

# Enhancement Effects of Online Edutainment Game-Play on Students' Scholastic Achievements in English and Mathematics

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**Abstract:** Whether online edutainment gaming can enhance active student learning, and/or have effects on general intelligences and scholastic achievements remains debatable within education. This study provides empirical evidence of learning as mediated through a novel purpose-built edutainment game-play programme called *e@Leader* on students' general intelligences and scholastic achievements in English and Mathematics, with 80 primary school students in a 2 x multivariate experimental-control study over four months. Student performances were measured in pre-post IQ and comprehension tests, and school's scholastic results, with additional data gathered from pre-post questionnaires, classroom observations and interviews. Pre-post intervention results showed significant increases of scholastic performances between groups in both English and Mathematics, and within the experimental *e@Leader* group regarding differential high-low participation levels ( $p < 0.05$ ). Follow-up analyses provided useful information regarding curriculum integration issues, thus supporting the claim for enhancement effects of online edutainment games upon student scholastic achievements, in an Asian educational context.

## Introduction and Theoretical Perspectives

Whether online edutainment gaming can really enhance active student learning, or have effects on general intelligences (IQ) and school academic performance remains debatable issues within education, and is also of great interest to educational researchers, policymakers, educators and parents.

Research results concerned with effects of computer-mediated game-play in student learning and development varied in the literature. On the one hand, critics of computer-mediated video games claim that students' use of computer-mediated video gaming is having a negative effect upon either their scholastic achievements or academic development, cognitive and social intelligences (e.g., Walsh, 2004; see also Craik & Lockhart, 1972; NIMF, 2002; for a more recent review, see Byron, 2009). However, little empirical data has yet been put forward by these critics to confirm their concerns for computer-mediated gaming as a productive learning tool and activity.

On the other hand, the impact of the use of video games for accomplishing educational learning is shown to be rather promising in the literature (e.g., Dickinson & Hui, 2010; Gee, 2003; Prensky, 2006). For instance, research has shown the following key findings: (a) Tests of general fluid intelligence (Gf) may be found to correlate with scholastic aptitude, for example, with regard to performance in school-based language and mathematics tests (e.g., Pind, Gunnarsdottir, & Johannesson, 2003), and computer-based cognitive learning tasks (e.g., Jaeggi, Buschkuhl, Jonides, & Perrig, 2008). (b) Frequent classroom use of the Internet, together with facilitative web-based learning environments can foster potential learning opportunities for students in terms of promoting higher levels of engagement, enhanced personal knowledge gain, and more diverse knowledge acquisition (e.g., Coiro, 2003). (c) Carefully planned video game usage has positive effects on the curriculum, in the engagement of students' deeper learning (e.g., Coller & Scott, 2009), facilitation of students' growth in "smart thinking" (Restak, 2009, p. 149), development of intelligence and social autonomy (e.g., Laird, 2007), significantly increased student attention and awareness to visual events (e.g., Green & Bavelier, 2003, 2006), and faster response times as measured by general perceptuo-motor enhancements and specific eye-hand coordination development (e.g., Dye, Green, & Bavelier, 2009). (d) The design of edutainment games can help reorganize brain processing areas such as perceptuo-motor and eye-hand coordination to enhance more efficient learning behaviors (e.g., Achtman, Green, & Bavelier, 2008; Gopher, Weil, & Bareket, 1994). General intelligence is often measured in terms of IQ scores. As IQ scores reliably correlate with speed of processing, the question as to whether gaming might lead to an increase in IQ has also been raised (e.g., Restak, 2009).

Despite the promising research outcomes, researchers such as Coiro and Restak do not seem to provide a clearly defined programme and explicit architecture for optimal design and effective learning outcomes. Besides the lack of controlled groups in many studies (e.g., Dickinson, 2008), there is also a lack of any online edutainment system which is capable of both the delivery of scaffolded tasks of increasing levels of difficulty (according to student performance success based on auto-regulative learning), and automated assessment of performance with such tasks being built into its operating system. This study aims to rectify these issues.

In summary, the claims for the enhancement effects of online edutainment gaming in formative school educational practice in terms of any improvements in scholastic achievements remains to be empirically tested.

Extending a previous study conducted in a primary school in Singapore (e.g., Dickinson & Hui, 2010; Tan & Boon, 2007), this study further examines the effects of a purpose-built online educational gaming and assessment programme called, *e@Leader*, on general intelligences and students' scholastic achievement, and the extent to which *e@Leader* might be incorporated effectively into the extant school curriculum to enhance improved students' scholastic performance in English and Mathematics, with primary school students in an Asian educational setting, such as Hong Kong.

