Enriching Student Learning Programming Through Using Kodu

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ABSTRACT

Motivating students to learn programming in everyday classroom contexts is a challenging task for teachers. The release of 3D programming tools has potential to engage students in learning and to address motivational issues for mainstream students in class. In this exploratory study that questioned student and teacher perceptions of learning while using a 3D environment it was observed that there was a residual of resistance to learning but that a significant percentage of students were motivated by the experience. Data was collected in an International study from the US, the UK and New Zealand. Microsoft Kodu Game Lab was used in the study because it was 3D, a free download and compatible with the trial school networks. Through presenting the lessons as a part of the everyday school program, the novelty factor was controlled and an attempt to change the core system curriculum delivery made. The exploratory studies found that on-task behaviours increased and frustration and boredom were reduced.

Keywords

Teaching, Programming, Video Games

1. INTRODUCTION

Engaging mainstream students in introductory programming lessons is a great challenge for Information and Communication Technologies (ICT) teachers (Guzdial and Soloway, 2002; Wiedenbeck, 2005; Corney, et al., 2010). The demanding nature and discipline of coding often tinges the experience of learning with negative features. For many students the situational demand to put together many conceptual and process skills simultaneously for an outcome that may be demonstrated by performance becomes overwhelming. Also the perceived career and personal ambitions students bring to programming classes may be a mismatch with their pre-learned life skills, aptitude and capability to produce successful outcomes. Guzdial and Soloway (2002) suggest that engaging students is critical to deep learning and maximizing the chance for success of each student. With the advent of object-orientated programming languages like Alice (Dann, et al., 2009), Scratch (Meerbaum-Salant, et al., 2010), Game Maker (Overmars, 2004) and Kodu Game Lab (MacLaurin, 2009), there has been an increased interest in the value of these tools to see if and how these tools can improve student engagement. Moreover these tools also represent the potential to capture an increased range of student experiences and to treat some of the previous negative or inhibiting learning experiences (Guzdial and Soloway, 2002; Leutenegger et al., 2007; Dann, et al., 2009).

The release of tools for the teaching of programming has exploited the object oriented and visualization worlds so that programming has become more like drawing a picture than writing a sentence. However even with picture drawing teachers are still challenged by student expectations and the preferred modalities of learning students bring to class. A computer game development tool presents students the opportunity to develop their own worlds rich in visual and auditory interactive content. The next step is to engage students and thus inspiring and motivating students to create their own designs (Lawhead, et al., 2003). With engagement in the curriculum content students can be challenged to think more deeply, critically and creatively about different levels of problems and the range of possible solutions. Using computer games in the classroom may increase student motivation, and enhance attention and concentration (Department of Education and Early Childhood Development, 2009). Another compelling reason for implementing the technology in the classroom is that playing and building computer games can make learning fun (Teske et al., 2010). If classroom lessons are presented in more captivating ways, it can make learning easier and possibly assist in motivating students to spend more time engaging in learning (Wiedenbeck, 2005).

In this study we embedded a 3D programming tool (Kodu Game Lab) into the everyday curriculum of students in three secondary schools in three different countries. In each situation the students had been learning programming in a text based environment and were then provided a new task support by the tool. The lessons were to be taught by the classroom teacher within the usual daily timetable as a control on novelty factors. No attempt to create a control group was made as the variation within samples was too great. To investigate the use and value of the tool the only metric used was what students and teachers said. In addition standardized tests were run to identify the students preferred modalities for learning and the teacher acted as an observer to record on-task or off task behaviors and expressions of emotion. No special attention was drawn to the event and it was presented as any other learning requirement in the school program.

We sought to address the following research questions:

RQ1. Is Kodu Game Lab a suitable tool for teaching introductory programming?

RQ2. What modality of learning is best suited to using a game development platform?

RQ3. Do levels of engagement or enjoyment improve through using Kodu Game Lab?

