Karaton: An Example of AI Integration Within a Literacy App

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Abstract. Integrating AI into educational applications can have an enormous benefit for users (players/children) and educational professionals. The concept of customisation based on user preferences and abilities is not new. However, in this paper the abilities of the players of a literacy skill application are being collated and categorized, so that in the future they can automatically offer the next instructional level without external manual support. The app Karaton has been designed in such a way that there is a presumption of competence and no child should feel a failure or need to wait to be told that they can try a higher level. It has been found that this improves self-confidence and encourages independent literacy skills.

Keywords: Literacy app · Reading difficulties · Dyslexia · Artificial intelligence

1 Introduction

Oral language is considered to develop spontaneously and in an informal way. Learning to read, however, is highly dependent on explicit instruction. Formal instruction is needed to develop this academic skill. Becoming a fluent reader is one of the most important standards children need to achieve at primary school. In most cases, repeated practice makes sounding out of written words a very accurate, fast and automatic skill, enabling the reader to focus on the reading content, comprehend what is being portrayed and enjoy it. This is the basis for learning other academic subject matters (Dehaene 2009). For children with dyslexia (5–7% of the school population) becoming a fluent reader is very difficult. They need to practice much more and even then it can be hard for them to achieve the same reading proficiency level as their peers, making these children more at risk of encountering broader academic disadvantages (Snowling 2000). In these cases and where there are struggling readers who lack fluency skills for whatever reason, it is extremely important to introduce highly motivating opportunities to practice for example word decoding. Research has shown that reading achievement at primary school age is highly associated with socioeconomic status at middle adulthood, independently of relevant confounding variables (Ritchie and Bates 2013).
1.1 Development of Karaton

Karaton came into existence as a personal project of the main author whilst at university. Having encountered the barriers caused by dyslexia and the lack of educational tools that supported individuals with reading fluency difficulties, a research project slowly evolved into an actual application. More than 100 individuals made up of speech therapists, teachers, parents and children were asked what they felt was lacking in the currently available tools on the market for those with dyslexia. The most important thing that resulted from the interviews was the conclusion that there were three main aspects that were important to the users. The tool should be based on recent scientific evidence; adults wanted to be able to see the progress of the children and the tool had to be motivating and fun to play.

The research also highlighted the fact that the games or tools currently on the market had two of the three aspects, but never the entire collection. The three aspects turned into three main pillars (motivation, evidence based, and tracking possibilities) when designing the tool that became Karaton. Throughout the building of the Karaton System there was a very close collaboration between the development team and teaching staff to ensure a proper balance between gamification elements and academic value.

Every mini-game that was built for the various strategies also had extensive user testing with children to ensure the goal for each game was clear, with as few instructions as possible. Other than the regular user testing with children there were also two larger scale testing phases. The first one was with 20 selected speech therapists who could test the system when it was still in development as a Beta version (March 2017). Their suggestions were integrated in the final release seven months later.

Another test phase took place in January 2019. This was focused on the use of Karaton in schools. 32 schools signed up to join this test phase. Classes usually consisted of about 30 children. The results from this test phase showed that it was a very intensive process for teachers to customize all settings in the system to each individual child’s needs. This was the beginning of a decision tree structure algorithm to enhance usability for the teachers.

1.2 Current Version of Karaton

In its current version Karaton is an educational adventure game that combines a real gaming experience with personalised literacy support. The Karaton system consists of two parts. The first one is Karaton, a serious game for children (Torbeyns et al. 2015). The main goal of this game is to provide children with different types of exercises based on their specific reading level in an engaging environment that improves reading fluency and reading motivation while boosting reading confidence (De Coster 2018). At the outset, it is important to take account of the fact that many of the players may be disaffected readers or those struggling with written language. Therefore, the design of the game involves very easy to understand interactions that are graphically stimulating. Children can navigate through the game without having to read complex instructions.

The central aim of the game is gathering materials to build a customised paradise on a deserted island. That requires the player to work through a series of mini-games, each
time gathering more materials. So, the gaming time is divided between practicing reading and building the paradise. Each mini-game offers a specific reading exercise. These are scientifically based on recent reviews of effective reading interventions (Galuschka et al. 2014; Scheltinga et al. 2016). The mini-games are ‘chopping wood’ and ‘sawing wood’ to exercise splitting words in syllables, ‘cleaving rocks’ and ‘ore oven’ to exercise word recognition, ‘lianes’ and ‘binding lianes’ to practice flash word reading and, lastly the ‘dodo-race’ and ‘balancing duel’ to practice spelling. Every time a task is correctly fulfilled (usually involving reading or writing a specific word) the child gains an item (wood, stones, lianes,…) that can be used to build furniture for his/her home.

The second part of the app is built around the Karaton Academy. This is a platform designed for parents and educational professionals to track and monitor the progress of their child. So, the game can be steered in two modes, an automatic mode and a manual mode. In the manual mode educational professionals can customise all the presented words in the different mini games and adapt it, based on their own insights, as to the educational needs of the child. Of course, this customisation depends on the characteristics of the mini-game (e.g. flash duration, amount of syllables, phonemes included, amount of distractors). Each time an exercise is completed the child receives feedback and his/her progress is logged. In the automatic mode a decision tree algorithm is used to decide if the child should advance to the next level. To date 50 levels are defined, based on several aspects of the word that are presented in the exercises: amount of syllables, syllable length and phonemic structure (CV1, VC, CVC, CCVC, CVCC, …), morphological structure of the word (composition, prefixes, suffixes),…

2 Methodology

At present, the decision tree algorithm for each type of exercise uses the predetermined steps provided in the design of the game and the professionals manually evaluate all the data gathered from children’s input. For example over a four month period, 35 students and 8 teachers using Karaton provided sufficient data to allow teachers to not only see progress, but also use personalisation strategies based on the children’s data to inform the next steps, such as a new mini-game or a repeat of a task where success was not obvious. This process is the basis for the predictive technology planned in the next phase.

