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Innovation of assistive technologies in Special Education: A Review

Anna Felicia, Sabariah Sharif, W. K. Wong, Muralindran Marriappan

School of Education and Social Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

Abstract: Assistive technologies in education have been rapidly expanding in recent years with the multiple of choices which are embedded in the school syllabus. Recently, the innovation has been penetrating schools worldwide more rapidly. This paper provides a critical discussion and review on the concepts of assistive technologies in education, applications, and research on the innovation. Central to the discussion is a better understanding of scientific usage of the technologies in schools. Assistive technologies further serves as a problem-solving tool or medium that enhanced learning via many factors such as critical thinking, multimodal learning and motivational approaches. The targeted goal of the paper, therefore, is to stimulate the discussion of assistive technologies as the innovation in education based on current research and practical applications.

Keywords: assistive technologies, innovation in education, special education.

1. Introduction

Assistive technology in the context of education can generally be defined as the application of any forms of technology that assist in the learning process. Assistive technology also includes services for evaluation, design, customization, adaptation, maintenance, repair and therapy, training or technical assistance (Christman,2003). Marshala (2000) defines assistive technology in the context of learning as any item, piece of equipment or system that helps people bypass, work around or compensate for learning difficulties. According to Virginia Department of Education's, Virginia Commonwealth University assistive Technology, often referred to as AT, is a product, process, strategy or technique that improves an individual's ability to function or acquire information.

Assistive technology can take several shapes and forms including an assistive writing tool, an adapted software program, a communication device, a pair of eyeglasses or something as simple as a piece of Velcro. Figure 1 describes the interaction and connection within activity (which include learning activities), human factors, and assistive technology interact together to affect performance within a variety of contexts as explained by Marshala (2000). Assistive technology is an umbrella term, which can be divided into two main groups:

(i) Hardware – refers to the actual equipment for example tape recorder, computer and calculator.

(ii) Software – refers to the programs that run on computer, telling the computer what to do.

The purpose of assistive technology is to work around specific deficits, rather than fixing them. It helps people with learning differences reach their full potential and live satisfying, rewarding lives. Examples of assistive technology according to Marshala (2000) include "hi-tech" and "low-tech".

(i) Hi-tech – such as reading machines that read books out loud through a computerized voice to help persons with reading difficulties (speech recognition)

(ii) Low-tech – inexpensive tools, for example tape recorder to permanently capture spoken.

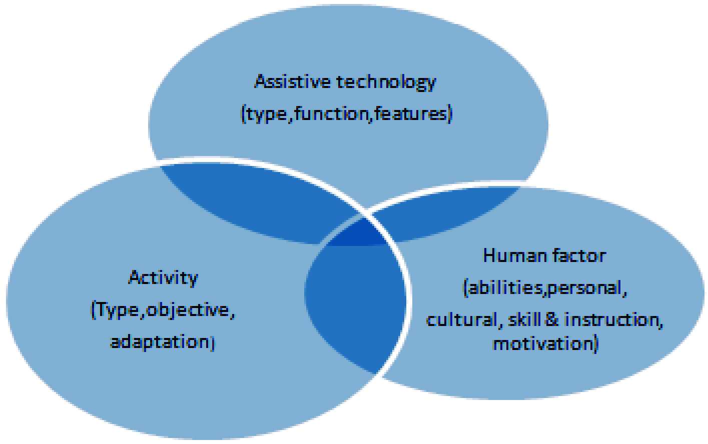

Figure 1 : The activity, human factors, and assistive technology interact together to affect performance within a variety of contexts (Marshala, 2000)

Assistive technology is one such tool that helps to increase the independence of persons with learning differences. In this context, assistive technology can be defined as any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities. It works not only because it bypasses weaknesses, but also because it takes advantage of a child's strengths. However, it is also important to understand that not all technologies are appropriate for all individuals. People have their own unique set of strengths, weaknesses, interests, experiences and special abilities. Therefore, a technology that may be advantageous for one person may be useless for another. The technologies are divided into 5 groups (Marshala, 2000):

(i) Written language technologies – for examples spell checkers, proofreading, speech synthesizers, speech recognition, outlining, brain storming/mind mapping, word prediction and alternative keyboards.
(ii) Reading technologies – optical character recognition (read text back out loud), speech synthesis/screen review, tape recorders and variable speech control.
(iii) Listening technologies – Personal FM listening.
(iv) Organization/Memory technologies – personal data managers & free-form databases.
(v) Math technologies – talking calculators & electronics math worksheets.

