Teaching children with and without disabilities school readiness skills

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Abstract: We know that computer assisted educational curricula are much more attention captivating and interesting to children compared with a classic paper and pencil approach to teaching. Educational computer games can easily engage students, captivate and maintain their attention allowing them both learning with teachers and practicing on their own time without the teacher's direct attention. Overall, computer based instruction increases the motivation and results in faster acquisition of skills. Also, teaching children with developmental disabilities requires special set of tools and methods, due to decreased level of attention towards stimuli presented and lessened capability to learn in the ways typical children do. Therefore, computer based instruction seems to be a good match for these diverse learners because it offers multiple exemplars, interesting and interactive practice with constant feedback, multiplied learning opportunities without direct teacher engagement, and customization to each child's needs. In this paper we present the expanded LeFCA framework that was proven successful for teaching children with autism basic skills and concepts, and we now tested it across various levels of learners with and without disabilities across 3 different languages: Bosnian-Croatian-Serbian (BHS), Italian and English (US). Within the pilot project, we produced four games for teaching matching, pointing out (based on visual and auditory stimuli) and labeling skills, which are considered to be primary skills needed for learning. We then expanded the frame with adding four more games that teach sorting, categorizing, sequencing and pattern making. The results of our user study, done with 20 participants in three different languages, showed that the created software in native languages was completely clear and user friendly for kids with and without special needs, and that is systematically and developmentally appropriately sequenced for learning. Additionally, we found that children were able to generalize learned skills, through a transfer to a new mediums or environments and their teacher reported that children were very motivated and enjoyed playing the games.

Key–Words: Educational software, autism, learn unit, learning shapes, interaction, multilingual

1 Introduction

Just by observation, we can easily conclude that children prefer video games or computerized approach to learning. These "different" media have capacity to engage children, maintain their attention and focus on the learning process. It is easier to achieve and maintain a child's undivided attention for long periods of time with computer games [1], which can give educators a wider window of opportunity to teach. Since the 1980's, we know that research has consistently shown that playing computer games produces faster reaction times, improved hand-eye coordination and has an affect on the player's self-esteem [2]. Computer games are useful educationally because they can assist children in setting goals, ensuring goal rehearsal, providing feedback, reinforcement, and maintaining records of behavioral change [3]. Also, they can provide elements of interactivity, allow participants to experience novelty, curiosity and challenge, which all may stimulate learning. Computer-assisted interventions can give children with different learning needs, the opportunity to work on basic building developmental skills, practice them on their own time and at their own pace, receive feedback (reinforcement and corrections), or to be engaged and learning even when teachers cannot give them the direct attention in larger classrooms. However, even though we know of these enormous benefits, it still appears that most of the computer games today have very little educational value, and most curricula objectives for all students in schools are still taught the "old-fashion" paper/lecture way.

Today, the driving forces in innovations in educational technologies are the needs of the ever-growing population of diverse learners, students on the margins. These are the learners for whom present teaching technologies and practices are least effective, for example, students with disabilities or exceptional talents [2]. Research in the field of video games for children with autism and intellectual disabilities showed great gains and generalization in social skills taught [4, 5]. Demarest presented a detailed case study of a 7-year old boy with autism, with serious deficiencies in language, understanding, social and emotional skills, but who continually excelled in video game playing [6]. This in turn helped the boy with self-esteem, had a very calming affect on him, and helped his basic skills development. Some of the therapeutic benefits Demarest outlined were language skills, mathematics and reading skills, and social skills. These are main curricular objectives for every child all over the world today. Additionally, studies have shown that children with autism may learn more quickly when using a computer than with traditional teaching strategies, and are more interested and motivated to learn through computer-assisted instruction [7, 8].

Other researchers have used video games to help learning disabled children in their development of problem-solving skills [9] and mathematical ability [10].

When designing computer-based instruction, lots of research has been done on the effectiveness and main characteristics of successful teaching software. Whalen et al. outlined the key components of successful computer programs for children [8], and they are:

1. Multiple exemplars: using variety of different examples of one concepts when teaching (e.g. to teach a concept of a COW, you need examples of a black cow, brown cow with flappy ears, skinny cow, black and white cow, etc.)

2. Variety of methods used to teach concepts: different response topographies (e.g. receptive and expressive identification, matching, sorting, pointing to, etc.)

