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Special education in science teaching

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Abstract
During the past years, Information and Communication Technologies (ICTs) have been studies in a large number of fields. The term ICTs refers to all kinds of technologies that let users to have access, use and manipulate information (Drigas & Ioannidou, 2013a). ICT can bridge the gap between groups of people with special (educational) needs. The growing number of researches that connects ICTs and assistive technologies (Drigas & Ioannidou, 2013), shows us that the use of them in the life of children and adults with special education needs is huge. In this part of the research we will report some of the most indicative uses of ICTs in the education of people with different learning needs (autism, visually impaired, hearing impaired/loss, sensory and physical impaired and dyslexic learners). Using ICTs and assistive technologies, involves more than overcoming environmental barriers, it is also a means of communication and expression of the personal and social characteristics of the learner. ICTs in special education (and education generally) can be used in every domain to improve it.
Keywords
Learning tool, Teaching tool, Learning Platform, Communication support tool, Diagnostic tool

ICTs in Special Education

I. ICTs usage among visually impaired learners

The main goal for ICTs on visually impaired people is the sight enhancement or the sigh substitution (Söderström & Ytterhus, 2010). For the partially sighted learners, the goal is to get the best of the screen that have in front of them in order to facilitate the performance of visual tasks (reading text, watching videos/images, selecting menus, navigate in websites etc.). The main tools for this is the screen magnifier software, that let users to enlarge all or part of the screen that they desire. Another function to this direction is the contrast change software, that let users adjust the contrast of the screen so to be able to see more clear the objects on the screen. Partially sighted people and learners have the possibility to access ICT without using assistive technology, but the access and use may be considerably limited without it. On the other side, providing ICTs to blind learners involves non-visual alternatives, through the assistive technologies that translate the visual interface into tactile or auditory output (or combination of two) (Söderström & Ytterhus, 2010).

II. Learners in the Autism spectrum

Children and adults with autism spectrum disorder (ASD) show some difficulties in social skills such as initiating conversations, responding in social situations and others. They also find difficulty in the face-to-face interaction due to difficulties recognizing and understanding facial expressions. On the other hand, research has found that individuals with ASD may find social interaction anxious and over-stimulating. As a results, many individuals with ASD experience loneliness as a result of the problems as above described.
A variety of technologies have been explored in the published literature including, tactile prompts and virtual reality environments. Specially, many studies, have documented the effectiveness of virtual reality environments (Parsons & Mitchell, 2002) and video technology

(MacDonald, Sacramone, Mansfield, Wiltz, & Ahearn, 2009) to tech complex social skills such as pretend play, understanding emotions and others. (DiGennaro Reed, Hyman, & Hirst, 2011). Screen based media have the potential to enhance interventions and social engagement, especially given the increasing availability of electronic social networking tools. (Rideout, Foehr, & Roberts, 2010)

These approaches have great appeal because they make good use of personnel resources, which are often very limited in service-delivery settings. Technology allows practitioners to engage in other work-related tasks or simultaneously work with more individuals at one time. The findings suggest that a resource that summarizes empirically supported technological interventions to teach social skills to children with ASD would be of value.

Another way ICTs play a huge part of a autism's person life is social media. Social media can be an attractive social interaction tool for individuals with ASD. Social engagement and connection with existing friends are motivators for use and sometimes can result in closer friendships and increased social engagement. Research found that one hour increase in SNS use, can increase face-to-face interaction time by 10-15 minutes. In the same time, shy adults, report higher levels of perceived interpersonal competence and confidence during online interactions. (Mazurek, 2013). Generally, studies indicate the great potential of the internet for adults with autism. The current study contributes to this by evaluating the success adults with ASD have with current technology and identifying ways the technology could be improved to better support social outcomes. (Burke, Kraut, & Williams, 2010). There has been increasing interest in examining the role of social media in adolescent development as well as ongoing debate regarding the impact of such media on social engagement. Some studies have found that the internet use can be a solitary and socially isolating activity, while others have argued that social media use can enhance social relationships among both adults and adolescents (Shklovski, Kraut, & Rainie, 2006). Online communications was often related to social topics and was motivated by a desire for companionship. Online communication, offer users the benefit of maintaining more control over social interactions than face-to-face or real time online interactions. These technologies offer opportunities for social interaction in a format than does not require attention to nonverbal cues, gestures, facial expressions or vocalization (all these areas are impaired among individuals with ASD). Thus, social media may offer promise for enhancing social interaction among individuals with ASD, because these environments provide more controlled and predictable way of communicating (Mazurek & Wenstrup, 2013).

