl, and Leszek A. Maciaszek (Eds.). SCITEPRESS, 506–513. https://doi.org/10.5220/0009565505060513

[17] D. Gwak. 2010. *The meaning and predict of Smart Learning*. Smart Learning Korea Proceeding, Korean e-Learning Industry Association.

[18] R. T. Hays. 2005. *The effectiveness of instructional games: a literature review and discussion*. Naval Air Warfare Center Report.

[19] Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. 2016. Deep residual learning for image recognition. In *Proceedings of the IEEE conference on computer vision and pattern recognition*. 770–778.

[20] Mattias Höjer and Josefin Wangel. 2015. Smart Sustainable Cities: Definition and Challenges. In *ICT Innovations for Sustainability*, Lorenz M. Hilty and Bernard Aebischer (Eds.). Advances in Intelligent Systems and Computing, Vol. 310. Springer, 333–349. https://doi.org/10.1007/978-3-319-09228-7_20

[21] Gary B. Huang, Manu Ramesh, Tamara Berg, and Erik Learned-Miller. 2007. *Labeled Faces in the Wild: A Database for Studying Face Recognition in Unconstrained Environments*. Technical Report 07-49. University of Massachusetts, Amherst.

[22] Vahid Kazemi and Josephine Sullivan. 2014. One millisecond face alignment with an ensemble of regression trees. In *Proceedings of the IEEE conference on computer vision and pattern recognition*. 1867–1874.

[23] T. Kim, J. Y. Cho, and B. G. Lee. 2013. Evolution to smart learning in public education: a case study of Korean public education. In *Open and Social Technologies for Networked Learning*. Springer, 170–178.

[24] Byoung Chul Ko. 2018. A brief review of facial emotion recognition based on visual information. *Sensors* 18, 2 (2018), 401.

[25] Akrivi Krouska, Christos Troussas, and Maria Virvou. 2018. Computerized Adaptive Assessment Using Accumulative Learning Activities Based on Revised Bloom's Taxonomy. In *Knowledge-Based Software Engineering: 2018, Proceedings of the 12th Joint Conference on Knowledge-Based Software Engineering (JCKBSE 2018) Corfu, Greece*. 252–258. https://doi.org/10.1007/978-3-319-97679-2_26

[26] André Teixeira Lopes, Edilson de Aguiar, Alberto F De Souza, and Thiago Oliveira-Santos. 2017. Facial expression recognition with convolutional neural networks: coping with few data and the training sample order. *Pattern Recognition* 61 (2017), 610–628.

[27] P. Markopoulos and T. Bekker. 2003. Interaction design and children. *Interacting with Computers* 15 (2003), 141–149.

[28] B. Meyer and N. Latham. 2008. Implementing electronic portfolios: benefits, challenges, and suggestions. *EDUCASE* 31, 1 (2008), 34–41.

[29] Donald A. Norman and Stephen W. Draper. 1986. *User Centered System Design; New Perspectives on Human-Computer Interaction*. L. Erlbaum Associates Inc., USA.

[30] Jean Piaget. 1970. *The origin of Intelligence in the Child*. Routledge & Kegan, London.

[31] H. D. Pitariu, D. M. Andrei, and A. M. Guran. 2010. Social Research Methods used in Moving the Traditional Usability Approach Towards a User-Centered Design Approach. In *Integrating Usability Engineering for Designing the Web Experience: Methodologies and Principles*, Tasos Spiliotopoulos, Panagiota Papadopoulou, Drakoulis Martakos, and Georgios Kouroupetroglou (Eds.). IGI Global, 701 E Chocolate Ave, Hershey, PA 17033, USA, 36–53.

[32] Janet C. Read and Stuart MacFarlane. 2006. Using the Fun Toolkit and Other Survey Methods to Gather Opinions in Child Computer Interaction. In *Proceedings of the 2006 Conference on Interaction Design and Children* (Tampere, Finland) *(IDC '06)*. ACM, New York, NY, USA, 81–88. https://doi.org/10.1145/1139073.1139096

[33] Elena Shoikova, Roumen Nikolov, and Eugenia Kovatcheva. 2017. Conceptualising of Smart Education. *ELECTROTECHNICA+ELECTRONICA* 3–4, 52 (4 2017), 29–37.

[34] G. Sim and M. Horton. 2005. Performance and Attitude of Children in Computer Based Versus Paper Based Testing. online.

[35] Gavin Sim, J Read, and Matthew Horton. 2016. Practical and ethical concerns in usability testing with children. *inGames User Research: Study Approach, Case, A. Peters, Ed* (2016), 1–33.

[36] Christos Troussas, Konstantina Chrysafiadi, and Maria Virvou. 2019. An intelligent adaptive fuzzy-based inference system for computer-assisted language learning. *Expert Syst. Appl.* 127 (2019), 85–96. https://doi.org/10.1016/j.eswa.2019.03.003

[37] Christos Troussas, Akrivi Krouska, and Cleo Sgouropoulou. 2020. Collaboration and fuzzy-modeled personalization for mobile game-based learning in higher education. *Comput. Educ.* 144 (2020). https://doi.org/10.1016/j.compedu.2019.103698

[38] UNESCO. 2020. As a new academic year begins, UNESCO warns that only one third of students will return to school. https://en.unesco.org/news/new-academic-year-begins-unesco-warns-only-one-third-students-will-return-school.

[39] Vladimir Uskov, Robert J. Howlett, and Lakhmi C. Jain. 2015. *Smart Education and Smart E-Learning*. Springer Publishing Company, Incorporated.

[40] R. Van Eck. 2006. Digital game-based learning: it's not just the digital natives who are restless. *EDUCAUSE Rev* 41, 2 (2006), 16–30.