To implement AI algorithms in the game, the aforementioned progress data and level recommendations produced by the existing decision tree algorithms will be gathered as training data. It is felt that this type of training data is suitable for an end-to-end ANN (Artificial Neural Network) based machine-learning model. The progress data, based on users’ personalised information (e.g. reading level), the difficulty level of each mini-game associated with reading exercises, users’ response times and game scores, will be normalised to feed into the proposed ANN model. As progress data has been evaluated by professional experts, their feedback will also be transferred into the

1 C = consonant / V = vocal.
training data to help build up this end-to-end machine learning model. Based on the children’s reading levels and performance in each game, the trained AI model will be used to predict the personalised difficulty level of the next game and provide a recommendation service, thereby creating an individualised learning path for each child.

3 Results and Discussion

The results from this work have yet to be completed, but currently experts involved in the A is for A project have analysed all the data from the different reading techniques and compared them with previous results. At present they have to assess the best course of action and adjust the parameters which can be a subjective judgement. Therefore this method is only as good as the assessment made by the person who is doing it and how often the assessment is carried out.

It appears that the use of AI techniques could offer a more detailed analysis of the particular words (and letters) that have been found to be incorrectly read and the creation of a personalised word list that is more specific to the needs of the child. For example when children make common errors such as reversals, with the letters b and d in some words, the use of machine learning captures these mistakes and integrates words using these letters into the next exercise level, so they can be repeated. The trials have also highlighted that there may be numerous combinations of letters that children mix up. Instead of trying to program all these separate rules, machine learning can help to detect the different combinations and provide useful information to teachers and other educational professionals. At a more advanced stage, the system could also be used as an assessment tool for individual reading strategies and their particular effectiveness for each child, as well as for the development of successive reading stages.

Moreover, the recent work undertaken has the potential to offer children with poor literacy skills improved support at a more targeted level, whilst increasing the effectiveness of the training offered. The use of AI also allows professionals to more easily detect these variations at an early stage and spend more time on particular difficulties in their own intervention or instruction. More individualised exercises or mini-games could be added where needed and the designers would receive enhanced feedback for the next stage of the app development.

Preliminary data of a recent randomized control trial (Gheeraert and Hendrix, in prep.) indicated that the Karaton game had at least the same effect on reading development as a training strategy using traditional interventions, e.g. repeated book reading. However, the affective processes that come with these activities are in favour of the game. Pupils enjoyed using the variety of mini-games and did not feel they were forced to start training with the app. Moreover, playing the game for a certain period of time increased their motivation to read and have fun while reading (De Coster 2018).

When discussing the outcomes of the research and in order to create a better understanding of the effective mechanisms of the game and further optimize the algorithms, it was felt that the separate mini-games should be offered specifically to struggling readers. This would be for a certain period of time to track their performance in detail. Thus offering the necessary extra information to train the AI system and create a better algorithm to adapt the mini-games to the ‘zone of proximal development’ of the
child for that specific reading strategy. Aspects such as graphemes included in the word, structure of the word (e.g. CVC or CCVC), errors made, reaction time of the response etc. could be used to match the difficulty level of the exercises with the skills level of the child. Furthermore, with a study in a larger group of children, the vocabulary database could be ordered, based on word level difficulty. The internal software could also be organized in an intelligent way, so that this ordering would adapt to the way each child plays a mini-game.

4 Conclusion

Early discussions about the use of AI models in Karaton have produced some indications that the methodologies chosen have the potential to enhance the app and better support those children finding certain aspects of typical literacy skills difficult to master.

On the games side an AI intervention would enable the offering of different types of vocabulary for each mini-game tailored to those that a child likes to play. There could also be incremental changes to the kind of materials the games provide for the building activities, that might increase in complexity to challenge and encourage the child. An example of this would be that a player has to collect 10 pieces of wood to build a chair in the early stages, but has to collect 50 pieces of wood at a more advanced stage in order to build a more complex object.

At present making sure there is a balance between instruction and degree of effort required to complete a game is one of the hardest parts in the design process. If the game is too easy a child will lose interest. Make it too hard and they will feel a failure. AI could be of enormous benefit in this balancing act and the games’ internal economy. There is a fine balance to be made between resources gained versus spent and support for literacy difficulties, whilst providing a confidence boost for players.

Current insights into the characteristics of these e-learning tools for reading, their actual implementation in schools and their effectiveness for children’s reading development and motivation are limited. This research has highlighted the need to address this gap by systematically analyzing the characteristics and implementation of the available electronic teaching tools in the domain of reading. There is also the need to review the effectiveness of these tools for children’s reading development and motivation, as well as developing a toolkit for teachers to enhance the effective implementation of strategies involving the use of electronic technologies in their classrooms.

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