Aspects of an Artificial Intelligence Assisted Learning (AIAL) System

Introduction

Education is facing various challenges at the moment and needs to be reinvented. Some of the methods used have been inspired by the industrial revolution when an assembly line one-size-fits-all approach was setup in schools.

Today, teachers are struggling to manage the number of students in a class thus making the quality of teaching inconsistent. Furthermore, they have to deal with students having different abilities in the same class which makes it impossible to give each and every child the individual attention they deserve. In most cases, students with low abilities might not get enough assistant to help them improve, whilst students at the higher end, do not get enough help to get them to excel. Furthermore, at the end of the day, teachers are swamped with never ending corrections which take away precious time which should be used by the teachers to improve the quality of their educational offerings.

On the other hand, students might find their class boring when compared to the exciting world of tablets, gaming consoles, etc. They are not excited when faced with resources or methodologies, some of which have not been updated for years. The amount of work given to them, both at school and at home, might be either too easy or overwhelming for some. The situation gets even worse when these children have no one to refer to at home for assistance. Finally, when faced with the dreaded exams, some of them tend to panic and fare badly.

Because of this, we are proposing an AI Assisted Learning (AIAL) System which manages most of these concerns. The system is preloaded with ready-made curricula based upon what is required by national governments. Teachers are also welcome to add their own material to the system. When a teacher delivers a lesson, she simply instructs the system to give the class an exercise on a particular topic. The system will then check the profile of every individual child and give him (on his personal electronic device) a tailor made exercise which is neither too easy, nor too hard. Furthermore, if the child gets stuck, the system will assist him with supplementary explanations inbuilt in the system. The level of explanations can also be tuned to match the abilities of the student. At the end of the exercise, the system automatically corrects the worked exercises and provides immediate feedback. These exercises form part of a continuous assessment methodology implemented through the system. This avoids the students from undergoing a final exams (since all the information is being gathered throughout the year) and it also feeds the AIAL analytics which can be used by the teacher. Through the analytics module, the AI will also predict and flag students which will be facing issues in the following weeks so that the teacher can intervene on them directly. The same methodology can also be used at home, where the homework is automatically generated by the system and appropriate explanations are provided to help the student get through it. Furthermore, gamification elements will be implemented in order to get students to do more work whilst enjoying themselves.

Through such a system, we believe that the teacher can focus on those students that are really in need. This will be done on a case by case basis (since a child with low abilities might require a lot of assistance but a gifted child might also require assistance in some topics), thus creating a fairer educational system which is personalized for the needs of each and every child which guarantees equity.

In the coming sections, we'll explore different aspects of the AIAL system which deals with homework, continuous assessment, computer based learning systems and accessibility.

Homework

Homework is defined as "the set of school tasks that are assigned by teachers for students to complete outside of school hours" (Cooper, Steenbergen-Hu, & Dent, 2012). Lee and Pruitt (1979) described the following types of instructional homework purposes:

- practice (i.e. practicing the material that is covered in class to master skills, increase speed, retain skills and study for tests)
- preparation (i.e. preparing the next lesson)
- extension (i.e. transferring prior learning to new situations).

In a separate study about the different types of homework, it was concluded that as a result of extension homework, the primary students' mathematics achievement was positively impacted. On the contrary, practice and preparation homework did not positively affect the student's marks. Another result showed that the amount of homework completed did not directly affect the students' mathematical achievements (Rosario, Nunez, Vallejo, Cunha, Nunes, Mourao & Pinto , 2015).

Moreover, (Fernandez-Alonso et al., 2015; Gustafsson, Hansen, & Rosen, 2013; Nunez, Vallejo et al., 2014; OECD, 2013; Rosario et al., 2005) has shown that the parents' level of education has a positive impact on students' academic performance. It has also been observed that adverse effects occur when parents engage in helping with homework in an intrusive way. Intrusive homework assistance does not benefit children's achievement and controlling parenting may lead to a decreased sense of autonomy and to a decreased feeling of oneself as an effective agent in the learning process (Pomerantz et al., 2007). The results of the study by Silinskas, Niemi, Lerkkanen, Nurmi (2012) adds to the previous literature on parental homework assistance and children's academic outcomes by suggesting that both mothers' and fathers' greater involvement in children's homework is a reaction to the child's poor performance at the beginning of the scholastic career. One of the results highlighted the fact that parents' help in both grade 1 and grade 2 was negatively related to the subsequent development of their children's skills for both mothers and fathers. In addition, a possible reason for this differential relationship was noted to be the didactic quality of parental involvement. This was suspected to be due to parents of low achievers being too unskilled to provide effective help to their children during challenging homework situations. These results indicate that some parents would benefit from advice from professionals in facilitating effective involvement with their children's homework. This help should be targeted towards the parents of children who show low early skill levels and whose education level is low. Darling and Steinberg (1993) also illustrated that the effect of these practices is largely determined by the style in which the practices are carried out. Other literature shows that results depend on the quality of the design and clarity of parental involvement activities on homework with specific learning goals for students (Epstein and van Voorhis, 2012). Núñez, Epstein, Suárez, Rosário, Vallejo, Valle (2017) concluded that low achieving students, in particular, perceived more parental control of homework in secondary grades.