Parvaneh et al. (2011), have done a research about effects of assistive technology instruction on increasing motivation and capacity of mathematical problem solving in dyscalculia students. There were 37 students (boys and girls), in age range of 7 to 11 of first to fifth grades, are selected among dyscalculia students of special difficulties learning centers in Tehran. Research instruments were WISC test, motivation measure questionnaire, math exam and "Math Explorer" software. Results showed that assistive technology instruction is effective on increasing motivation and capacity of mathematical problem solving (basic addition and subtraction) in dyscalculia students. Therefore, assistive technology instruction (computer program instruction; "Math Explorer") is proper for dyscalculia students.

In addition ,Madeira R.N. et al. (2009), develop a mobile and web-based student learning system for optimize the use of teaching resources. This system was specially developed to teach undergraduate students at School of Technology of Setubal/Polytechnic Institute of Setubal. This system provide to the students a tutorial, a set of exercises with several oriented questions, interactive animations, assessment tools, a chat room and a game for evaluation purposes. To provide a better mobility, this system has a module to be used with a mobile device.

Gang & Siegel (2002), have done a study to evaluate the effect of sound-symbol association training on visual and phonological memory in children with a history of dyslexia. It was found that:

(i) children with dyslexia and children whose dyslexia had been remediated, the sound-symbol training scores were significantly lower than those of the comparison groups.
(ii) Children with dyslexia and children whose dyslexia had been compensated showed significantly lower than those of the comparison groups.

(iii) Children with dyslexia and children whose dyslexia had been compensated seemed to have difficulty encoding the novel sounds in memory.

Assistive technology has opened many educational doors to children, particularly to children with disabilities. Alternative solutions from the world of technology are accommodating physical, sensory, or cognitive impairments in many ways. And by the existence of computer, more advance and complicated assistance device for special students can be applied.

2. Computer Assisted Instruction (CAI)

CAI, as the name suggests, is the use of a computer to provide instruction. The format can be from a simple program to teach typing to a complex system that uses the latest technology to teach new keyhole surgery techniques (Cotton, 1991). CAI draws on knowledge from the fields of learning, cognition, Human Computer Interaction (HCI) amongst others. Computer- assisted instruction (CAI) and some of the ways they are being used in both general and special education.

(i) Drill & practice

(ii) Tutorial

(iii) Simulation & problem solving

Computers can be used for reinforcement learning, planning and information management using multimedia, hypermedia, and telecommunication systems.

According to Science Scope 2003, in 1997, Individuals with Disabilities Education Act Amendments insured that students with disabilities have access to general education. This act adheres to the motion that parents, students and teachers will work together to design and individualized education program for special needs students. As a result, the inclusion of special needs students into regular classes has been mandated. Research supports the use of computer-assisted instruction (CAI) for special needs students as a supplement to traditional instruction. One of the obvious benefits is that a computer allows special needs students to work at an individual pace.

Teimoornia et al. (2011), Information Technologies encourages active learning. Active learning is a form of learning encourages group work that leads to learning, to share knowledge and development. Panagiotakou & Pange (2010) highlighted that the use of automatic movement recognition technology in preschool music education provided better results in concentration and interest. A research by Jayne M. Leh & Asha K.Jitendra (2013), to evaluate the effectiveness of CMI (computer-mediated-instruction) & TMI (teacher-mediated-instruction) on the word problem-solving performance of third-grade students who are struggling in mathematics while controlling & balancing the key instructional features (e.g priming the problem structure, use of visual representations) deemed critical to successful word problem-solving across conditions. After 6 weeks of word problem-solving instruction that incorporates essential instructional elements (priming mathematical structure, using schematic diagrams) is effective 7 feasible for schools to implement using teachers or computers. CMI & TMI can be used in a complimentary fashion with technology for supporting the teacher.

Furthermore Huang et .al., (2013), the computer-assisted mathematical learning system developed for the study can serve as a supplementary tool that helps teachers with remedial instruction and enhances the problem-solving ability of low achievers. Seo & Woo (2010), a research was conducted according to CAI (computer assisted instruction) “Math Explorer”. The study was important in:

(i) Identifying critical user interface design features of computer-assisted instruction programs in mathematics for students with learning disabilities.

(ii) Designing & developing a multimedia CAI program, “Math Explorer”

(iii) Demonstrating how the identified user interface design features could be practically embedded in mathematics CAI programs for students with LD

(iv) Conducting usability testing to assess whether “Math Explorer” was usefully designed in terms of its interface for students with LD.