3. On-repetitive trials: Always using multiple exemplars and not repeating the same trial, over and over again, because it may result in memorized responding rather than a generalized response.

4. Customization: one should be able to adjust, tailor, and customize the program to the child's individual needs.

Universal Design for Learning (UDL) is a concept based on our two decades of research about learner differences, the capacities of new media, the most effective teaching practices, and fair and accurate assessments of students' learning [11, 12, 2]. It provides research-based guidelines on how to apply current knowledge about students with "different" learning needs (i.e. learners on the margins) to the design of curriculum, in our case a computer-based curriculum. UDL principles are multiple exemplars and flexible methods of presentation, expression, practice, and engagement, in order to support recognition, strategic and affective learning [12].

These principles align with Whalen et al.'s recommendations of multiple exemplars, varied representation of tasks and stimuli, variety of response topographies, and adjustability to each particular students skill's level and capabilities [8].

Furthermore, for the past 50 years, research showed that the basic teaching unit, upon which all learning and effective instruction are based on is a three-term-contingency (i.e. learn unit) [13, 14, 15]. It consists of an A-antecedent, B- behavior as a response to an antecedent, and a C-consequence in a way of reinforcement for correct responses and correction for incorrect responses. Skinner's tree-term-contingency has been proven effective not only as a teacher-student interaction, but of one between a learner and a teaching device, famous Skinner's teaching machine [16, 13] or Emurian et al. 's computerized instruction [17]. Therefore, a computer game we have designed and developed, is entirely based on the learn unit, an interlocking three-term contingency between a computer who presents visual and auditory antecedents and delivers feedback, and a student who emits the responses to computer's antecedents. In addition, it follows Whalen et al.'s components of successful computer program in education [8]. Finally, the score is provided to the student and the teacher at the bottom of the screen throughout the game, and a total score at the completion of the game. Even though providing a student with a score after completing an online test or a game is common in educational software, applications that provide more immediate feedback, as the student is responding to each trial, are proven to be better [18].

2 Framework Development

Previous studies showed that learning process of children with autism may be enhanced and their motivation increased when using computers and computer-assisted instructions, compared to traditional teaching methodologies [19, 20, 8, 7]. Based on various studies investigating the flow [21], motivation [22] and requirements of an effective learning environment [23], the model for educational game design pro-

Game No.	Game name	Instructions	Skill taught
1	Find the same	Click on/touch one of the three presented shapes that is identical to the shape in the lower left corner.	Matching (visual stimuli)
2	Find the different	Click on/touch the shape that does not belong to the group of presented shapes.	Pointing out/Selecting (visual stimuli; logic)
3	Where is the shape	Click/touch the shape heard.	Pointing out/Selecting (auditory stimuli; matching auditory to visual stimuli; receptive language development)
4	Name shapes	Name the presented shape and confirm the correctness of the answer.	Production responding (labeling; expressive language development)
5	*Categorize	Distribute/insert shapes into corresponding plates.	Sorting/Categorizing (visual stimuli; concept of "same")
6	*Sequence of 2	Click on/touch the shape in the lower left corner, which will continue the displayed sequence of shapes.	Pointing out/Selecting (visual stimuli; patterns - early math skills)
7	*Sequence of 3	Click on/touch the shape in the lower left corner, which will continue the displayed sequence of shapes.	Pointing out/Selecting (visual stimuli; patterns - early math skills)
8	*Where are the name of shapes	Click on/touch all the shapes the which you heard.	Pointing out/Selecting and categorizing (auditory stimuli)

Table 1: Names of the games with corresponding instructions and taught skills used in the study. Games marked with * are the newly developed ones.

posed by Song and Zhang [24], and significance of the player/learner profile to the design process [25], a simple cartoon-like environment seemed suitable for such an educational platform.

Taking into account various methodologies for game design and development [26, 27, 28, 29, 22, 21, 23], their importance to the process, and the complexity of problem, a careful analysis was conducted. For learning basic concepts, assuming mouse or touch-screen ability, five modes of learning were utilized:

1. MATCHING (basic pre-reading skills)
2. POINTING OUT / SELECTING (receptive language development)
3. SORTING / CATEGORIZING (logic and higher order thinking)
4. PRODUCTION RESPONDING (expressive language development)
5. SEQUENCING/PATTERN RECOGNITION (Basic mathematics skills)

The framework (available at: http://lefca.net) consists of 8 different games, corresponding to different tasks and modes of learning. Four of them have been previously developed and tested with a pilot study conducted by Hulusic and Pistoljevic [30], and four are new: "Categorise", "Continue sequence of 2", "Continue sequence of 3", and "Where are the shapes", corresponding to sorting/categorizing and pointing out/selecting modes of learning, Table 1.