Prior academic achievement was also significantly associated with students' homework behaviors. These associations were found between prior academic achievement and the time students spend on homework, the management of this time, and the amount of homework completed (Núñez, Epstein, Suárez, Rosário, Vallejo, Valle, 2017). When secondary school students' academic performance is poor, they tend to spend less time doing homework, manage their time less effectively, and complete less homework. Moreover, students with lower achievements reported that their parents exhibited monitoring and controlling behaviors on their homework. Therefore, unless parental involvement in homework is carefully balanced with caring control and supporting messages, low achieving students may avoid homework and disengage from school, especially in the secondary grades. Numerous studies confirm that, over time, parental involvement with students on homework is associated with higher student achievement. Positive practices of parental involvement may promote students' cognitive, linguistic, mathematical skills, metacognitive skills and strategies for a self-regulated learning, as well as positive attitudes toward school and motivation to learn.

One alternative to parental involvement is tutoring. A major shift in arithmetic problem-solving strategies from counting to fact retrieval was observed with tutoring. Supekara, Swigarta, Tenisona, Jollesa, Rosenberg-Leea, Fuchsb and Menona (2013) showed that after undergoing tutoring, students displayed notable improvements in the speed and accuracy of arithmetic problem solving and the greater use of retrieval strategies (rather than counting methods). Moreover, no behavioral measures such as intelligence quotient, working memory, or mathematical abilities predicted performance improvements that occurred after tutoring. The findings also provide evidence that individual differences in morphometry and connectivity of brain regions associated with learning and memory are strong predictors of responsiveness to math tutoring in children.

Consistent with this interpretation, it is further noteworthy that children with dyscalculia demonstrate structural deficits in the hippocampus and the entorhinal cortex (Rykhlevskaia, 2009) and they typically have poor skills in retrieving arithmetic facts from memory (Geary , Hoard, Byrd-Craven & DeSoto, 2004)

Continuous Assessment

Continuous assessment refers to the use of one or several assessments during the course period, instead of a single final exam in the last weeks of the semester. Continuous assessment can be used to improve student learning in higher education settings (Rezaei, 2015) as well as to improve student engagement (Holmes, 2015). In both cases, continuous assessment can be used to provide feedback to students (de Kleijn, Bouwmeester, Ritzen, Ramaekers, & Van Rijen, 2013) and teachers (Domenech, Blazquez, de la Poza, & Munoz-Miquel, 2015). It has two important cognitive benefits.

- The first benefit is the testing effect (Roediger & Karpicke, 2006) which states that repeated testing of information leads to better retention of this information.
- The second benefit can be referred to as the spacing effect (Kornell, 2009), spreading studying across the study period leads to longer retention than last minute cramming.

Therefore, continuous assessment can lead to more effective study behavior and promote the student's academic achievements. Other research regarding student ability and continuous assessment shows that higher achieving students benefit more from intermediate exams rather than from continuous assessments (De Paola & Scoppa, 2011) since higher achieving students started regressing to the mean with continuous assessments (Kerdijk, Tio, Mulder, & Cohen-Schotanus, 2013). On the other hand, lower achieving students perform better on each continuous assessment (De Paola & Scoppa, 2011).

Day, van Blankenstein, Westenberg & Admiraal (2018) concluded that students do not perform better on courses whether these courses use continuous assessment or not. This contrasts with previous research that discovered that, in most cases, continuous assessment positively influences students' achievement (Domenech et al., 2015; Ibabe & Jauregizar, 2010; Rezaei, 2015). Day, van Blankenstein, Westenberg & Admiraal (2018) also concluded that student achievement is not dependent on the type of continuous assessment. The main findings show that male students performed worse than their female peers in courses without continuous assessment. In contrast, in courses using any type of continuous assessment, this gender difference disappeared. Results from the study indicate that continuous assessment may be a potent measure to improve male students' success by closing the gender achievement gap, and that students with high levels of intrinsic motivation do not benefit from continuous assessment. Additionally, continuous assessment can be used as a measure to improve student achievement and keep students motivated throughout the year. Furthermore, continuous testing is important as it will ultimately benefit students since a significant positive correlation between the continuous assessment grades and the final exam grades was noted. Moreover, a positive relationship between the continuous assessment grades and the percentage of students passing a given subject was also noted (de la O González, Jareño & López , 2015).