The three critical user interface design features were identified as:

- Instruction driven
- Manifest structure
- Adaptive interaction interfaces

Each of the features was further specified with seven implementation guidelines for example, controlling the amount of mathematics instruction, using visual representations, animations and graphics, and selecting appropriate fonts and colors. Coleman, Hurley & Cihak (2012), a study was done to compare the effectiveness and efficiency of teacher-directed and computer-assisted constant time delay strategies for teaching the students with moderate intellectual disability to read functional sight words. It was found that the students with moderate intellectual disability often depend on one-to-one instruction and may benefit from instruction with the PowerPoint software. The special students who need the special attention and one to one care benefit the most from the computer-assisted instruction. In Cullen et al. (2013), a research was done to examine the effects of a computer-assisted instruction program on the acquisition of sight words for four African American fourth graders with mild disabilities. It shown that computer practice using Kurzweil 3000 was functionally related to increase sight word recognition.

As overall, CAI promotes active learning within learners, enhances the problem solving ability and increases the learners concentration and interest towards the learning. Instructional software, on the other hand is designed to develop or improve specific skills in such areas as reading, writing and math. Instructional technology (software) delivers through computer-assisted instruction. And another approach which promotes active learning is via mobile learning-comic application.

3. A Mobile Learning-Comic Application

Research revealed that comic can be used as learning tool, even if the comic is in multimedia format. According to Tilley (as cited by Alleyne, 2009), comics are just as sophisticated as other forms of literature, and children benefit from reading them as much as they do from reading other types of books material. Vassilikopoulou et al., (2007) supports this belief and suggests that digital hypermedia comic has educational strengths. Most of the student-teachers thought that using comics helped them to think differently about the learning situations and to begin the process of restructuring their understanding, and it was easy to use too (Vassilikopoulou et al, 2007). Comic can be beneficial in an interactive format with a lot of pictures. In advance technology, comic is also showcased in mobile device.

Hence, comics is a visual medium used to express ideas via images, often combined with text or visual information. Comics frequently takes the form of juxtaposed sequences of panels of images. Often textual devices such as speech balloons, captions, and sound effects indicate dialogue, narration, or other information. Comic strip a comic strip is a drawing or sequence of drawings that tells a story. Umar et al. (2012), the finding reveals that there is potentially to design and develop the mobile comic application for dyslexic children. A research was done to implement mobile comic application as a way of learning for dyslexic children. There is potentially to design and develop the mobile comic application. It was found that:

* Unified Field Theory of Design, to design the content by transforming data to become wisdom.

* Cognitive evaluation theory (CET), to develop the mobile application comic with special instruction.

Umar et al. (2010), a mobile comic application (named as D-mic) was developed. And D-mic reveals good responds in interactive learning. Figure 2 shows one of the Graphic user interface that has been applied in D-mic. Out of a total of 3 students, all of them were able to perform the task; using D-Mic. They admitted that they understand the story message, enjoyed the learning process, and very enthusiast in using D-Mic. It has been also highlighted that mobile comic application named as D-Mic was tested using the Hallway & Think Aloud Protocol usability testing methods and were employed among three dyslexic students to test the prototype. As a result, D-Mic reveals good responds in interactive learning. As well as evidence that the mobile application interface design communicates effectively to the dyslexic children. Neil Cohn (2005) stated that interactive comic plays an important role as a social interactivity for a further visual language. He believed that interactive comic has a “modality holistic” method, where real-time narratives are combine all three “modalities” in which language can manifest: spoken, gestures and drawn. The language is used for various communicative purposes, gestured language provides a wealth of information in addition to speech and drawn language, is the visual that support the two languages.

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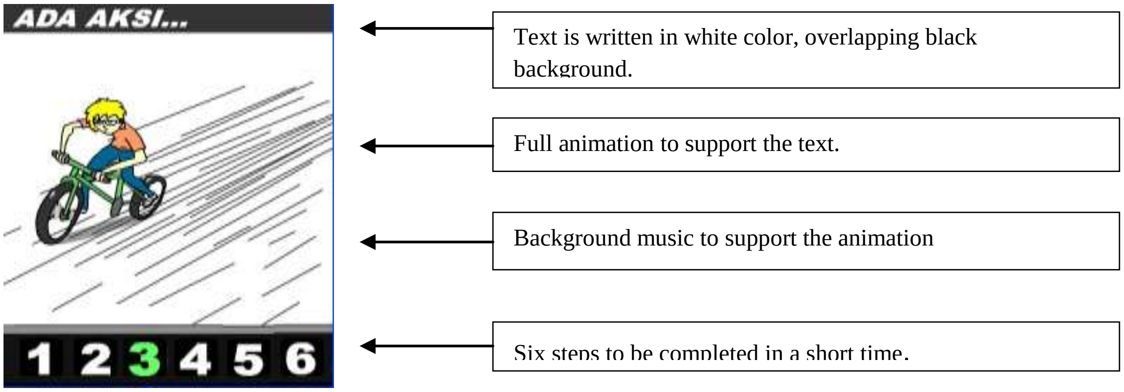