The findings of this study will increase knowledge and practical understanding of the specific ways in which innovative edutainment gaming, such as *e@Leader* can enhance active student engagement and learning (Dickinson & Hui, 2010), and thus will inform future larger scale explorations in different cultural settings. The learning process will also enrich students' learning experience through the use of a technologically-mediated tool in both a fun and experiential way (e.g., Vygotsky, 1986; Wertsch, 1985, 1991).

### What is *e@Leader*?

*e@Leader* is a purpose-built and self-paced online edutainment system incorporating real-time auto-regulatory psychometric assessment which aims to enhance students' general intelligence and the learning of socio-emotional 'soft' skills (e.g., metacognitive, academic, sensory-motor and social personal skills) through 260+ different *e@Leader* games, including more than 1,000 comprehension quizzes called Brainboxes, with each focusing on a range of comprehension knowledge and skills such as literal, analytic, interpretive and critical levels of understanding.

The construction of *e@Leader* was informed by research-based knowledge in neuroscience (e.g., Calton, Dickinson, & Snyder, 2002; McGonigle, Chalmers, & Dickinson, 2003; Minsky, 1985), cognitive psychology and artificial intelligence (e.g., McGonigle, 1991) and education (e.g., Bransford, Brown, & Cocking, 1999), with reference to principles in experiential learning and student-centered inquiry (for detail, see Dickinson & Hui, 2010). Currently available to 400 primary schools in Hong Kong, the careful design and contribution of *e@Leader* has been recognized by the communities in Hong Kong, winning the Creativity Award in 2008 and ICT Award in 2009.

### Research Questions

This study addressed some questions: (1) Does online edutainment gaming enhance active student learning (e.g., Gee, 2003; Prensky, 2006)? (2) Does online edutainment game-play participation have effects on: (a) students' general intelligence (IQ), and/or (b) scholastic achievement (e.g., Pind et al., 2003; Jaeggi et al., 2008)? (3) What are the possibilities and challenges for integrating *e@Leader* into the school curriculum in Hong Kong?

### Methods, Techniques, or Modes of Inquiry

#### Participants

A cohort of 80 4th graders ( $N = 80$ ) with mixed academic abilities was recruited from two classes in a primary school in Hong Kong. Students in one class were assigned the experimental group ( $n = 40$ ) and the other as the matched control group ( $n = 40$ ), as recommended by the teachers. The teachers also mentioned that the students in the control group demonstrated better scholastic performance than the students in the experimental group.

#### Design and Measures

This study was both experimental and analytical, utilizing mixed quantitative and qualitative methods following institutional human subject research guidelines.

Quantitative inquiry was derived from a 2 x multivariate design. Students' multiple performance data on intelligences and scholastic achievements were obtained through independent pre-post-course psychometric assessment measures of general (Raven's Standard Progressive Matrices test or SPM) and emotional intelligences (BarOn) (e.g., Dickens & Flynn, 2001), together with standardized school tests of English and Mathematics as routinely practised by the school. An additional independent measure of a paper-and-pencil English comprehension test was also conducted to examine students' information processing and reasoning abilities. Pre-post questionnaire responses were also gathered concerned with the students' background information and game use experiences.

Qualitative data were collected through classroom observation related to *e@Leader* implementation and student-teacher interactions, semi-structure interviews with selected students representing a range of participation levels and teachers from different subjects focusing on in-depth *e@Leader* use reflection and curriculum integration issues, and researchers' field notes through participant observation. Classroom observations and interviews were video-recorded and transcribed for analyses.

#### Procedure

Pre-course scholastic examination grades, questionnaires, psychometric and comprehension tests were collected from all participants prior to the study in March, 2010.

Then, each experimental group student engaged in a daily interaction with *e@Leader* for a maximum period of 30 minutes per session, 7 days per week through a personal online *e@Leader* account between March to June, 2010. A formative activity report was presented to the teachers in May, 2010.

After a four-month daily *e@Leader* interaction, post-course scholastic examination grades, modified questionnaires, and psychometric and comprehension tests were collected from all participants in June, 2010. Two classroom observations were video-recorded. Semi-structured interviews were conducted with 4 teachers and 15 experimental students from the *e@Leader* group and were later transcribed for analyses.

## Analyses

Quantitative data were analyzed statistically with a analytic software called Stat3. Qualitative data such as interviews and discourse in classroom observations were coded and analyzed based on themes from a discourse analysis perspective (e.g., Cazden, 2001; Gee, 1999) using a software data management tool called Atlas.ti.