During continuous assessment and examinations, many students experience stress in the period before and during the actual tests. Research over the past two decades identified stress and the hormones together with the neurotransmitters released during and after a stressful event as major modulators of human learning and memory processes, with critical implications for educational contexts. While stress around the time of learning is thought to enhance memory formation, thus leading to stronger memories, stress distinctly impairs memory retrieval and could lead to underachievement in exams. The study of Vogel and Schwabe (2016) showed the implications of stress effects on learning and memory processes for the classroom. It was concluded that moderate stress can enhance memory formation for emotional material and information that is related to the stressful context, whereas high stress levels may impair the encoding of stressor-unrelated material. Therefore, since emotional material is typically better remembered than neutral material, an emotional positive component may be added while students learn new information to enhance later memory. A final result shown was that giving students practice exams may familiarize the students with the exam situation and reduce stress levels. Test anxiety is defined as "the set of phenomenological, physiological and behavioral responses that accompany concern about possible negative consequences or failure on an exam or similar evaluative situation" (Zeidner, 1998). Burns (2004) showed that anxiety at the time of the final exam was related significantly to expected performance on the final exam and also noted a strong positive correlation between anxiety at the time of the final exam and scores on the first two exams, as students who scored higher on the two exams were more anxious. In addition, no evidence supported a relationship between the amount of time spent studying and anxiety at the time of the final exam. Furthermore, a negative relationship between test anxiety at the time of the final exam and performance was not observed.

Interactive Computer Based Learning Systems

According to Felder and Silverman (1988), individuals learn through three learning modalities: visual (pictures, diagrams, charts), verbal (sound, words), and kinesthetic (touch, taste, smell). Technology-assisted learning tools provide new learning experiences that could help accommodate diverse learners with different learning styles. Therefore, by incorporating mobile applications into the classroom, the teacher could more effectively cater to needs of students with diverse learning styles. Ling, Harnish, Shehab (2014) presented active learners with the opportunity to follow along on their own app, while allowing reflective learners the chance to internalize these changing conditions as they happen. The use of direct manipulation with hand and touch sense also allows for kinesthetic learning which could potentially get students more engaged. Moreover, this aligns with other research that has shown that people are more motivated to learn when they are actively engaged in learning (Felder & Brent, 2003). Mobile apps can provide an additional way of interaction through direct manipulation on the touch-screen interface. It was concluded that when learning through examples with the mobile app, students performed better on problems that required them to apply their knowledge (Ling, Harnish & Shehab, 2014)

Aberšek and Kordigel Aberšek (2012)'s main result showed that for good and effective e- learning tools the philosophical and didactical part is equally or possibly more important than heuristics. They also concluded that an important feature of this tool is that it entails the implementation of learning strategies designed to involve the student in the learning process as well as a relatively high level of interactivity with instantaneous feedback. Through these technologies and didactic techniques, the student is placed in an "active" role, as opposed to a "passive" environment of one-way teaching. The teacher can then act as a facilitator and author of the learning environment instead of merely being a one-way communicator. Adesina, Stone, Batmaz, Jones (2014) concluded that it is very important for Computer Aided Assessment (CAA) tools to focus on the steps and problem-solving processes that students use when solving mathematical word problems in order to provide more precise feedback. Similar performance scores were obtained when the interactive tasks on the CAA environment were compared to paper and pencil tests. In addition, more insight into the student's problem solving process was provided by the CAA tool. Additional practical benefits of CAA include automatic scoring, rapid feedback and increased accessibility (Conole & Warburton, 2005). CAA is can also perform Continuous Assessment and analyze the resulting scores. Continuous assessment which also includes feedback through the end of topic quizzes ensures staged progression, which indicates that pupils are working on activities that are just beyond their current ability level and more challenging than their previous accomplishments. The characteristics are known to facilitate learning (Inal & Cagiltay, 2007; Shin et al., 2012; Vygotsky, 1978). The specific design features such as immediate feedback, continuous assessment and task repetition, which are embedded in the learner-centred software, might contribute to the observed learning gains after using this intervention. This allows children to regulate their own learning activities and serves to create an individualized learning environment that is not characteristic of normal classroom practice (Condie Munro, 2007; Rose et al., 2005). Learner control has been shown to be an important influence on improved learning outcomes (Morrison, Ross, Baldwin, 1992) and may create a sense of learning autonomy.