The framework uses a simple, easy-to-navigate pipeline, Figure 1. The user first selects a language, and is directed to the game selection. Each game has a title and short instructions, Figure 2. After the user selects a game by clicking on the appropriate "box", the game loads and starts. All shapes, throughout the game are used randomly, and are displayed with the same visual appearance. After the game ends, a user is provided with a final score and the Back/Repeat selection. By choosing back, the user goes to the game selection menu. Clicking on repeat button will restart the game. All answers are followed with the positive or negative feedback (both visual and auditory) and score update. Incorrect response is followed by the correction animation, which indicates the target stimulus.

Although there is a negative trend of using Flash content due to the lack of native support on Apple

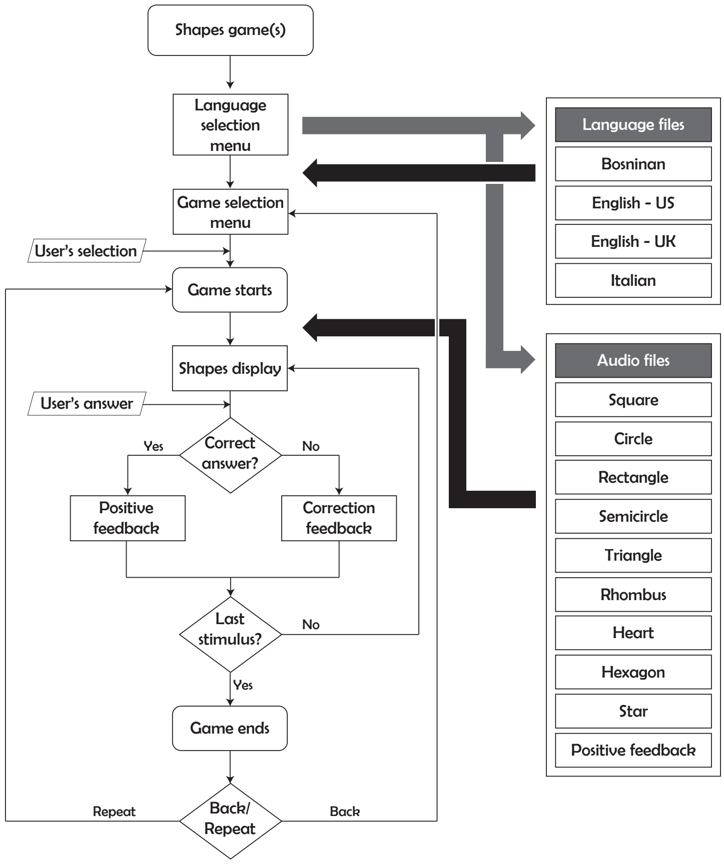

Figure 1: The interactive logic of the games.

devices, Flash is still widely used. According to online resources [31], 99% of all Internet desktop users have Flash Player installed on their machines, which gives it a great potential for web usage, without a need for any additional software installations. In addition, since Flash supports vector graphics, all the graphics elements are scalable with no quality degradation, which makes the framework suitable for multiple devices and screen resolutions. Furthermore, the framework can be offered for download and thus allow even users with slow internet connection to use it effectively.

3 User Study

The first case of using such applications in B&H schools was with LeFCA learning framework, which was tested in a pilot study with 4 children that were diagnosed with Autism and/or other developmental delays with autistic elements in public special education institute "Mjedenica", Sarajevo, B&H [30]. The results showed an increased pace in learning new concepts and the ability of the children to generalize these skills and use them in new environments, such as personal computers, or being able to use acquired knowledge in regular daily educational paper/pencil or vocal tasks.

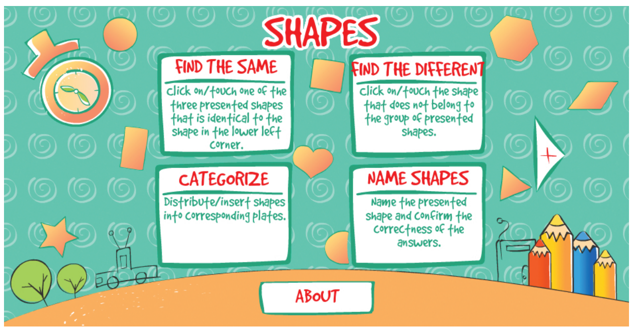

Figure 2: The main menu for selecting between the four games.