ICTs in teaching mathematics in Special Education

I. Visual Impaired students

There are many problems with understanding and conquering of knowledge for the visually impaired students especially in mathematics where the knowledge is represented mostly by structural information such as complex symbols, formulas and graphs. Educational software comes to play a special role and overcome this situation (Mulloy, Gevarter, Hopkins, Sutherland & Ramdoss, 2014).

Edwrads, McCartne and Fogarolo (2006) designed the Lambda System (Linear Access to Mathematics for Braille Device and Audio Synthesis) for teaching mathematics to students with visual impairments .This attempt was made in order to enhance the accessibility in mathematical education through the development of non-visual alternatives based on the use of technology. Lambda, which is strictly connected with MathML version, uses the tactile writing system Braille, a synthetic speech and a visual display. It represents mathematical symbols with visual and Braille symbols. Each Lambda code symbol has a spoken representation. Screenreaders transform the contents of the computer screen into Braille or speech or both of them. The editor allows to write and to manipulate mathematical expressions in a linear way and provides a series of compensatory functions. Lambda is a universal code and it is suitable for secondary-school to university students who have acquired some basic skills in computer science.

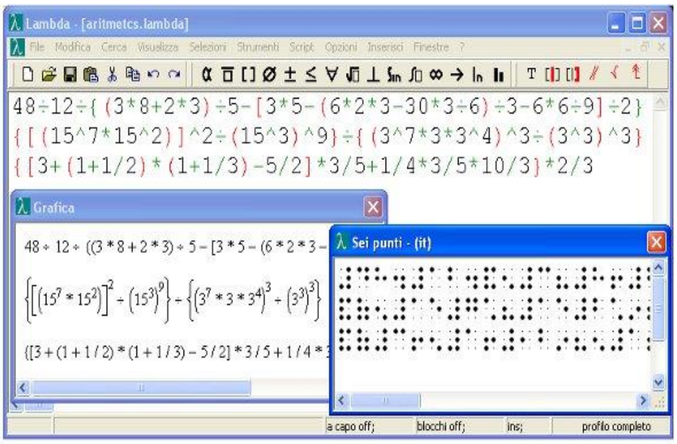

Figure 1. Numeric expression as rendered in the Lambda Code with Lambda symbols and a Braille representation.

II. Students with Dyscalculia

Dyscalculia is a learning disability characterized mainly as a difficulty in basic arithmetic skills, such as addition, subtraction, multiplication and division (Pólya, 2012). It is presumed to be due to a specific impairment in brain function. Therefore, the construction of adaptive software informed by the neuroscience findings on the core deficit in the sense of number will be a promising approach (Butterworth, Varma & Laurillard, 2011). Käser et al., (2013) developed the computer-based training program Calcularis based on brain areas that are underperforming or functionally deficient in children with developmental dyscalculia or mathematical learning problems. The program combines the training of basic numerical cognition with the training of arithmetical abilities and it is based on neuro-cognitive findings of the typical and atypical development of mathematical abilities. Therefore, the main objective of the educational software is to support neural development through the development of mathematical thinking. The games are structured according to number ranges. The areas, that are focused, are the number representation and the number understanding. Users can be trained at the transcoding between different number representations as well as at cardinality, ordinality and relativity of numbers. Evaluation of the program was carried out through a study with 41 children in the 2nd–5th grade of an elementary school in Switzerland. Participants were divided into a training group completing a 12-weeks training and a waiting group starting with a 6-weeks rest period. The children played the game for 20 minutes per day for 5 days a week. The results had very positive training effects in mathematical skills after completion of the training. Children significantly improved their subtraction skills over the course of the 6-weeks-training and they were capable of not only solving more complex subtraction tasks but also faster. Calcularis proved to adapt to the level of each user and the feedback from participants was positive. Finally, the software is available only in English and French and the full version requires a subscription.