There are various characteristics that an Interactive Assisted Learning System should incorporate. Melnyk (2016) concluded that when creating Electronic Educational Game Resources (EEGR) in mathematics for primary school students, the integrity and systematization of learning material is an important criterion. This material has to form a single training cycle and cover all issues of the curriculum with the content of each lesson being connected with the previous one and gradually become more complicated according to the curriculum. Moreover, developers should always keep in mind that the resource is designed for primary students, therefore the system should be presented in a way which is interesting and understandable to the students. The assistance should also be clear and precise. Visual aids and their conformity with the content of the EEGR is another significant quality requirement for the EEGR, especially for primary school students. Visual aids increase students' interest, keep their attention within a required time span but they should not cause any fatigue or negative emotions. Sound and color design of EEGR should be non-aggressive; sounds should be soft, melodious and based on children's songs. Soft pastel colors should be preferred. Moreover, all audio instructions should be recorded with a calm, clear and friendly voice. An uncomfortable font can cause fatigue, therefore, it is necessary to provide the EEGR with a possibility to change the font size and style easily if it is necessary. Monotonous music can annoy the students and cause negative reactions. This fact should be taken into account by the EEGR developers providing students with a possibility to turn a tune off or to change it. All these factors are extremely important to create a positive emotional environment. It is also imperative that the teacher is able to monitor students' work in the network both individually and for the whole class using an electronic device during the lesson. These techniques will help to increase the efficiency of education in primary school. (Melnyk , 2016).

Intelligent tutoring systems are a type of computer system that aims to support and improve learning and teaching processes in certain domain knowledge, considering individuality of a student, as in a traditional one-to-one instructional process. This process, also known as human tutoring has been confirmed to be successful and presents the most efficient learning and teaching process (Bloom, 1984; Cohen, Kulik, & Kulik, 1982). Johnson, Phillips, Chase (2009) concluded that unlike many other computer-based education systems, artificially intelligent (AI) tutors respond dynamically to the individual learning needs of each student. Thus an AI tutor does not employ pre-programmed instructions to anticipate particular student responses but it uses its own ability to try to understand the part of the problem the student is working on and constructs responses in real-time. In contrast to all other computer-based education systems, Koedinger and Aleven (2007) explain how ‘‘intelligent tutoring systems draw on artificial intelligence technology to provide interactive instruction that adapts to individual students' needs and, most typically, supports student practice in learning complex problem-solving and reasoning". Part of the challenge in creating an AI tutor is finding an appropriate balance between giving and withholding assistance (Koedinger & Aleven, 2007). Showing students how to solve a problem (giving assistance) can be effective in some cases, but requiring students to solve problems on their own (withholding assistance) can be equally effective. (Halabi et al., 2005; Lindquist & Olsen, 2007; Schmidt & Bjork, 1992). The mechanism that enables an intelligent tutoring system to give assistance is an algorithm called model tracing. The system uses its production rules to construct a model for solving each problem presented to it and then compares this model to the approach taken by the student. This allows the tutor to provide confirmatory feedback, corrective feedback, or hints upon the student's request. Due to this feedback, the tutor can provide a great deal of support early in the learning process, and then allow the student to seek less support as competence is built. This pedagogical approach has been effective for human tutors (Wood, Bruner, & Ross, 1976) and is expected to be helpful for intelligent tutoring systems, provided that students are capable of recognizing when they need help (Aleven & Koedinger, 2000). Johnson, Phillips, Chase (2009) illustrated that both academically strong and weak students gained as a result of using the tutor. This indicates that the increase in performance can be attributed to the tutor. The research is consistent with prior results where an interactive computer based tutoring system has had a positive impact on students' learning (Wegner, 1999, Abersek, 2010). Students who use some kind of tutoring system for self-learning or evaluation also score higher in exams than those who use traditional study methods (Aberšek, Kordigel Aberšek, 2011). Outhwaite, Gulliford, Pitchford (2017) showed that large learning gains were sustained when students were re-assessed after 5 months suggesting that hand-held tablet technology with learner-centered software is an effective means of supporting early mathematical development. These findings are consistent with other research demonstrating improved mathematical performance in young children following tablet technology-based educational interventions delivered at preschool (Schacter Jo, 2016) or at home (Berkowitz, Schaeffer, Maloney, Peterson, Gregor, Levin Beilock, 2015). Moreover, Fuchs and colleagues have also shown that the combination of computer-aided intervention and one-to-one tutoring can significantly improve mathematical abilities (Fuchs , 2006; Beirne Smith, 1991).