Figure 2: Screen shot of D-Mic (Umar et al. 2010)

In Umar & Nor Aziah (2012) DDR (Design & Development Research six phase model) was used to develop a mobile learning comic application- a partial process. The six phases are:

(i) Identify the problem
(ii) Describe the objectives
(iii) Design & develop the artifact
(iv) Test the artifact
(v) Evaluate testing result
(vi) Communicate the testing results

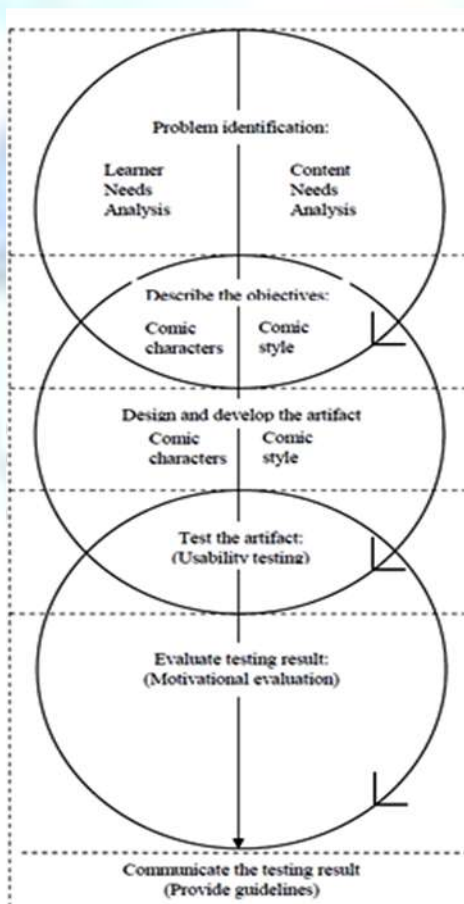

Figure 3: Conceptual framework of the overall research showing six phases top down. They are categorized based on three cycles of processes; Analysis cycle, Development cycle and Evaluation cycle and the research focuses only on the Learner Needs Analysis part of the Analysis cycle. (Umar et al. , 2010).

The result shows that:

(i) based on teacher's opinions, mobile comic application can be good approach to teach dyslexic children as it provides tailored visuals, story that relates to their lives and multisensory engagement.
(ii) based on the student interview, the dyslexic children were found to be motivated using mobile comic application. Comic styles features composition techniques, framing techniques, story characters and contrast colors were found to be relevant and useful.

Retalis (2009), the web comics combine text and imagery as well as hypermedia and streaming elements. The EduComic project places children in the role of creators, rather than merely receivers of information. Children write and draw about their personal experiences and interests, thereby engaging them in the learning process and motivating them to succeed. The point of the project is not to drop a web comic on a child's desk and say: "read this". Rather, the project partners have been training teachers in order that they design learning scenarios where students (in groups or individually) will have the opportunity to draw upon stories (of then complex) that they then revise, publish and share with others in their communities. But, the project consortium is not suggesting that educational web comic books should substitute for traditional books or for standard reading and composition lessons. As comic and mobile-comic always interactive and popular in its own ways, via visual effect it is also motivating and important in enhancing development of thinking skills among young learners and special students.

4. Animation and Virtual Manipulatives

Virtual manipulatives are interactive, Web-based, computer-generated images of objects that children can manipulate on the computer screen. Similar to the ways they slide, flip, rotate, and turn a concrete manipulative by hand, children can use a computer mouse to slide, flip, rotate and turn a dynamic visual representation as if it were a three-dimensional object (Rosen & Hoffman, 2009). Meanwhile, any piece of animation used for the purpose of learning can be termed as an educational animation.

Howard et al.,(2011), there are two main contributions of animation in instruction:

(i) There are the ability to elicit the attention of the learner to important features of the lessons
(ii) Prompt the learner as appropriate to ensure correct responding.

Past research showed that animated learning material did bring positive impact by attracting students and motivating them to focus. Taylor et al., (2007), results showed that appropriate animated learning materials were perceived as being more useful than equivalent static learning materials by both the students with dyslexia and the control group of non-dyslexic students. Umar R.S. et.al .,(2011), it was found that the dyslexic students were attracted to the animated learning content. It has simplified the learning and motivated them to focus in learning.