Therefore, the framework was extended and enhanced in several dimensions:

- by developing four new games

- by using new modes of learning
- by adding two more languages, Italian and English (with two variances: US and UK English)
- by adding both participants with various developmental disabilities and children with typical development in the study.

This allowed us to test the framework using more modes of learning with different levels of complexity within the tasks, and on diverse populations (with distinct cultural backgrounds, developmental abilities and in different languages).

3.1 Design

The participants were starting to play the game as the previous participant mastered all eight games, in a delayed fashion, with the games order rotated, sequence change for better experimental control. Criterion for mastery of the game was 1 time 90% of 100% correct responses (8 or 9 correct responses per total of 9 trials presented in each game). The data were looked at as total numbers of learn units (i.e. trials) required for mastering the game, reach predetermined criterion level. Numbers of learn units to criterion were calculated per country in order to compare the rates of acquisitions.

3.2 Participants

The participants in this study were 20 children with and without disabilities from Bosnia and Herzegovina, Italy and USA, ranging in age from 4 to 13 years old. Eight students with disabilities participated from "EDUS-Education for All" centers in B&H and five from "TICE Learning Centers" in Italy. Four typically developing students and three students with disabilities participated from a "Fred S. Keller School" in USA. Typically developing children were all 4 to 5 year old, while children with disabilities (e.g. Autism Spectrum Disorder - ASD, Intellectual Disability, Emotional and Behavior Disorder, Learning Disability) were between ages 5 and 13. Developmentally, all children with disabilities were functioning on a 3 to 5 year old levels due to their disability. Seven out of 15 children participating were diagnosed with ASD which is characterized with attending difficulty, language and communication delay, social maladjustment and overall difficulties to learn from traditional eclectic methods of education. All the participants had been already exposed to "matching" and "pointing to" instruction, and some "shapes" instruction using paper/lecture style of teaching as part of their daily education. EDUS, TICE and FSK classrooms are all based on evidence-based instruction and individualization of all educational programs for students attending (CABAS® system). All instruction in all the classrooms (with and without the LeFCA framework) was done through learn units, teacher delivering instruction and reinforcement and corrections while continually taking data on all students responses and behaviors.

3.3 Apparatus

For testing our framework, the children sat at the computer table or at the classroom desk, in front of a computer. In B&H a Sony VPCL111FX/B - VAIO L Series All-in-One 24" Touch-Screen Desktop PC was used, Figure 3. In Italy and USA, a 17 inch iMAC desktop and Mac Book Pro, 13 inches laptop were used. A teacher, collecting data using a data collection sheet was present at all times.

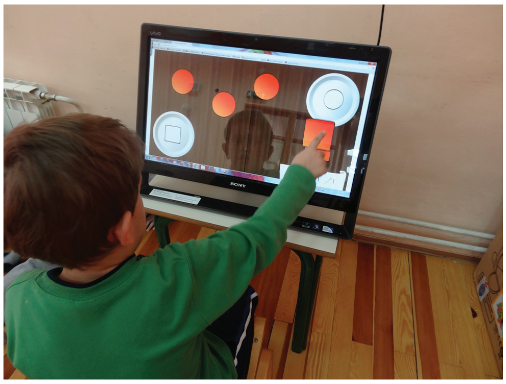

Figure 3: A child playing the "Categorize" game on a touch-screen display.

3.4 Procedure

Each participant played all the games in a sequence and was allowed to proceed to the next game upon the mastery of the previous one. After the successful mastery of all the games, next participant was starting with the same procedure. The sequence of games was looped, and all participants were starting the procedure with a different game. In some cases, some advance skills were not in the students' repertoire, so many participants were not able to complete the sequencing with 3 exemplars game, it was simply too difficult for their level of functioning and it was not appropriate to teach at this time due to the missing prerequisite skills.

LANGUAGE (PARTICIPANTS)	Game 1	Game 2	Game 3	Game 4	Game 5	Game 6	Game 7	Game 8	TOTAL MEAN
BHS (8)	9	9	14.6	25	9	21.4	47.6	10.1	18.2
ITALIAN (5)	9	10.8	12.6	37.8	10.8	31.5	27*	9	18.6
ENGLISH (7)	9	9	10.3	21.9	9	15.4	23.4	9	13.4
*only one student was able to complete this game									

Table 2: Average numbers of learn units needed (e.g. learning opportunities) in order to master each game per country.