Bakker, van den Heuvel-Panhuizen, Robitzsch (2015)'s results suggest that the games were most effective in enhancing students' multiplicative insight. This is in line with the finding from Ke's (2009) review that games seem to promote higher-order thinking more than factual knowledge acquisition. When utilized in this way, mini games were found to promote students' multiplicative operation skills (procedural knowledge) as well as their insight in multiplicative number relations (conceptual knowledge). Miller and Robertson (2011) also showed the effectiveness of hand-held mathematics mini-games in improving 10 and 11year old's mental computation skills. The amount of time spent on the mini-games affected the improvement. The tool was more effective when the debriefing sessions occurred at school to show the students how to use the learning tool rather than when the students played the games at home without prior instructions. (Bakker, van den Heuvel-Panhuizen, Robitzsch , 2015)

Students' perception and feedback on Interactive Computer Based Learning Systems is a very important. Biscomb, Devonport and Lane (2008) concluded that students did not perceive computer-aided assessment (CAA) negatively and staff clearly noted that this form of assessment had certain time saving benefits since it can provide lecturing with a solution to heavy marking workloads.

An important finding was the fact that the lecturers, acknowledged that the use of CAA was an up-front investment of time, at the start of the module that leads to long-term savings. The time needed to write the bank of questions was then recuperated at a later stage as the marking process was not so time-demanding. In addition, the benefits of CAA for reflective practice were also highlighted as the technology allowed for an analysis of student progression and achievements in relation to each individual question set. A disadvantage was that it is hard to test deeper forms of learning through a CAA. In another study a qualitative analysis of questionnaires' results revealed that most students were pleased while working with the evaluated system and that they were open-minded to embrace this kind of learning and teaching support (Stankov, Rosic´, Zˇitko & Grubisˇic , 2007). Another interesting finding was that primary school pupils embraced learning and teaching process with the computer-aided learning system better than university students.

Learning accessibility for children of all abilities

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) defines inclusive education "as a process of strengthening the capacity of an education system to reach out to all learners" (UNESCO, 2008a). Poon-McBrayer, Wong (2013) concluded that the heavy workload of teachers together with the schools' inability to offer long-term employment to some of the teachers, psychologists and aides also contributed to the high staff turnover rate of professionals associated with inclusive education which resulted in more teachers being inadequately equipped. In addition, the importance of maintaining a good school ranking has driven schools to reduce tolerance for under-performance which may lead to exclusion of students with disabilities in inclusive settings (Rogers, 2007). Moreover, Lim and Tan (1999) concluded that the competition between schools have led to a narrow focus on student outcomes and worked against diversity.

Differentiation refers to a student-centered pedagogical strategy which aims at responding flexibly to individual students' learning styles, readiness levels and speeds of learning in order to maximise their learning opportunities in the classroom (Stradling and Saunders 1993; Tomlinson 1999). In practice, Tomlinson (1999, 2001) divides the differentiated instruction into the following areas: adapting content (materials, curriculum objectives), adapting process (teaching methods, learning tasks, pace of learning), and adapting products (assessment and means to indicate learning) (Raveaud , 2005; Stradling and Saunders, 1993). The researchers have interpreted this incongruity such that students appreciate individualization, but resist overtly differential treatment of students. The reason for this is their fear of stigmatizing some students or excluding them from the full class membership and their concerns about the fairness of not requiring the same workload as all students (Nelson et al. 1998; Nelson et al. 2000; Vaughn et al. 1993). Furthermore it was noted that giving individualized tasks makes students compete with each other. The difficulty level of the tasks is also used to show one's place in the pecking order among students and as a means by which to emphasize one's own superiority over peers. Differentiation as a pedagogical solution serves to meet children's individual learning needs (Vehkakoski, 2012). In addition, the fact that students have been separated from mainstream classrooms in certain subjects due to their perceived poorer skills may also increase students' need to avoid appearing stupid and to prove their competence. From the viewpoint of learning, this kind of ego orientation can be harmful, as students' energy goes into protecting their image as successful students and attention is diverted from learning as an end in itself (Urdan 2004; Tholander 2011). Schniedewind and Davidson (2000) illustrated that a way to improve classroom cohesion is to apply co-operative learning methods and individualized instruction so that whilst the students are completing different tasks and learning different materials, they are all cooperatively contributing to a common goal, and have equal accountability for the outcomes in a non-competitive climate.