Moyer et. al.,(2002), explained two types of representations on the World Wide Web are being called virtual manipulative; those are static manipulative and dynamic visual manipulative. Static visual representations are essentially pictures. They are the sorts of visual images ordinary associated with pictures in books, drawings on an overhead projector, sketches on a chalkboard, and so on. Although such representations resemble concrete manipulative, they cannot be used in the same ways that concrete manipulative can. That is, a student can actually slide, flip, and turn concrete manipulative but cannot perform the same actions with the static picture of the concrete manipulative. These static visual representations are not true virtual manipulative. In contrast, dynamic visual representations of concrete manipulative are essentially "objects". They are visual images on the computer that are just like pictures in books, drawings on an overhead projectors, sketches on a chalkboard and so on. In addition, these dynamic visual representations can be manipulative in the same ways that a concrete manipulative can. Just as a student can slide, flip, and turn a concrete manipulative by hand, he or she can use a computer mouse to actually slide, flip, and turn the dynamic visual representation as if it were a three-dimensional object. This kind of visual representation is truly a virtual manipulative. A virtual manipulative is best defined as an interactive.

According to Inoue (2007), educational virtual reality (VR) may result in a significant improvement over traditional instruction because it is not only an interactive multimedia tool but also a learning environment that is extremely close to reality. VR is indeed one of the ranges of more recent computer-based technologies that may increase the possibilities for interactivity. VR can mean anything from a simple "simulation" program to full "immersion" involving special equipment and that only by exploring the various levels of VR can one gain a true understanding of the term's meaning. VR creates the illusion of 3D.The most sophisticated VR level involves users manipulating an environment in which they fully immersed, wearing a special glove and a head-mounted display (HMD). Together, these two pieces of equipment sense and register the user's movements, and using a series of fiber optic cables, send the information to the computer, which interprets the data and converts them into visual imagery. The findings shown that learners benefit most from the VR mode, irrespective of their learning styles, indicating that VR offers promise in accommodating individual differences in term of learning styles.

In this modern era, animation and virtual manipulative have been embedded in more advance technologies via game and robotics application in education. The next section will review through the latest technology applied in education.

5. Game Learning and Robotics Application

Robots are becoming an integral component of our society and have great potential in being utilized as an educational technology. Robotics has attracted the interest of teachers and researches as a valuable tool to develop cognitive and social skills for students from pre-school to high school and to support learning in science, mathematics, technology, informatics and other school subjects or interdisciplinary learning activities (Alimisis, 2013). Saridaki et al. (2008), using the game as a medium, students are able to explore and understand their environment and imitate behaviors and processes in order to increase their creativity and imagination. Students with special educational needs in particular have an opportunity to learn through virtual drill-and-practice/role-playing in order to facilitate their socialization. Moreover, game play supports the concentration of attention and enables students to prove their skills and knowledge. Special education students and students with intellectual disability , in particular can additionally employ educational software and digital games in order to experience everyday life subjects such as mathematics, reading and vocabulary, improve problem-solving skills and prepare themselves for personal safety, social integration and vocational training.

Chun et al., (2013) , a research have been done to investigate game learning and mastery learning (Bloom,1981; Carrol, 1963). The research involve whether both approaches to instruction are able to enhance the effectiveness of mastery learning. As a result, the integration of mastery learning strategies with game-based learning provides greater benefits for students learning mathematics. Wouters & Oostendorp (2013) found that instructional support in game-based learning environments improved learning. Blunt (2007) it was found that students in classes using game scored significantly higher means than classes that did not. There were no significant differences between genders, yet both genders scored significantly higher with game play. There were no significant differences between ethnicities, yet all ethnic groups scored significantly higher with game play.

According to Afari (2012), findings suggest that during exposure to games, students experienced an improvement in the three psychosocial features of the learning environment (teacher support, involvement and personal relevance) and also academic efficacy and enjoyment of mathematics lessons. The results of this study offer potential opportunities for mathematics educators to incorporate the use of mathematical games in the curriculum as a practical way to improve classroom environments and students' attitudes. Meyer & Sorensen (2009), explained that it is the game related practices of children in out of school contexts which are pivotal points of interest for a consideration of how games may be transformed from an extrinsic design that involves drill- and task-based educational material to contextualized simulations, i.e. an intrinsic design, that involves fruitful thinking, real language interaction and learner engagement. Chuang T.Y & Chen W.F. (2009), results indicate that computer-based video game playing not only improves participants' fact/recall process but also promotes problem-solving skills by recognizing multiple solutions for problems.