III. Students with Down syndrome

Students with Down syndrome face many math difficulties which are attributed both to global intelligence level and/or to their atypical cognitive profile (Sella, Lanfranchi & Zorzi, 2013). Gonzalez et al. (2010) designed an automatic system for the detection and analysis of errors in arithmetic operations to support the personalized feedback. This method focuses on the simplest mathematical algorithms, the addition and subtraction, carried out by all students and especially by students with Down syndrome who struggle with abstract concepts. The system detects a list of possible mistakes such as starting operation from left, confuses numbers, adds different order units. Then, an algorithm analyzes these data as a result of the interaction between the students and the platform. Moreover, it presents the errors in the corrected answers or it allows them to correct their mistakes. This is a great advantage of the system because it promotes self teaching in mathematical problems as students can learn from their own mistakes. Except from

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this fact, teachers can help them have a better understanding of their difficulties. The first experiment involved a group of students with Down syndrome and the results confirm what was said above.

IV. Students with hearing disabilities

Students with hearing disabilities or deaf students have not a satisfactory performance in the fields of science and engineering, thus a highly interactive computer animation tool using sign language is an emergency necessity to increase the mathematical skills of deaf children (Adamo-Villani, Carpenter & Arns, 2006).

SMILE (**S**cience and **M**ath in an **I**mmersive **L**earning **E**nvironment) is an effective and enjoyable immersive learning game which intend to the interaction of deaf and hearing children of age 5–10 in math and science-based educational activities. The project uses fantasy 3D avatars that communicate in American Sign Language (ASL) and spoken English. In the interactive virtual world of SMILE students can explore the town of 'SmileVille' enter buildings, select and manipulate objects, construct new objects, and interact with the 3D characters. They performed on hands-on and goal-oriented activities, which are developed with the elementary school educator and deaf educator in order to provide STEM (Science, Technology, Engineering and Mathematics) concepts according to the math/science curriculum. SMILE includes standard VR interaction devices such as a 6DOF wand, a pair of pinch gloves, and a dance platform. The evaluation on a group of 21 children ages 6½ - 10 including 7 deaf children using ASL showed that the game was enjoyable and user friendly. Nevertheless, the learning outcomes of using SMILE have not been assessed yet (Adamo-Villani & Wright, 2010).

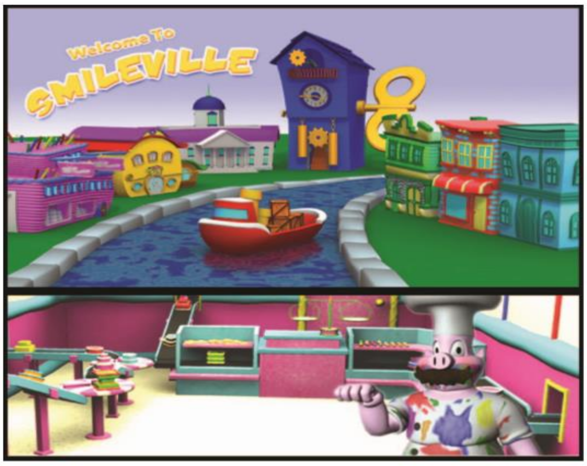

Figure 2. 3D rendering of SmileVille (top), 3D signing character in the bakery (bottom).

ICTs in teaching physics in Special Education

Robinson used the virtual world of Second Life for Deaf college students at National Technical Institute for the Deaf at Rochester Institute of Technology (NTID/RIT) in order to understand the concept of acceleration. Deaf students can't use spontaneously prior knowledge in order to solve problems which are necessary for active learning. They want clear minutely and detailed lab protocols that means dependent learning. They think that homework is easier than work of real lab because homework problems are clear. The aim of Second Life is to bridge the gap between real lab and homework.