2. RELATED WORK

There has been an increased interest in the use of computer games in education to engage students in the learning process (Gee, 2003). The concept is not new but the ready availability of rich digital environments has become more accessible for schools in the last decade. Some of the key issues have arisen from the cost

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of implementation, the suitability of staff training and the ways to embed or isolate the experience from daily programs. Also students are much more familiar with visual game play with the evolution of PlayStation and Xbox video game consoles. In many respects they arrive pre-disposed to the arts of playfulness and using digital media for fun (Squire, 2008). The use of computer games in education and training is widespread and has been successfully applied in pilot training and with other professional groups (Prensky, 2001). Computer games such as Microsoft Flight Simulator, Quake, Doom and America's Army have been used to teach activities that would be too difficult, expensive and/or dangerous to teach in real life (Prensky, 2003).

The major benefits of using computer games in education are that:

- Students can learn by doing (Gee, 2003; Shaffer et al., 2005)
- They can facilitate practice in safety (Prensky, 2001)
- There is an opportunity to try something we may not be able to do in real life (Prensky, 2001)
- Through actively engaging students we may also improve student participation and recall (Prensky, 2001)

Rosas et al. (2003) suggests that computer games are good for learning because they offer the opportunity to improve school achievement, increase motivation, and enhance attention and concentration. Another compelling reason is that computer games can make learning fun, (Griffiths, 2002; Squire, 2008; Prensky, 2001; Shaffer et al., 2005). While these authors do not suggest that all learning needs to be fun, they do suggest that if we can present some topics in a more captivating way, it may make learning easier and possibly assist in motivating students to spend more time engaging in learning. Engaging students in carefully designed environments where fun is managed with challenges (enjoyable frustrations) tends to engage and relax participants. Students in relaxed (but participatory) states tend to learn new concepts faster. Conversely, when a student is in a tense state they tend to struggle to learn new concepts (Gee, 2003).

There are challenges and risks associated with using a computer game development tool in the classroom. It has been suggested that there might be a relationship between too much violence in computer games (and television) and aggression (Strasburger et al., 1999). From this and additional research it appears that excessive exposure to violence desensitizes people (Anderson et al., 2003) which may lead to a distorted view of reality and ambiguity in the learning processes (Wutzel et al., 1984). The other potential challenge is getting students to focus on the learning activity at hand and/or refocus on other class activities. Anecdotal evidence suggests that students may be easily distracted to play the games rather than make their own or alternatively find it difficult to return to a 'normal' class routine when the game development lessons have finished.

This proposed study is similar in scope to the work undertaken by Meerbaum, Armoni and Ben-Ari (2010) who investigated the use of Scratch (Dann et al., 2009) in a middle school environment. Our study provides useful comparison as it employs a different visual programming tool (Kodu Game Lab, 2011) which, unlike Scratch and Game Maker, offers an isometric three dimensional user experience. Moreover, as Kodu Game Lab is supported on both the Xbox 360 and a Personal Computer with a Windows operating system (Windows XP and above). The software also supports the use of the Xbox 360 Controller on the PC making this software potentially more accessible and easier to use. Qualitative measurements and anecdotal evidence (Stolee et al., 2011; Strasburger et al., 1999) have been typically used when evaluating educational programming environments. As an exploratory study we focused on the student attitudes and behaviours.

Engaging mainstream students in introductory programming courses is one of the many challenges for ICT teachers (Guzdial et al., 2002; Skinner et al., 1993). According to Wiedenbeck (2005) most ICT students have a high interest in playing computer games and this interest can be leveraged to engage students in learning to make their own computer game. Research trials were run in a Year 12 class to evaluate the impact of using Game Maker and to observe student engagement levels (Overmars, 2004). The results showed enhanced on task student behaviours and so the tool was introduced as part of the regular teaching program across the curriculum in Grades 7 to 12. The case outcomes showed high levels of engagement and the learning of key programming concepts (logic, loops, nested loops and inheritance) with enthusiasm and enjoyment, which had not been observed in the past.

The selection of a suitable program learning tool was made by evaluating a selection of tools available to the market. The selection was to be based on cost (zero), school system compatibility, and visual learning impact. In figure 1 a comparative analysis of tools is that were evaluated in the final selection.