Research by Kazakoff et al. (2012), the impact of programming robots on sequencing ability during a 1-week intensive robotics workshop at an early childhood STEM (science, technology, engineering & math education) elementary school in the Harlem area of New York City was examined. Using robotics in suitably designed activities promotes a constructivist learning environment and enables students to engage in higher order thinking through hands-on problem solving. In the constructivist model, the students are urged to be actively involved in their own process of learning. The group of children who participated in the 1-week robotics and programming workshop experienced significant increases in post-test compared to pre-test sequencing scores. Figure 4 illustrates one of the examples of the story sequencing card sets used for post test. Children were assessed using a picture-sequencing task. During robotics week children used LEGO Education WeDo Robotics Construction Sets, with the CHERP hybrid tangible-graphical software, and a variety of art materials to build and program their robots. CHERP is a hybrid tangible and graphical computer language designed to provide young children with an engaging introduction to computer programming. The LEGO education WeDo Robotics Construction Set is a robotics kit that allows children to build LEGO robots that feature working motors and sensors. Robotics offers children and teachers a new and exciting way to tangibly interact with traditional early childhood curricular themes. The work demonstrates that it is possible to teach young children to program a robot with developmentally appropriate tools, and, in the process, children may not only learn about technology and engineering, but also increase their sequencing abilities, a skill applicable to multiple domains – mathematics, reading and even basic life tasks.

Figure 4: Figure illustrates one of the examples of the story sequencing card sets used (Kazakoff et.al. 2012).

A research by C-W Wei et al., (2011), a Joyful Classroom Learning System (JCLS) was designed. It includes the experiential learning theory, constructivist learning theory and joyful learning. The JCLS system has been applied in real world for supporting children to learn mathematical multiplication. The formal experiment, including an experimental group and a control group, was conducted with 47 elementary school students in grade two in Taiwan. The experimental group, composed of 24 students including 9 boys and 15 girls, was arranged to learn with the JCLS. The control group, composed of 23 students including 10 boys and 13 girls, was arranged to learn with traditional learning method by using the blackboard. The experimental group shows, using robot to design Robot Learning Companion can simultaneously increase learners' motivations and offer a more joyful perception to learners during the learning process. It helps the students to concentrate on the instruction and learning activity. On the contrary, in Gerretson et al. 2008, the data reveal that the teachers struggled to integrate the technology in a manner that supported interdisciplinary instruction, particularly because lack of time and appropriate curricular materials. However, robotic technology to be used as a model to support education for sustainable development, specific curriculum, adaptable to local contexts, needs to be readily available. Table 5.1 shows five components and potential devices used for designing JCLS.

Table 5.1 : Five main components and potential devices to be used for designing a JCLS (Wei, C-W. et al.,2011)

Element	Example	Function
Robot learning companion	LEGO MINDSTORMS NXT Wowwee, Robosapien And Aldebaran Robotics Nao	Interaction
Sensing input device	Barcode, RFID, QR Code Electronic pen, and Laser projector keyboard	Input
Mobile computation unit	Laptop, OLPC, Netbook, PDA Samrtphone, iPhone & iPad	Processing and storage
Mobile display device	Embedded display in the RLC Protable projector, Touch screen Electronic paper & Eye screen	Output
Wireless local network	Bluetooth, Wi-Fi, ZigBee & GroupNet	Data exchange

According to Vinesh Chandra (2010), the user-friendly nature of the new generation of robots presents new opportunities for teachers to revisit their pedagogical approaches of teaching mathematics. Through innovative learning activities, robotics can show the connections between mathematics and the real world. More importantly it captures children's attention and interest and as consequence they enjoy the experience. Activities with these qualities are more likely to deliver desirable learning outcomes. Meanwhile, recently the PERMATA pintar Negara program conducted by University Kebangsaan Malaysia used the LEGO NXT Mindstorms for robotic and programming (Rizauddin, Melor & Noriah, 2010). The PERMATApintar Negara is a unique program conducted by Universiti Kebangsaan Malaysia (UKM) whereas highly potential students all around Malaysia is selected based on IQ test called UKM1 and UKM2.

It has been proved that during the 3 weeks camp, the students can upgrade their sense of creativity by developing various types of robot with the versatility of LEGO NXT Mindstorms. It helped to facilitate an active learning environment, interpersonal communication skills and programming skills among students. By using the LEGO NXT Mindstorms that has been largely used as an affordable, motivational and effective teaching material for robotic and programming, the camp can provide hands-on experience which gave the selected students the opportunity for creativity and sense of achievement. It has been proved that during the camp, the students can upgrade their sense of creativity by developing various types of robot with the versatility of LEGO NXT Mindstorms.