Second Life is the largest 3-D immersive, interactive environment accessed through computer software. It has well-developed graphics and in world physics controls the behavior of objects and avatars. Second Life belongs to commercial entity, Linden Labs. This virtual world enables physics students to interact with a three-dimensional environment without to use specialized equipment. All they need is an Internet connection and a computer with an appropriate viewer software and that is provided free of charge from a number of sources.

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Every student controls his own avatar .All avatars interact with virtual world or other avatars. Furthermore students use Webbasing a online homework. Webassign give the ability to instructors for creating their own homework problems, allowing for student input of experimental data and immediate feedback about answers. In physics classes students can use the virtual equipment as they want, as often they want even nights or weekend and they can have a long distance between them .Instructors can teleport their avatars to students' locators to answer questions or pose quires.

In present study deaf pupils make their own avatar to touch a button. Avatar touches sphere and it moves. They collaborate with their classmates by helping of own avatars in order to calculate acceleration from values of moving sphere's velocity or find it from graph of velocity vs time. Certainly are available activities relating to density and mass. There are activities related to translational motion, friction, uniform circular motion, rotational motion of rigid bodies, moment of inertia, gravitational acceleration, and mechanical statics. Deaf pupils prefer dependent learning and collaborative learning. So Second Life gives them the chance for collaboration and clear pathways (dependent learning). Their work looks like real –labs and their homework recaps a real life lab but in a virtual space. So they managed to understand the concept of acceleration and to complete their homework. [1]

Zamfirov et. al presented a new method for teaching physics and astronomy to 13-14 years old students with hearing disabilities who are studying mainstream or specialized schools in Bulgaria. They developed a specialized multimedia sign dictionary with title "Humans and nature, Physics and astronomy" which is useful not only to students who have hearing disabilities but and to students with healthy hearing. The dictionary (textbook and multimedia CD) provides a large number of basic terms from physics and astronomy. A lot of various illustrations are included and there are explanatory texts. The terms are explained in Bulgarian, Bulgarian Sign Language and English. It includes items represented by signs and articles with additional information. Also, there a number of pictures Corresponding articles, definitions and terms contain hyperlinks. The multimedia CD has been created using HTML and Javascript. The signs are shown in FLASH CLIPS which are created in Macromedia Flash. The audio has been dubbed and edited in Cool Edit Pro so there isn't parasitic noise and performer's voice is clear. The recorded video has been edited in Ulead Video Editor and then imported to FLASH with minimal compression. HTML and FLASH can be played on Windows and Unix machines with a graphical environment and browser installed.

Because the CD uses English, Bulgarian and Bulgarian Sign languages Bulgarian students without hearing disorders be able to learn English and students with hearing disabilities be able to understand easier physics concepts through visualizations of the Bulgarian pronunciation of the English term and acquire the skills lip-read terms in both spoken languages—English and Bulgarian. The advantage of this tool is that can depict many physical processes and phenomena those are very difficult to be explained by helping of words. This dictionary gives to the audience the opportunity to learn the way that think and understand the world, the deaf people. This sign methodology can be used and in other subjects like biology, chemistry and geography.[2]

Bulbul et al. adapted a physics simulation from blind students by process of adaption which can be called as "re-simulating" and researched the effects of adapted simulation for two blind students in the classroom environment from different classes. They used the 'Moving man simulation' from Colorado University's Phet Group which helps students to understand cause-effect relationships between variables. The website has been updated regularly and developed. All simulations are accessible freely Moving man simulation is related to concept of motion including, position, velocity and acceleration Graphs. The simulation has two parts. One of them is independent part in which users enter values of position, velocity and acceleration. These values are chosen from them. The other part is the dependent part in which belongs man's motion and motion graphs because both of them are dependent on entered values. If students change moving man without to enter values, then the moving man part will be used as independent part.