## Results and Discussion

Analyses of this study showed some important findings.

Firstly, the findings of this study echo the key idea as proposed by Gee (2003) and Prensky (2006) that active student learning and performance could be enhanced by the use of online edutainment gaming systems, as indicated by empirical evidence concerning increases in scholastic English and Mathematics test scores in primary school students, with experimental (*e@Leader*) and non-exposed control (*non e@Leader*) groups using *e@Leader*, and students' active learning as observed in their daily online participation in terms of exposure and usage. For example, one-tenth of the students participated more than 85% time during the 4-month interaction period, with 4 students participated almost on a daily basis during the entire intervention period. Furthermore, students' active participation and enthusiasm as demonstrated individually and in groups was observed during classroom observation and interviews with students. For example, a student commented in an interview that "At first I don't think it is fun, but [I] got better and better." Another student expressed that "Thank you for letting us play *e@Leader* and we get to exercise our brains. I think I learn many things through *e@Leader*. Also, I am very happy. Although I made some mistakes while playing the games, but now I know."

Secondly, with regard to the specific effects of online gaming interaction based on IQ, there is no significant difference between the experimental (*e@Leader*) and control (*non-e@Leader*) group users. This finding contrasts the findings of previous studies (e.g., Jaeggi et al., 2008; Pind et al., 2003) including the one conducted by the authors in Singapore (e.g., Dickinson & Hui, 2010). Such contrasting finding might be explained by the short intervention time (i.e., 4 months). A comment made by a teacher in an interview echos this concern, "time is too short ... you may see effects in half a year to 9 months with students in P. 4."

Moreover, the comparative performance of students scholastic examinations in English and Mathematics revealed mean score differences in some scholastic areas *between* the experimental *e@Leader* and *non-e@Leader* control groups.

**Table 1: Baseline vs. 4-month *e@Leader* exposure comparisons for English and Mathematics: Experimental ( $n = 40$ ) vs. controlled groups ( $n = 40$ ).**

Student Group/Exam Score	English Grammar		Mathematics	
	Baseline	4 Months	Baseline	4 Months
Experimental Mean Score	86.30	84.40	81.70	86.63
Control Mean Score	91.60	88.20	88.70	89.77
	$*p < 0.005$	$p > 0.05$	$*p < 0.0005$	$p > 0.05$

Table 1 shows that baseline comparisons of experimental (*e@Leader* users) versus control students, of the same grade and class standard in terms of both English and Mathematics showed significant differences in their grade scores, despite the latter examination being of a greater level of difficulty.

Specific analyses within the *e@Leader* group in relation to their differential participation levels showed additional important findings.

**Table 2: Baseline vs. 4-month *e@Leader* exposure comparisons for English and Mathematics: Experimental group only ( $n = 40$ ).**

Student Group/Exam Score	English Grammar		Mathematics	
	Baseline	4 Months	Baseline	4 Months
Experimental Mean Score (high frequency users)	87.60	84.70	83.50	86.80 ( $*p < 0.05$ )

Control Mean Score (low frequency users)	85.20	81.20	79.60	
	$p > 0.05$	$*p < 0.05$	$p > 0.05$	

Table 2 shows that, baseline comparisons of *within*-sample partitioning of the *e@Leader* user group according to their relative exposure and usage, (i.e., the highest vs. lowest third in terms of login frequency) revealed no significant differences in their baseline grade scores for both English and Math examinations.

However, post intervention results (i.e., after 4 months *e@Leader* interaction exposure) revealed significantly differential effects in English, with those students using the *e@Leader* programme the most showing an average 3-4 % point higher performance relative to the lower frequency users. This finding of the scholastic improvement with *e@Leader* users in English is consistent with our additional independent pre-post comprehension tests. For example, the *e@Leader* users made improvement in each of the 5 comprehension sub-tests, whereas non-*e@Leader* users made improvement only in 3 of the 5 comprehension sub-tests; and their cumulative improved scores were higher than those made by the non-*e@Leader* users (i.e., +65 vs. +6 correct points respectively). In terms of Mathematics, for the high (but not the lower frequency) users of *e@Leader*, the average difference between the baseline and final Math examination scores was significantly increased.

Follow-up analyses showed some consistent findings.