In term of programming, in Sullivan & Bers (2012), boys had a higher mean score than girls on more than half of the tasks, very few of these differences were statistically significant. Boys scored significantly higher than girls only in two areas: properly attaching robotic materials, and programming using Ifs. The TangibleK Program consisted of a six lesson robotics and programming curriculum that was implemented in three different kindergarten classrooms (N = 53 students).The study looks at the TangibleK Robotics Program in order to determine whether kindergarten boys and girls were equally successful in a series of building and programming tasks. Overall both boys and girls were able to complete the program.

Highfield (2010), describes a series of tasks in which robotic toys are used to develop young children's mathematical and metacognitive skills. Thirty-three children participated in the project, of whom 11 were children, aged three and four years, and drawn from a metropolitan pre-school. Twenty-two Year 1 children from a nearby state school were also involved. None of the children or teachers had experience with robotic toys before they began the project. In both settings the children and their teachers chose to use the Bee-bots and Pro-bots, although a range of robotic toys were supplied. The children were engaged in "play" experiences with the toys and then completed weekly tasks, developed collaboratively by the teachers and the researcher, for approximately 2 hours per week over 12 weeks.

Robotic toys present unique opportunities for teachers of young children to integrate mathematics learning with engaging problem-solving tasks. Bee-bots and Pro-bots, developed as part a larger project examining young children's use of robotic toys as tools in developing mathematical and metacognitive skills. The toys served as catalysts, providing unique opportunities for tasks focusing on dynamic movement. The development of tasks that have multiple solutions engenders flexible thinking and encourages reflective processes. As children program the robot and then observe its movement they can see their program in action and decide if their plan has worked as expected. This visual process encourages children to reflect on their program thus making mathematical concepts "more accessible to reflection". There were three different types of tasks:

(i) structured tasks (teacher-directed tasks designed to develop particular concept or skills)

(ii) exploratory tasks (structured to allow application of knowledge, exploring concepts and skills more freely)

(iii) extended tasks (open-ended and child-directed tasks with which children engaged for an extended period of time, and with limited teacher scaffolding)

Figure 5 : A Bee-bot

Figure 6 : A Pro-bot

Table 5.2 : Task in the Year 1 context (Highfield, 2010)

Task	Descriptor
Comparative steps	A structured task: Starting from a base line, the children predicted and compared the step lengths of the two robots informed the children's understanding of the robot step as unit of measure.
Partitioning and doubling distance complete the task.	A structured task : Using a start, finish and half way point with masking tape) children estimated and programmed the robot to move to the half-way point and then doubled the number of steps to
Robot people	A structured task : Using the language of robotic programming to program the robot. To enable spatial concepts including viewing from different orientations and perspectives.
Robot speedway	An exploratory task : Setting about a number of small cones and programming the toy to weave between the cones.
Moveable island	An extended task : creating a teacher-made island on a grid, by adding a series of obstacles (Example : bridge & quick sand), for creating the adventure for the toys.
Design your own island	An extended task : children, working in small groups, design and made island for their toy. Children programmed the robot to move through their island.

Exploratory and extended tasks provide opportunities for problem solving, whereas structured tasks focused on discrete skills required in the more advanced tasks. It also promoted persistence and sustained engagement as the children attempted to complete the problem solving goals.

Table 5.3 : Task in pre-school context (Highfield ,2010)

Task	Descriptor
Positional language	A structured task : Moving the robot to a finishing point Example : "move from here to under that chair" (altering the length and complexity of the instructions increases task difficulty.
Robot play & investigation	An exploratory task: Free play, working in pair or individually, programming the robot to move between partners to develop measurement concepts; changing the distance increased task difficulty.
Building a robot home	An exploratory task : Using plastic blocks to construct an appropriately sized home for robot. To develop 2D and 3D spatial sense and measurement skills.
Constructing & representing tracks	Exploratory task : Using pre-cut lengths of wooden track to make a series of tracks and programming the toy to move around the track using a variety of tools such as directional image cards.