For sighed students there are boxes to enter values position, velocity and acceleration but blind students followed verbal directions. Also blind students used a movable paper hoop as a moving

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man. A ruler was used as path of moving man.. Ruler was marked at the middle as a reference point and the piece of paper was circled to move on the ruler. This part is independent part because users choose the position of man and direction of motion. A kind of board which was used for adding and removing black stick to draw a graph is the dependent part because the kinds of graphs are based to their decisions. Sighed students of one class used interactive board and others used projector machine to see the graphs and blind students used their re-simulated materials. All students enjoyed the activities as it was expected and blind students participated in the course. [3]

Using ICTs and STEM in teaching mathematics in Special Education

Inclusion of immersive virtual learning environments and visual control systems to support the learning of students with Asperger syndrome

The study intends to take one step further the use of Virtual Reality. The fully immersive approach supports the learning of social skills and executive functions. The research lasted three years and the participants were 20 students with Asperger syndrome in primary and secondary school. They all had special education teachers. Students had to carry out certain tasks in the immersive virtual reality (IVE). The tasks were implemented in the real classroom in identical situations and students' behavior were observed and commented by their teachers in monthly interviews.

Equipment: Two big screens in L formation provide the immersive effect. One screen provides the front view and the other is placed on the floor on a platform. The system captures student's movement as well as voices, sounds, songs, gestures and behaviors. Special glasses give the feeling that the 3D image is in front of the student's eyes. Virtual school environment shows students and teachers (avatars). Once the student is within the IVE he/she can interact with the avatars and develop different tasks. All actions performed by the student are recorded and analyzed.

Results: Students had more problems understanding the tasks than secondary students. Difficulties increased when the task required an individual decision in a non-structured environment (bedroom, playground). Asperger students' interpret the tasks literally and had problems following the task step by step. Special educators said that the students showed a better progress than in previous years when the IVE was not used. Students with Asperger, through visual strategies such as IVE and by planning highly structured and support tasks, can improve executive functions and social skills. (Lorenzo, Pomares, & Lledó, 2013)

Effects of a computerized working memory training program on working memory, attention, and academics in adolescents with severe LD and comorbid ADHD: a randomized controlled trial

Working memory is a central component of executive functions, and an important mechanism in both LD and ADHD. Frequently it is below average in LD and ADHD populations. Although it is supposed to be a fixed trait, research has suggested that it can be proved through intensive computerized training. The purpose of this study was to evaluate the effectiveness of Working Memory (WM) training in students with severe LD and ADHD symptoms attending a special school in Canada and under medication. The study was held by a licensed psychologist and lasted for two years. Two groups of students were selected, one attended the WM training program, the other a Math training program and the outcomes would be compared.

Participants: 60 adolescents with the following criteria: a) full time attendance at the school b) diagnosed with LD and ADHD c) age 12-17 d) IQ>80 e) English as a primary spoken language**.**

Method: The WM program was Cogmed RoboMemo software program. It was consisted of a set of visual spatial and auditory-verbal tasks; a fixed number of trials, with increased difficulty adapted to each student and was followed for 45 minutes a day. The Mathematics training program was chosen by The Academy of Math, covered 10 essential skill areas and was followed for 45 minutes a day also.

Results: The major finding was that WM had a strong beneficial effect on the students' performance on a measure of auditory-verbal WM as well as an effect on visual-spatial WM. (70% reached the improvement score). Students receiving math training showed small improvement on math scores (57% mastered over ten skills). However, there was no evidence of improvement of other cognitive abilities, behavior or academic function. The lack of long-term follow-up is a substantive limitation of this study. The findings on WM support the hypothesis that WM shows remarkable neuroplasticity across a wide range of age but further development of the program is required. (Gray et al., 2012)

Accommodating Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM)
STEM education frequently engages the senses, particularly vision and hearing. Low vision and blindness present numerous challenges to classroom learning, particularly in STEM fields where instruction relies heavily on graphically conveyed information, such as charts, graphs, diagrams, engineering drawings, photomicrographs, and 3-D simulations.