Gasser, Grütter, Torchetti, Buholzer (2017) also concluded that Cooperative learning formats might represent a promising teaching method in order to foster the notion that fairness, social inclusion and effective academic group functioning are not exclusive goals. In order to prevent social exclusion it is important that teachers are aware of the possible negative effects of academic pressure on children's inclusive attitudes. Thus, the findings suggest that teachers would improve the social participation of their students if they do not exclusively focus on academic goals, but also think about how they can provide social and emotional support to students, especially in times of increasing academic expectations. This study also indicated that children were more likely to exclude hypothetical hyperactive peers than low-achieving peers for reasons of effective group functioning. These findings parallel previous research indicating that children hold negative attitudes towards hyperactive peers (Harnum, Duffy, & Ferguson, 2007; Hoza, 2007). An example is that 12-year-old children often attribute negative characteristics, such as carelessness to hyperactive children and avoid engaging with them in social or academic activities (Law, Sinclair, & Fraser, 2007). One possible explanation for these findings is that children view hyperactive behaviors such as interrupting others, making noises or fidgeting, as disruptive and conflicting with the smooth and effective functioning of social interactions. Hyperactive children also display higher rates of aggressive behavior such as teasing or hitting, and, as a consequence, peer problems arise quickly (Hoza, 2007). Apart from competitive classroom norms, other variables such as classroom climate or teachers' attitudes towards children with difficulties or disabilities might also relate to children's exclusion decisions (White & Jones, 2000). Research indicates that compared to typically developing children, both academic and behavior problems are associated with social rejection and being involved in bullying or victimization (Estell et al., 2008; Hoza et al., 2005; Wentzel & Asher, 1995). Additionally, increasing pressure may have negative implications for the social inclusion of children who do not conform to academic and behavioral norms at school (Wettstein, Ramseier, & Scherzinger, 2016). Results also revealed that older children were more likely than younger children to consider group functioning in situations where inclusion of the child with the disability would negatively impact effective group functioning.

Schwab (2015) concluded that in inclusive classes, students with special educational needs (SEN) had lower scores on all four sub-themes of social participation (friendships, interactions, peer acceptance and self-perception of social integration) than students without SEN. Koster, Nakken, Pijl, and van Houten (2009) identified social participation as the most suitable concept and showed that four key themes exist: friendships/relationships, interactions/contacts, acceptance by classmates and perception of the pupil with SEN. Bossaert, Colpin, Pijl, and Petry (2015) on the one hand showed that students with autism spectrum disorders reported less intimacy regarding their friendships than students without disabilities, but on the other hand, they did not find differences in students' perceptions of shared friendship quality between students with disabilities and their peers. The literature clearly shows that students with SEN have fewer interactions with classmates than their non-disabled peers (Koster, Pijl, Nakken, & van Houten, 2010; Schwab, 2014).

Studies show that children with low socio-economic status (SES) and children who have English as an additional language (EAL), have significantly lower mathematics ability levels compared to their peers (Anders et al., 2012; Denton & West, 2002). On the other hand, no effect of EAL status and SES were found on learning gains following the tablet intervention. This suggests the mathematics apps are accessible to all children. The multi-sensory nature of the mathematics apps and clear and simple instructions with multiple representations of information (such as, pictures and interactive animations), might have provided additional support to pupils whose first language was not English. In another study, S. Fuchs, Fuchs, Hamlet, Powell, Capizzi, Seethaler (2006) assessed the potential for computer-assisted instruction (CAI) to enhance number combination skill among children with concurrent risk for math disability and reading disability. It was concluded that math CAI was effective in promoting addition. On the other hand, subtraction number combination skill and transfer to arithmetic story problems did not occur.

Despite the lack of significant results for subtraction and transfer to arithmetic story problems, the findings on the addition fact retrieval measure are noteworthy because the retrieval of number combinations represents a difficult type of competence to promote among students who have a math disability (Fleishner et al., 1982; Geary et al., 1987; Goldman et al., 1988). S. Fuchs, Fuchs, Hamlet, Powell, Capizzi, Seethaler (2006) targeted first graders at risk for development of learning disabilities with the hope that effecting superior number combination skill at this age might reduce long-term vulnerability to math difficulties. Additionally, Christensen and Gerber (1990) found that students with learning disabilities were disadvantaged by the game-like format, perhaps due to the distracting nature of the presentation. Many studies have shown that math fact retrieval deficits often occur concurrently with reading difficulty (Geary, Ham son, & Hoard, 2000; Jordan & Montani, 1997; Lewis, Hitch, & Walker, 1994). Phonological deficits have also been shown to underlie both word reading (Brady & Shankweiler, 1991; Wagner et al., 1997) and arithmetic fact retrieval development. Given the relation between reading and math skill (Aiken, 1972), this procedure for designating risk should yield a group of children with more severe deficits than would occur solely on the basis of math performance.