Software/ Features	Alice	Scratch	Game Maker	Kodu Game Lab
Isometric 3D	✓	✘	✘	✓
Xbox 360 Controller	✘	✘	✘	✓
Integrated game play mode	✓	✘	✓	✓
Integrated game sharing facility within software	✘	✓	✘	✓
Integrated tutorials	✓	✘	✘	✓
Price	free	free	free (demo version)	free

Figure 1. Comparison of game development tools

A reasoned choice based on the selection criteria was made to use the Kodu Game Lab (2011a, b). Kodu Game Lab (MacLaurin, 2009; Meerbaum et al., 2010) is a tile based visual programming tool (see figure 2) that allows the user to create and play video games (Stolee et al., 2011). The graphical user interface is presented in isometric 3D and the graphics are similar to those found in commercial video games developed for younger audience (like the Sims (Hayes et al., 2009)). There are other similar commercial off the shelf software tools such as Alice (Meerbaum et al., 2010), Scratch (Resnick et al., 2009), and Game Maker (Overman, 2004).

Kodu Game Lab (MacLaurin, 2009) differs from other tools in several ways as detailed in figure 1 when compared against the selection criteria. The Kodu language is entirely event driven and thus differentiates as a learning tool when compared to Scratch and Alice (Stolee et al., 2011).

Figure 2. Programming interface in Kodu

While it is significantly different than other mainstream programming languages, Kodu allows the user to explore many fundamental programming concepts including; Boolean logic (negation, conjunction, and disjunction), objects, control flow and inheritance. Kodu Game Lab was also adopted due to the potential of the isometric 3D presentation and the use of the Xbox 360 controller to appeal to a younger audience. The rich visual, auditory and kinaesthetic attributes of the software have the potential to make it attractive and distinct for the students. The initial investigation involved two classes of students in one school and was then scaled out to four other schools for a comparison of results.

3. THE PARTICIPANTS

The New Zealand study involved 19 participants. Of the total population 68% were male and 32% were female. The majority (95%) of the class identified as being European/Pakeha (Caucasian) and the remainder identified as being Maori.

The UK study involved 23 participants who were middle school students aged between 12 and 13 years old, 65% of whom were Male and 35% were Female. 100% of the population identified as being European.

The US study involved 18 participants in this study were middle school students aged between 10 and 13 years old, 67% of whom were Male and 17% were Female. 44% of the population identified as being European, 17% as Asian, 6% as African American and 12% as Native American.

4. METHODS

To understand the students' perceptions about programming, programmer perception and to obtain demographic data students were asked to participate in a pre-exposure survey. We also asked the students questions about game playing frequency and what (if any) gaming platforms they used. To collect the perceptual and demographic data a five-point Likert scale was used. The Likert scale provided a very positive (5) response a positive response (4) a neutral response (3) a negative response (2) and a very negative response (1).

To get a better understanding of how the students comprehend information an existing framework was used. A modified version of the VARK questionnaire (Fleming, 1995) was used to understand each student's modality of learning. The VARK questionnaire focuses on the learners sensory modalities for validating how learners respond to a particular situation, challenge or learning materials. A visual learner tends to prefer information presented graphically, an aural learner tends to prefer to be told information or receive it aurally. A reading/writing learner tends to prefer to read or writing information whereas a kinaesthetic learner needs to personally experience the learning (usually through hands-on experience). To measure each student's modality of learning we presented each student seven scenarios, each scenario had a four solutions and students were asked to select the solution that they felt they would use. Each solution was typical of each modality of learning. The responses were then collated and selected the most frequent response (the mode). If a mode could not be found, these students were identified as multimodal.

Throughout the study the students underwent continuous structured observation by the class teacher and levels of engagement, fun, collaboration and peer teaching were observed – as were levels of boredom and frustration during each lesson. To ensure that the observed behaviour was a result of the lesson and not other mitigating factors, the class teacher also provided a rating of any external factors. To collect the data the class teachers were given guidance and a class observation form with a five point Likert scale to measure each observed behaviour for each student. The observation sheet included the definition and attributes of each behaviour for observation.