Computer-based accommodations for students who are blind or who have low vision
- Voice synthesizer software (for text-to-speech transcription)
- Screen readers
- Scanner hardware and software (used in combination with text-to-speech software)
- Text-based browsers and email clients (in combination with a screen reader)
- Specialized mathematics software
- Braille translation software, Braille printers, refreshable
- Braille displays
- Braille-to-speech conversion software

Portable note taking devices with QWERTY keyboard and voice output
- Voice activated mouse
- Large monitor
- Software screen magnification
- Voice control of menus and toolbars
- Voice recognition dictation software
- Word processing software featuring word-completion, spelling checker, etc.
- "Mind mapping" software and other software aids to composition

Mathematics: Students who are blind frequently use the Nemeth Code for Braille Mathematics and Science Notation, but usually there are discrepancies between the print and Braille versions. Teachers of blind and low-vision students often do not have the skills or knowledge necessary to prepare the materials or to teach Nemeth Code with confidence. Visual aids enhance imagery, which helps to recall geometrical terminology. The most direct application of computer applications for dexterity limitations has occurred in mathematics education, where the computer has largely displaced the calculator, graphing implements, and the drawing of mathematical symbols on paper.
Physics: The laboratory should be "multisensory" in order to be effective for all students, especially those with disabilities. Accommodations could include the use of computer-based software relevant to such as speech-to-text dictation (for dexterity limitations) or text-to-speech (for vision impairments or LD). Mathematical processes could be done via accessible electronic documents, such as an accessible Microsoft Word format.

Deafness and Hard of Hearing
The authors concluded that "deaf and hearing individuals may encode information in qualitatively different ways. This study determined that deaf and hard of hearing students may focus on irrelevant aspects, especially in assignments with word problems. Hence, accommodations should be aimed at streamlining material so that students are able to focus on the relevant details needed for problem solving.

Solutions: Kelly et al. (2003) developed a software application aimed at both deaf and hard of hearing students and students with learning disorders to improve analytical and problem-solving skills, particularly with regard to word problems. Kelly et al.'s (2003) Problem Solve was designed to address these issues, especially among high school and university learners. (Moon, Todd, Morton, & Ivey, 2012)

Computer- assisted instruction on the mathematics performance and classroom behavior for students with ADHD.

Children with ADHD have high levels of impulsivity, hyperactivity and inattention, which lead to academic, behavioral, emotional and social problems. In the field of Mathematics students with ADHD experience difficulties in problem conceptualization, speed of processing and calculation strategies. They fail to automatize even the most basic skills with serious implications in later learning of higher mathematical and technological skills. Research indicates that students with ADHD have better performance when tasks match their individual academic needs.

The present study examined three hypotheses. First, Computer Assisted Instruction (CAI) would lead to higher mathematical performance of second-through-forth grade students of ADHD. Second the on-task behavior would increase. Third, students and teachers would consider CAI an acceptable intervention. Three children were selected. They all had ADHD. None was taking any psychotropic medication. The two of them worked on their computers in the classroom while the other students in the class did seatwork assignments. The third worked in the computer lab.

The Math Blaster Ages 6-9 Software package was used in the present study. This software develops skills in addition, subtraction, multiplication, division, percentages, fractions and decimals. The program gave immediate and frequent feedback and points for correct answers. After gaining points, students were allowed to play a video game for 1 or 2 minutes. The BOSS application (Behavioral Observation of Students in Schools) observed active engaged behaviors and off-task ones. There was a baseline phase during participants used only paper and pencil for tasks in mathematics and an intervention phase where participants received CAI. Results showed increases in math fluency and decreases in the off-task behavior. Students and teachers found the computer intervention highly acceptable. (Mautone, DuPaul, & Jitendra, 2005)

CONCLUSIONS

Finally we have to underline the role of digital technologies in special education domain that is very productive and successful, facilitates and improves the assessment, the intervention and the educational procedures via Mobiles [38-47], various ICTs applications [48-81], AI & STEM [82-92], and games [93-99]. Additionally the combination of ICTs with theories and models of metacognition, mindfulness, meditation and emotional intelligence cultivation [100-127] as well as with environmental factors and nutrition [34-37], accelerates and improves more over the educational practices and results, especially for students with disabilities.

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