Table 5.4 : Processes and concepts explored while using simple robotic toys (Highfield ,2010)

Spatial concepts	* Capacity : creating & measuring space (example : tunnel to fit the robot inside) * Angle of rotation : exploring the rotation of the robot * Directionality : examining concept (forward, backward, rotate, left and right) * Position on a plane : using increasingly complex language (example : over there) * Transformational geometry : exploring concepts such as rotation and linear motion.
Measurement	* Informal and formal units : Such as hands, blocks and measuring tapes in creating programs. * Identification and literation of a unit of measure : Example , when moving the toy – using hand and eye gestures as place holders in measuring distance. * Direct comparison : using the toy's length to compare directly the distances needed to complete a pathway.
Structure	* Grid : Developing and using grids showing the toy's step length to assist in planning and developing programs. * Gesture & movement : Using gestures and body movement to indicate and imagine the structure of regular steps.
Number	* Perceptual and figurative counting : to ascertain the number of steps required to complete a given pathway. * Comparison of number : compare the movements pathways
Problem solving	* Estimation : Require to complete a pathway * Re acting * Trial and error * Recall of prior knowledge * Investigating multiple solutions * Evaluating solutions
Representation	* Semiotic understanding of symbols; Example – the forward arrow meaning one step forward * Constructing and recording programs using symbols: symbols include tallies, arrows and invented notations to show movement and location

Whereas in 2005, a PhD dissertation by Donald Sanford Griffith Junior examined potential relationships between high school students' attitudes and interests in science, mathematics, engineering, and technology, and their participation in the FIRST Robotics Competition six-week challenge to design, and built robot. A sample of 727 South Carolina public high school students participated, and data were collected using pre- and post-survey questionnaires. Data analyzed was collected from the group of students participating in FIRST Robotics (treatment), the experimental group, and the group of students who are not participating in FIRST Robotics (control). Findings indicated that there were significant attitudinal differences between students in the experimental group (FIRST), and students the control group pre- and post-survey responses, with students in the FIRST group had statistically significant higher attitude means than control students. It proved that robotic in learning did bring the positive differences toward the students attitudes toward the learning.

A PhD dissertation by Laughlin (2013) in USA investigated whether a causal relationship existed between student participation in after-school robotics programs and their mathematics scores on the Renaissance Learning STAR Math standardized test given at school to assess mathematics skills and learning. The scores of students who participate in the robotics program were compared to the scores of students who do not participate in the program. The study determined that although the STAR Math scores for students participating in the after school robotics program increased following program participation, their increased scores were not significantly different from the increased scores of students who did not participate in the robotics program when the results were controlled for grade, sex, and gifted designations. Robotics program participation did not lead to higher STAR Math scores compared to scores of nonparticipating students. It proved that eventhough robotic tools did bring positive impact towards learning but sometimes the result may be varied depending on the variables controlled during the program.

A master thesis by Vollstedt (2005) purposed was to improve student knowledge and interest in science, mathematics, robotics, computer programming, and engineering as well as improve the methods in which instructors teach science in local schools. In order to improve science education, a curriculum based on LEGO Educational Division's "Race against Time" was created which utilizes LEGO Mindstorms for Schools kits and Robolab software. The curriculum included sections that were both hands-on and Internet based. Twelve local middle school teachers were trained in building robots with LEGO bricks and programming them with Robolab. The middle school teachers introduced the program to their students. Results of pre and post physics, Robolab, and engineering attitude tests as well as teacher interviews showed that the curriculum helped improve students' knowledge of science, mathematics, robotics, computer programming, and engineering.

In 2003, a pilot project has been conducted on integrating a hands-on robotics component into two summer programs for inner-city high school students: the Science and Technology Entry Program (STEP) and Playing2Win (P2W). A paper by Goldman et al., (2003) presented the pilot project using an educational robotics curriculum that was developed to enhance teaching of standard physics and math topics to middle and early high school students in inner-city schools in New York City. The lessons were centered around the LEGO Mindstorms robotics kit and the RoboLab graphical programming environment. The project had multiple goals to support its main purpose. The primary goals were to develop and test curriculum, curriculum materials and supplemental resources using the LEGO robot, geared toward an inner-city public school population. A secondary goal was to examine the use of practical applications for the technology within a non-traditional educational environment in order to anticipate technical difficulties in our implementation plan. The project was composed of four stages: (I) Curriculum Development, (II) First Implementation, (III) Innovation and Modification, and (IV) Second Implementation. This has the further benefit of expanding the base of teachers trained in educational robotics and giving them the tools, experience and confidence to integrate robotics into their curricula in the future.

Summary and Conclusion

Assistive technologies especially for special students are useful in helping and enhancing the learning process via constructivist approach. Thus it has the potential to be the most effective technology for helping students accelerates their learning and retention of information. However, it needs to be accepted by teachers before it can be used effectively and productively in educational and learning purposes. The assistive technologies as discussed in the paper, offer a truly new and inventive way to teach and engage students. It also offers teachers and students unique experiences that are consistent with successful instructional strategies.

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