Engagement was defined as being on or off task and sustained involvement in learning activities and a positive emotional tone (Skinner & Belmont, 1993). Enjoyment was defined as showing signs of delight, or smiling. Boredom was defined as a lack of interest in and/or difficulty concentrating on the current activity (Fisher, 1993; Hill, 1985). Frustration was defined as showing signs of annoyance, creating a disturbance, or frowning. Collaboration was defined as students working with others and peer teaching was defined as students showing other students how to do a skill related to the learning objectives. To ensure that the resulting behaviours were primarily a result of lessons and not other external influences, we also asked the class teacher to note any observable or stated external influences.

Students were provided the opportunity to reflect on their own levels of performance for each observation criteria. The class teacher was provided with an observation sheet for each lesson which included a five-point Likert scale for each observed behaviour. The students were provided an online data collection tool using a three-point Likert scale to reflect on each observed behaviour. The three points were; High, Normal, or Low.

When the students had completed all four lessons they were asked to participate in a concluding survey. To compare any changes in view of programmers or programming we asked the same questions in the second survey as were asked in the first survey. Additionally, to further understand the students' perceptions of the lessons, we asked two open-ended questions:

- Complete the following statement: Using Kodu was _____
- Please write any other comments you may have about the game making lessons

5. DATA ANALYSIS – NEW ZEALAND

The students reported moderate to high levels of enjoyment with 12% of students indicating high levels of enjoyment and 12% indicating they enjoyed the lessons. This represented a collective 32% of the students reporting an enjoyable experience. Over 53% provided a neutral response which is also significant. Furthermore, 21% of the students indicated that the lessons were significantly better than the other lessons they have and 16% of the students indicated these lessons were better than their other lessons. This represents 37% reporting that these lessons were better and 21% indicating that these lessons were worse.

The levels of observed enjoyment and engagement by the class teacher were moderately high. Table 1 shows the results of the observed Enjoyment and Engagement behaviours.

Table 1[1]: Observed Engagement & Enjoyment Behaviour

Rating N=19	1 (low)	3	5 (high)
Enjoyment	3%	29%	71%
Engagement	6%	9%	89%

Conversely the levels of observed boredom and frustration by class teacher were not high. Table 2 shows the results of the observed boredom and frustration behaviours.

Table 2[1]: Observed Boredom and Frustration Behaviour

Rating N=19	1 (low)	3	5 (high)
Boredom	75%	22%	3%
Frustration	69%	25%	6%

The levels of collaboration and teaching were also observed. Table 3 demonstrates that both the amount of collaboration and teaching were moderately high.

Table 3[1]: Observed Collaboration and Peer Teaching

Rating N=19	1 (low)	3	5 (high)
Collaboration	3%	57%	40%
Peer Teaching	6%	60%	34%

We also asked the students to reflect on their own experience and were able to compare this reflection with the class teachers' observations. Although it would have been interesting to compare the teacher observation of each student with that individuals own refection, the information was not collected in a way to make it possible. The students reflected moderately high levels of both enjoyment and engagement and surprisingly (given the complaints about the hardware and software) the number of students who reported low enjoyment and engagement was much lower than expected. Moreover, the levels of enjoyment collected through the student reflections survey is significantly higher than the results collected in the final survey.

The amounts of reflected boredom and frustration (Table 5) were low. The amount of reflected collaboration and peer teaching (Table 6) were moderately high.

[1] Although the class teacher was asked to use a five-point Likert scale only three of the data points were used

From the study we found that the moderating variable modality of learning had some influence on student engagement with the technology. 83% of the students who reported high and very high levels of enjoyment were students who identified as having kinaesthetic modalities of learning. 50% of the students who reported low or very low levels of enjoyment were students who identified as having aural/ auditory modalities of learning.

Although the reported amount of game use was very high (33% playing computer games every day and 33% playing two to three times per week), prior exposure to playing computer games did not appear to have an impact on the levels of enjoyment.

Although there appears to be a difference between the teacher's observations and the student reflections after each lesson, the student answers to the open ended questions appear to provide a much better summary of the student perceptions. Over 62% of the students used the words fun, cool or enjoyable when answering the first open ended question "Using Kodu was ____." However, only 14% of the students used words like boring or sad.