In terms of the students' perception of their scholastic improvements in English, Mathematics and confidence in learning as a result of online edutainment gaming participation, a majority of the *e@Leader* users perceived that online edutainment game-play can improve their English, Mathematics and confidence in post-intervention responses, whereas only approximately half of the non-*e@Leader* users perceived such improvements (e.g., 68% vs. 42 % for their perceived improvement in English, 64% vs. 42% for their perceived improvement in Mathematics, and 58% vs. 47% for their perceived improvement in confidence, for the *e@Leader* and non-*e@Leader* users respectively.) As regards the specific responses to the *e@Leader* programme, the post-intervention responses of the *e@Leader* users were similarly different (i.e., 75% for their perceived improvement in English, 49% for their perceived improvement in Mathematics, and 61% for their perceived improvement in confidence).

It is interesting to note that the students' perception in school grade improvements contrasted the teachers' perception of students' improvements for English and Mathematics as a result of online edutainment game-play. For example, 4 of 5 teachers interviewed did not think that there would be any improvements in students' scholastic grades in English and Mathematics. While the *e@Leader* users did demonstrate scholastic improvements in the post-intervention measure, it would seem interesting that the students' perception of their scholastic achievements as a result of online edutainment gaming reflects more consistently their game-play behaviour outcomes than their teachers' perception.

Both *e@Leader* and non-*e@Leader* users revealed similar reflections in their enjoyment in recent game-play participation. For example, *e@Leader* users showed a slightly higher level of enjoyment in both pre-post intervention responses (e.g., 95% vs. 88 % and 81% vs. 74 % with regard to enjoyment, for the *e@Leader* and non-*e@Leader* users in their pre- and post-intervention responses respectively).

To sum up briefly, the students in the *e@Leader* group made more explicit improvement than those in the control group, as a result of the *e@Leader* exposure and interaction.

## Concluding Remarks

Extending the previous study (Dickinson & Hui, 2010), it is rewarding to observe in this study students' active learning can be operationalized through edutainment-game-mediated tool in a fun and experiential way across the different data sets. This study has provided empirical findings to demonstrate scholastic improvements in English and Mathematics both between and within groups. Also, the design of *e@Leader*, has accomplished the technical scaffolds lacking in many edutainment systems.

The following claims can now be put forward based on our findings from multiple data sources.

In response to the first research question, the findings support claims for the use of at least one purpose-built online educational gaming system (i.e., *e@Leader*) in enhancing active student learning, as measured by school students' scholastic performance differences in English and Mathematics and with reference to their participation levels, that is, higher vs. lower frequency levels (Gee, 2003).

In response to the second question, contrary to previous studies (e.g., Dickinson & Hui, 2010; Jaeggi et al., 2008; Pind et al., 2003), after four-month's daily interaction with *e@leader*, results showed no differences in IQ score categorization, excepting *e@leader* exposure (i.e., high vs. low frequency users). In addition, there are differences between the experimental (*e@Leader*) versus control (non-*e@Leader*) users in scholastic achievements in English and Mathematics, both between and within groups.

Last but not least, follow-up analyses of multiple data sets illustrate the complexity of the issues. The findings have useful implications for integrating online edutainment gaming into the school curriculum. Based on the teachers' responses from the interviews, some useful strategies and challenges are outlined below:

To fruitfully integrate online edutainment gaming experience within the school curriculum, the process should incorporate the following important aspects: (1) It should be supported through a “whole-school” approach involving collaborative research-teacher partnerships in careful and long-term planning, and implementation. (2) The content of the edutainment system should align with the content provided within the curriculum. (3) The design of online edutainment system should be thoughtful, for example, adopting a “sensory” approach to using both “games” and “songs” and supported via an interactive platform which will allow teachers to freely navigate and utilize the system for learning and teaching instruction and activities, both within and outside classrooms, and through online and face-to-face interaction.

However, the integration process can be time-consuming and challenging in terms of work load issues, lack of instruction time in terms of priority and funding issues, and mentoring and training issues to share experiences within a collaborative learning community. The current group of teachers was all very enthusiastic with the use of online edutainment gaming in motivating students to learn, but they were not entirely convinced that such practice will lead to any scholastic improvements in English and Mathematics.

In summary, it is our current belief that the environmental effects of providing specific training and curriculum content through online, computer-based edutainment gaming systems can indeed lead to increases in students’ scholastic performance by the transfer of core cognitive skills learnt whilst engaging with such educational tools (e.g., Tan & Boon, 2007; Yung & Dickinson, 2008).

For future research, the authors may explore issues involving multi-users in student-centered learning with larger groups of students at multiple grade levels, both within and across sociocultural groups, over a longer period of time, and new topics such as the washback effects of online educational games in teaching and learning, policy-making issues involving learner autonomy and self-regulation in life-long learning.

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