Metaphorical language is commonly used in everyday language and it is important for both communicating and reasoning about abstract concepts (Gibbs, 1994; Lakoff & Johnson, 1980). Understanding non-literal language forms, such as metaphors and idioms, requires the listener to go beyond what is said (i.e., the literal meaning) to infer what is meant. Mashal, Kasirer (2012) showed that children with learning disabilities (LD) scored significantly lower than typically developed (TD) children in the comprehension of conventional metaphors and idioms. However, visual and novel metaphor comprehension, which does not rely on prior knowledge, did not differ between the two groups. Furthermore, the results suggest that higher analogical thinking facilitates visual metaphor comprehension in the LD group. In the TD group, metaphor comprehension correlates with higher semantic knowledge. When verbal and pictorial information are contrasted in an explicit verbal recall task, visual information is recalled better. This effect is known as the picture-superiority effect. The study demonstrated a developmental trend in the picture superiority effect in recognition memory (Defeyter, Russo, & McPartlin, 2009). The picture superiority effect was not seen in the 7 year old children but the effect was significant among the 9 year olds, 11 year olds and adults. Another explanation for the advantage of pictures over words is that pictures have more attention-inducing qualities than words. Children with learning disabilities may benefit from these advantages given that they have language deficits and may also have attention deficits. These findings suggest that visual metaphors are not advantageous for children with language impairments. However, when no language impairments are present, children with LD perform as well as TD children in visual metaphor comprehension. Therefore the ability to think metaphorically is not deficient in children with LD. However, LD children were underscored in metaphor comprehension when the expressions were probably more familiar and accessible to the TD group (idioms and conventional metaphors). One of the main conclusions of the study illustrated that in the LD group, visual metaphors were better understood than conventional metaphors, indicating a pictorial advantage to visual metaphors for LD children. Thus, LD children rely on the process of recognition of target–vehicle similarity during visual metaphor understanding (Ortony, 1979), and it seems that this ability plays a more important role in the LD group than the TD group.

Based on research using eye tracking it has been shown that dyslexic children have many types of visual deficits (Jones, Obrego´ n, Kelly, & Branigan, 2008; Xiu-hong et al., 2009). One of the approaches that addresses the neurological and cognitive cause of dyslexia is the sensorimotor theory. This theory, also known as the magnocellular deficit hypothesis, associates reading difficulties to irregularities in magnocellular neurons projecting visual information to the primary visual cortex (Livingstone, Rosen, Drislane, & Galaburda, 1991). It has been proposed that some dyslexic readers have impaired functioning of the brain cells that detect transient movement information in the visual field (Galaburda & Livingstone, 1993). If these cells are impaired, unstable fixation and concomitant difficulty in processing orthographic information may occur (Stein & Talcott, 1999) as well as processing of multiply presented visual items (Omtzigt, Hendriks, & Kolk, 2002). The results also suggest that the two groups rely on different cognitive resources when they process visual metaphors and idiomatic expressions. Whereas visual metaphor comprehension is associated with the recognition of similarities in the LD group, semantic knowledge is associated with better idiom comprehension in the TD group. Based on the finding that similarities test accounted for a greater share of the variance in visual metaphor understanding in the LD group, it may be concluded that analogical thinking ability is associated with better visual metaphor understanding.

From the research above, it can be noted that not all students learn at the same rate or use the same learning styles, and that the amount of homework completed does not directly affect the students' achievement. This may indicate that not all students require the same amount and type of homework. This highlights the importance of personalized classwork and homework in order to allow the student to increase or reinforce their knowledge while avoiding boredom. In a study carried out on students in primary school settings it was concluded that higher enjoyment and lower boredom predicted greater subsequent achievement and in turn, greater academic achievement predicted subsequent greater enjoyment and lower boredom. (Putwain, Becker, Symes & Pekrun , 2018)

The Artificial Intelligence Assisted Learning system could generate this personalized work and also act as a tutor by offering effective help of an 'equal' quality to ensure that all students are progressing at similar rates. The AIAL app could act as a technology-assisted learning tool which can be used inside the classroom and at home. This app may possibly act as an incentive to motivate students to learn. Additionally, the AIAL system could offer help only if requested by the child in order not to seem intrusive and allow the child to complete the classwork or homework alone until they require help. The system could also correct the work and provide immediate feedback to the student. This would reduce the teachers' workload and allow them to focus more on students who are struggling with a particular topic. Findings from studies also show significant immediate and sustained learning gains following the intervention of a technology-assisted learning tool, particularly for children identified as low-achievers. The AIAL app can also help improve classroom cohesion by setting a common goal which ensures that all students are aiming towards completing this goal and reduce excessive competitiveness. Moreover, explicit positive reinforcement could be given to students through trophies and goals obtained in the AIAL app. Continuous testing through classwork, homework or assignments could be more beneficial than a final exam as the students' stress levels will only be moderate. Furthermore, the continuous testing will ultimately be of benefit to them especially if they have a final exam.