Table 4[1]: Student Reflected Enjoyment and Engagement

Rating N=19	1 (low)	3	5 (high)
Enjoyment	17%	44%	20%
Engagement	16%	42%	23%

Table 5[1]: Student Reflected Boredom and Frustration

Rating N=19	1 (low)	3	5 (high)
Boredom	32%	38%	12%
Frustration	31%	34%	16%

Table 6[1]: Student Reflected Collaboration and Peer Teaching

Rating N=19	1 (low)	3	5 (high)
Collaboration	14%	39%	28%
Peer Teaching	23%	40%	18%

6. DATA ANALYSIS – USA

When asked if the students enjoyed the lessons 40% indicated that they enjoyed the lessons a lot and 20% reported that they enjoyed the lesson. This represents 60% of the students who completed the second survey reporting a positive experience, while 20% of the students reported a negative experience. Moreover, 80% of the students indicated that the lessons were better than the other lessons they have. 50% of the students indicated that they would like additional lessons.

When asked the open-ended questions:

- Complete the following statement: Using Kodu was ________
- Please write any other comments you may have about the Game Making lessons

All students reported a positive experience through the use of words like fun, awesome, & cool.

From the study we also found that the moderating variable modality of learning had some influence on student engagement with this technology. 30% of the students who reported high and very high levels of enjoyment were students who identified as having kinaesthetic modalities of learning. 21% of the students who reported high or very high levels of enjoyment were students who identified as having aural/ auditory modalities of learning.

Although the reported amount of game use was high (44% playing computer games every day and 28% playing two to three times per week), prior exposure to playing computer games did not appear to have an impact on the levels of enjoyment or engagement.

There was some influence on student perceptions about computer programming, and careers in the computer industry. There was a 20% increase in students who strongly agreed with the statement "I would like to be a computer programmer someday". Moreover, there was a 30% increase in the number of students who strongly agreed with the statement "I am similar to people who are really good with computers and technology" and a 50% increase in the number of students who strongly agreed with the statement "I could be good at computer programming.

7. DATA ANALYSIS – UK

When asked if the students enjoyed the lessons 23% indicated that they enjoyed the lessons a lot and 15% reported that they enjoyed the lesson. This represents 38% of the students who completed the second survey reporting a positive experience, while 23% of the students reported a negative experience. Moreover, 38% of the students indicated that the lessons were better than the other lessons they have. 38% of the students indicated that they would like additional lessons.

When asked the open-ended question, “Complete the following statement: Using Kodu was ________.”, 77% of students reported a positive experience through the use of words like fun, fascinating, cool & enjoyable.

From the study we also found that the moderating variable modality of learning had some influence on student engagement with this technology. 38% of the students who reported high and very high levels of enjoyment were students who identified as having kinaesthetic modalities of learning. 23% of the students who reported high or very high levels of enjoyment were students who identified as having aural/ auditory modalities of learning.

Although the reported amount of game use was very high (74% playing computer games every day and 22% playing two to three times per week), prior exposure to playing computer games did not appear to have an impact on the levels of enjoyment. We have not been able to establish a positive relationship between using a game development platform and an increase in the interest in programming (and therefore computer science). The reliability and performance of the legacy hardware appeared to be a significant contributing factor on reported enjoyment and frustration.

8. DISCUSSION

The engagement of students with the curriculum is challenging for teachers. The use of games to focus students onto the learning objectives has been utilized for centuries and the opportunity to utilize computer games is a more recent extension of the theme. The teaching and learning experience of students in mainstream classes in middle schools is fraught with complexity. An intervention into the daily program is challenged by transfer from previous experiences, interpretations and learned adaptive behaviours. A student is challenged by multiple stimuli and the competition between cognitive, social, and experiential networks of sense making in the learning world. The teacher as facilitator and best guide may structure, sequence and manage experiences but is challenged in the multiplicity of mediations of the learning environment. Nothing is neutral.