4 Results and Discussion

All the participants had 100% correct responding the first time they played the "1. find the same" game. Additionally, most of them had the similar high scores for games "2. Find the different", "5. Categorising/sorting" and "8. Where are the shapes" game, Table 2. This is due to the fact that these are the first basic skills typical children develop by the age of 2 naturally. First lessons in all educational curricula are on attending, matching and selecting repertoires, which are the basic academic skills needed for further learning. All children had these school readiness skills in their repertoire and they were able to demonstrate generalization by using them in a different environment, on the computer, which is the main goal of all education and instruction. In the other games, requiring more complex skills with more prerequisites, we see the same variability across the countries and the levels of functioning. The most demanding and highest order skill taught in the games were production responding tasks required in games 4, 6 and 7 ("name the shape", and sequencing games). These are higher order skills for language and math skills development, and the average numbers of learn units per country, ranging from 21.9 to 47.6, show that all across languages needed more repeated practice to master them (e.g. 2.4 to 5 times), This is a more demanding skill because children are not merely matching the same or similar stimuli or selecting a response, they have to produce it themselves. Therefore, the higher numbers of learn units for all participants are expected. We see that children in all countries and with and without disabilities needed more practice to master these skills. Also, some of the children were lacking prerequisite skills (e.g. Italy) and were not ready to work on these tasks yet. We also see across all three groups increased numbers of learning opportunities for a third game ("Where is the shape?") which demands next order of matching, auditory to visual, so the children could not only rely on the visual stimuli to complete the task. Instead, they needed to focus on auditory stimuli which is a particularly difficult skill for children diagnosed with ASD. Children with autism who do not have fluent speaker behavior developed, usually have not fully reached a listener stage of verbal development either. That is, they do not yet attend to human voices and do not respond to/understand vocal commands, therefore teaching this skill is very time consuming and difficult, as we see in the results presented in Table 2.

Total mean of needed trials to master a whole computer game in English group (13.4) was significantly lower then in Italian (18.6) and BHS group (18.2). This is due to the level of skills USA participants had in repertoire prior to playing the game. Four of their participants were typically developing children and three were high functioning children diagnosed with ASD. This in turn was demonstrated in the speed these kids were able to master all the components of the game. The children from BHS and Italian group had very similar mean number of learn units to master the game (18.2 and 18.6), because their participants were all children with disabilities with similar matching repertoires. They were all speaker and listeners, and many of them come from a low socioeconomic background. For these children, this might be the first time they are playing a computer game in their native language. For Bosnian-Herzegovinian group, this was the first software these children encountered that they could understand. Their 3 classrooms shared one computer, while children in USA classrooms were exposed daily to the technology as part of their daily curriculum. Therefore the value and significance of developing such educational games that are free and accessible to all for the countries in transition and economically disadvantaged groups, is even greater.

5 Conclusions and Future Work

This educational computer game was designed based on decades of research on science of learning and human behavior, and not only on educational theories.

In addition, it is based on a learning frame-learn unit, which is the best known measure and a predictor of the students learning [15]. While typically developing children learn these basic shape concepts early in their life through natural learning process, children with autism and other developmental delays might not be able to do so. The complexity of their disorder has affected their learning speed and often the motivation to learn at all. Therefore, this framework helps children to build up their early cognitive abilities and school readiness skills using basic interaction with a teacher (i.e computer) while being highly motivated and supported. For some of these children and their teachers, using this game will introduce them to a computer for the first time, and hopefully open a new door to more fun and differentiated learning and teaching. All the teachers reported that the children really enjoyed using the software and repeatedly asked to play the games. Skill-development materials, for example, can be designed to provide built-in models of performance, opportunities for supported practice, immediate feedback, and extended communities of practice [32]. A teacher in a large classroom can now be able not only to model a process for a student but to provide the kind of customized attention necessary to maximize a student's progress, delivering personalized feedback, practice, and scaffolds.

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In the future, we plan to conduct a more detailed study in order to better understand the differences between learning with and without the framework. In addition, more participants will be used in the study and a more comprehensive statistical analysis of the data acquired data will be performed.

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