In conclusion, the Artificial Intelligence Assisted Learning (AIAL) application could provide a form of individualised effective support for early Mathematics and English Language development, which is both challenging and stimulating and which could lead to beneficial outcomes in students' learning. This app could also be particularly beneficial to low achievers and students with learning difficulties and could help to close the gap in the primary school classrooms.

Conclusion

In this chapter, we discussed various elements of the AIAL System which is being created to help students and assist teachers in primary schools. Various HCI components will be implemented in order to make the app more accessible and helpful to its users.

One important HCI concept which will be implemented in the AIAL system is usability and ease of use. This is an essential feature since this app is being designed for primary school students and teachers who may have only a basic proficiency level of IT. One way in which usability can be implemented is through clearly differentiated parts of the application. Therefore, sections for classwork, homework, the student's user profile and work due will be programmed in a way to ensure that the student can easily find the work or information he/she is looking for. The work due section will be composed of worksheets, mostly homework, that has been moved, by pressing an icon, either by the teacher or by the student. These worksheets will be in a separate section, sorted by date, to help the child remember and keep up to date with the work that is due for that particular subject. In addition, the structured application aims to provide this app with a low learning curve for both teachers and students in order to be able to independently access all the features being offered in the app.

The application also involves two-way communication between the AIAL system and the student by acting as a tutor if the student finds any difficulties. The system could offer assistance by showing other similar or related problems to the student, depending on which part of the solution, the student is struggling with. This could be done by having the system analyse the student's partial answer/s to try to get an understanding on what the student has already understood and where he/she actually needs help.

Another area which has been studied as part of our research is human learning and understanding. From previous literature, it was learnt that continuous assessment is a better tool to boost the learning process in comparison to final exams. Moreover, when students have fun during the lesson, they are more concentrated and learn more. These two points can be implemented in the AIAL system as the use of continuous assessment will occur through the use of periodic tests which will be generated by the system. Moreover, the interactive application will enable students to stay interested in the classwork/homework they are performing and prevent boredom, which in turn promotes learning. This

AIAL app can be used as an additional tool in the classroom as an engaging and stimulating classwork activity in conjunction with other pen and pencil exercise worksheets given out by the teacher.

A further important aspect in student learning, especially to primary students, is that of reinforcement. Positive reinforcement will be given to the students when they achieve a pre-set goal set by the teacher. An example of a goal is completing all the homework given in that week. If the student reaches this goal, a trophy will be given to the student which he/she will be able to view on their user profile. Viewing the trophies and seeing an ever-increasing number on their profile could act as an incentive and increase motivation in the students. This will also help students to respect deadlines without adding extra pressure. On the other hand, the AIAL system will also provide constructive feedback to the student. This will occur immediately after the student completes a classwork/homework worksheet. The AIAL system will correct the personalized worksheet and show the student which problems are right and which are wrong. The student may then opt to either rework the worksheet or else view the answers with the solutions to the problems they got incorrect. This will allow the student to recognise their mistakes and allow them to focus on understanding the process behind the solutions to the problems they answered incorrectly.

A user friendly interface for student and for teachers will also be implemented. By implementing intuitive and easy to learn controls to use the app for both students and teachers, the app will assist learning in the classrooms. For the students, rather than using a mouse and a keyboard, they will just interact directly with the tablet through tap and/or drag motions for the numbers, operators or words. Similarly, when the teacher inputs a topic and sample question to the AIAL system, they will use a drag and drop block style, similar to a visual programming language. The AIAL system will then understand the input given and generate personalized classwork and homework depending on the level of the student that is recorded in the student's user profile. Every time a student completes work (classwork, homework or tests), the AIAL system will update the student's profile on the app. The student's profiles of all the students in the class can be accessed by the teacher in order to provide the teacher with ready-made analytics and also indicate to the teacher which students are struggling with a particular topic. In so doing, we are confident that we can create a system which guides the students through the learning process in a personalized way thus ensuring that every child develops its own capabilities to the full.

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