Our study was kept simple in order to capture the immediacy of experience. Far greater complexity exists within the learning environment than has been mined. We only filtered some variables and have left others unattended. A control group was not used as the variability between and within main stream classes is too great for useful measures. There are many relationships that have a bearing on student engagement in such environments. The study shows that in the attention competitive environment of secondary schools in three countries a particular game making tool has been embraced by a high percentage of students. By the same count there are still a large number of participants who are not impressed and form a residual of non or anti learning participants. Further analysis of the residual was made possible by the measures of two moderating variables – modality of learning and teacher observation. Modality shows that one modality (kinaesthetic) prefers the game making learning experience ahead of the others. One of the other modalities (read/write) showed little motivation gain through the learning experience. The result indicates that benefits from an enriched learning environment are a trade-off between modalities. The tool used captured the attention of 75% of the participants in varying degrees across three modalities (and combination of modality) but failed to motivate 25% of the sample.

Attempts to enrich learning experiences are a calculated trade-off of interacting variables. The introduction of a 3D game making tool into a general school curriculum has potential to capture the attention of students who enjoy computer game play. The research in three countries showed that there was not a strong relationship between students who said they had a high game play record and enjoyment with the tool. This suggests that the computer games they play and the way they play may not result in learning how to learn. Consequently when faced with a similar interfaces but different objectives the motivation or the learning skill requirement may not transfer between experiences. Hence the research indicates that the enriched learning experience has a more general learning appeal. As a corollary the transfer of learned violence from computer game play may not transfer to the education environment with the ease or to the extent indicated in the literature reviewed. The educational environment appears to provide a different set of objectives for learning and a gaming context in which a different set of outcomes may be expected.

In general the students in the three countries reported the enriched learning environment provided greater enjoyment and engagement in the learning of computer programming. The boredom and frustration indicators show that engagement was occurring at a high level and that the recorded size of these measures showed learning challenges being managed. The experience and perceptions developed did not transfer to a consistent indication of improved or changed perception of computer science or employment in the industry. The result may be both indicative of student perception of the future and the immediacy of the experience (remembering the lessons were punctuated with technical and service issues). The curriculum intervention was a calculated trade-off and it brought motivational benefits to the majority of students. The question of performance based learning and improved programming skills were not asked in this research. The key question concerned engagement and the results indicate that this 3D game making tool caught the student attention, challenged them to think and to do, and to express enjoyment of the experience.

9. CONCLUSIONS

The findings in this study are consistent with the findings of the Department Education and Early Childhood Development Report (2009) and the Teske and Fristoe (2010) study. The game making tool for learning programming provided a supportive and productive learning environment that engaged a significant percentage of the students in general mainstream Schools in three countries. It catered for students with diverse learning requirements and acted as both a trade-off and a catalyst for engagement. The literature reviewed indicates that such learning engagement is indicative of deep thinking. Students were involved with problem solving, game making processes as solutions and the creation, design and deconstruction of multimedia texts. The students demonstrated engagement in problem solving and creative thinking. However, there does not appear to be a relationship between using a game development platform and an increased interest in programming (and therefore computer science) as suggested by Guzdial and Soloway (2002).

The studies to date by the authors have been of an exploratory nature and have focused on the motivational inheritance for student learning engagement. One of the main problems faced has been the ability to control the stimulus variables in a classroom environment where many uncontrolled stimuli impact on the factors for research. In particular transfer from other contexts, environments and emotional states have an influence on the controlled variables and moderating variables. We have attempted to control the novelty factor by embedding the learning experience in the daily experience of any student and yet it is still likely that any given response may be the result of immediate or past experience transfer. Similarly attempts to classify past learning and learning modalities has stabilized the control set further but still leaves difficulties for general claims regarding a one-fix-all solution.

The feedback from the students was generally positive but also showed a residual of dissatisfaction. Some of the dissatisfaction can be explained from the feedback during the lessons and the reflective observations that showed the stability of the software and hardware appears to have had some impact on responses. While acknowledging the limitations imposed by the design and execution of the exploratory study the measureable changes suggest that an object orientated education tool to introduce programming concepts to secondary school students provides motivational value. The concepts of game and fun were used by students to express satisfying learning experiences in routine school classes.

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