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Towards a K-12 Game-based Educational Platform with Automatic Student Monitoring: “INTELLIFUN”

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Since the twenty-first century, digital technologies are increasingly supporting teaching and learning activities. Because learning is effective when it starts early, advanced early years' educational tools are highly recommended to help new generations gain the necessary skills to successfully build opportunities and progress in life. With all the digital learning advances, there are still many problems that teachers, students and parents are facing. Students' learning motivation, problem solving ability remain weak while working memory capacity is found low for children under 11 years old which cause some learning difficulties, such as developmental coordination disorder, mathematics calculation, and language impairments. The latest PISA, Programme for International Assessment, shows that Qatar has seen the lowest scores compared to other countries with similar condition in mathematics, sciences and reading performance and is ranked 63rd of 65 countries involved, even though the Qatari GDP, General government expenditures, is high (OECD 2012).

Another problem affecting the educational experience for young children is family engagement. Parents need to be more involved in the learning process and have quick and timely detailed feedback about their children's progress in different topics of study. In fact, the schools days are limited and parents can play an important role in improving their children progress in learning and understanding concepts. The traditional assessment tools provide global grading usually by topics of study (e.g., Algebra). Parents need a grading system by learning skills (e.g., addition facts to 10, solving missing-number problems, subtraction of money) to have a clear view about the specific skills that their children need to improve. Finally, teachers need also an automated skills-based students monitoring tool to observe students' progress in correspondence with the learning objectives to focus on personalized tutoring tactic and take accurate decisions. Such a tool allows the teachers to focus more on the students' weaknesses and take the necessary actions to overcome with these problems.

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Recent studies showed that students can become more motivated to learn with game-based learning tools. These interactive elements facilitate problem solving and make learning new concepts easier and encourage the students to work harder at school and also at home. Active learning using game-based model guarantees long-term retention of information which help the students increase their exam scores while acquiring the needed skills appropriately. We have conducted a survey and analyzed the features of 31 leading existing technologies in the digital learning industry. We found that only 21 of them offer educational games, 22 are dedicated for elementary age range, 15 offer digital resources to support mathematics and sciences, 11 consider some digital tools for assessment to test children skills and 6 include automated progress reporting engine where most of them need manual data entry support from teachers. There is a need for a complete solution of a game-based learning platform with automatic performance and progress reporting without any manual intervention, and in particular customized to fit with elementary schools curriculum standards.

We developed an educational platform called 'IntelliFun' that uses educational games to automatically monitor and assess the progress of elementary schools children. It can be applied to wider scope of course using outcome-based learning using games. Our intelligent game-based 'IntelliFun' platform provides a potential solution for many serious issues faced in education. Its entertainment gaming features improve students' learning motivation, problem solving ability and working memory capacity. In parallel, its students' performance monitoring features empower family engagement. Having these features integrated in one technology, makes 'IntelliFun' a novel creative solution in digital education.

To generate students' outcomes while playing the games, we have to use an effective technology to relate the curriculum standards and the learning objectives with the game worlds' content (i.e., scenes and activities). The technology we have used is an ontology-based approach. We have designed a new ontology model to map the programs curriculums and learning objectives with the flow-driven game worlds' elements. The children' performance is evaluated through the ontology using information extraction with an automated reasoning mechanism that is guided by a set of inference rules. Technically, using ontologies in the field of education and games is very challenging and our data model forms a novel solution to two issues:

- The complexity of designing educational data models where learning objectives and curriculum standards are matched and incorporated in serious games, and
- The complexity of providing advanced reasoning over the data.

This allows the fusion of many challenging technologies: digital education, semantic web, games, monitoring systems and artificial intelligence.

Our work is deeply rooted in the state of the art in educational games and digital education systems. The curriculum ontology was inspired by the British Curriculum Ontology (BBC 2013). The instances related to learning objectives are extracted from the elementary curriculum standards of Supreme Education Council of Qatar. Ontology model in games follows story-based scenarios described with Procedural Content Generation (Hartsook 2011) and HoloRena (Juracz 2010). We used the trajectory trace ontology described in STSIM (Corral 2014) to design the student monitoring ontology. To evaluate student's performance, we used inference rules based-reasoning engine to query correct, incorrect and incomplete actions performed by the player as described in Ontology-based Information Extraction (Gutierrez 2013). To measure the learner's performance, certain key indicators should feed the reasoning engine which executes appropriate calculation methods.

The platform is implemented in a 3-tier architecture where mobile game applications are used. These games can query and update the ontology in real time through a web service by invoking data management, reasoning, monitoring and reporting operations using Apache Jena Ontology API. The platform can be used to dynamically generate the content of the games based on the children' preferences and acquired knowledge. The platform monitoring features allow the teachers to focus on the children' achievement of every learning objective and empower also the parents' engagement in their children's learning experience. In fact, they can follow up the children and know their weaknesses and strengths. 'IntelliFun' is used to improve the children's learning outcomes and keep them motivated while playing games.

We aim to start testing our platform with real users. We will use the mathematics curriculum for grade 1 as case study. Our user study will include students, parents and teachers who will answer an evaluating questionnaire after testing the technology. This will help us evaluate the efficacy of the platform and ascertain its benefits by analyzing its impacts in improving students' learning experience. An interesting research direction to take into consideration in future work is the use of data mining techniques in the reasoning engine to evaluate students' performance with complex performance key indicators. We can also consider dynamic generation of game worlds' content based on students' preferences and acquired learning skills.