Enhancing Introductory Programming with Kodu Game Lab: An Exploratory Study

Allan Fowler
Waiariki Institute of Technology
Rotorua, New Zealand
allan.fowler@waiariki.ac.nz

Brian Cusack
AUT University
Auckland, New Zealand
brian.cusack@aut.ac.nz

This quality assured paper appeared at the 2nd annual conference of Computing and Information Technology Research and Education New Zealand (CITRENZ2011) incorporating the *24th Annual*

Abstract

This paper shows that embedding computer games into the regular classroom curriculum can positively effect student learning perceptions and attitudes. The studies showed that boredom was reduced and on task behaviors increased. No attempt was made to investigate the relationship between the effect of embedding computer games into the regular classroom curriculum and educational achievement as this is the subject of further research. It is also noted in the findings that computer games in the classroom do not enhance every student learning experience but rather the benefit is unequally distributed across different learning styles.

Keywords

Teaching; Programming; Computer Games; Kodu Game Lab

Introduction

This paper investigates the use of an integrated game development tool in a New Zealand middle school. A series of exploratory studies were run to see if student engagement could be enhanced by embedding game development into the regular classroom program. The integrating of games into classroom programs to enrich learning has become easier with the increased range of digital media and the greater access to cost effective computing. In this research a series of exploratory studies were run to see if student engagement could be enhanced by embedding games into the regular classroom program. An integrated game development environment was used that provided an exploratory context for creativity and games to engage students in learning programming concepts.

There has been an increased interest in the use of computer games in education to engage students in the learning process (Gee, 2003; Squire, 2003). The concept is not new but the ready availability of rich digital environments has become more accessible for primary and secondary schools in the last decade. Some of the key issues have arisen from the cost of implementation, the suitability of staff training and the ways to embed or isolate the experience from daily programs.

The use of computer games in education is common and has been successfully applied in pilot training and with other professional groups (Prensky, 2001, Prensky, 2002). 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, 2002).

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 (op cit)
- Through actively engaging students we may also improve student participation and recall (op cit)

Rosas et al (2003) suggest 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 possibly some 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 & Donnerstien, 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 (Wurtzel, 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.

Engaging mainstream students in introductory programming courses is one of the many challenges for ICT teachers (Guzdial & Soloway, 2002; Skinner & Belmont, 1993). Research shows that 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 (Wiedenbeck, 2005). In this research trials were run in a Year 12 class to evaluate the impact of using Game Maker (Overmars, 2004). The results showed enhanced on task student behaviors 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.

Microsoft Kodu Game Lab (MacLaurin, 2009) is a tile based visual programming tool (see figure 1) that allows the user to create and play video games (Stolee, & Fristoe, 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. There are other similar commercial off the shelf software tools such as Alice (Dan et al, 2009), Scratch (Resnick et al, 2009), and Game Maker (Overmars, 2004). Kodu Game Lab (MacLaurin, 2009) differs from these tools in several ways as detailed in figure 2.

Figure 1. Programming interface in Kodu

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 2. Comparison of game development tools

The Kodu language is entirely event driven and thus this differentiates this as a learning tool when compared to Scratch and Alice (Stolee & Fristoe, 2011). 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 (op cit) and inheritance.

Kodu Game Lab was also used for this study 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 kinesthetic 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.

Related Work

This study is similar in scope to the work undertaken by Meerbaum, Armoni and Ben-Ari (2009) who investigated the use of Scratch in a middle school environment. Our study provides useful comparison as it employs a different visual programming tool (Kodu Game Lab) which, unlike Scratch and Game Maker, offers an isometric three dimensional user experience and most importantly, obviates the need to learn syntax. 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 have been typically used when evaluating educational programming environments (Stolee & Fristoe, 2011). As an exploratory study we focus on the student attitudes and behaviors.

The study

To evaluate the effectiveness of using Kodu to introduce the programming concepts an investigation involving students was conducted on two classes of Rotorua Intermediate School (a middle school in New Zealand). The goal of this study was to measure the levels of engagement, enjoyment and how much fun students had while using the tool. To measure engagement and enjoyment the class teacher observed the behaviors and recorded effects on a standardized table on occurrence. We defined engagement as on or off task– sustained involvement in learning activities and a positive emotional tone as classified by Skinner & Belmont (2003). We defined enjoyment as showing signs of delight, or smiling. We left the definition of fun up to the individual student to express in response to a questionnaire.

Moreover, we wanted to see if this tool appealed to any particular modality of learning (Fleming, 1995). Modality was considered a moderating variable. As an exploratory study the unit of research was kept to 'what people said' and the possibility of developing and standardizing further metrics left open.

The Participants

The participants in this study were middle school students aged between 10 and 13 years old, 49% of whom were Male and 51% were Female. 63% of the population was European, 27% Maori, and the remainder identified as being Pacific Islanders (8%) or Asian (2%). These students were from two different classes. Class 1 was a mainstream class. Class 2 was a group of students whose parents had enrolled (and paid for) the students in additional computing lessons. The additional computing lessons were not included in this study.

The Learning Materials

When introducing a new software application into a formal school setting, it is necessary to ensure that the relevant learning materials are available so the courseware can be easily integrated into the existing curriculum framework. To facilitate this we adapted[1] Kodu Classroom Kit (Kodu Curriculum, n.d.) to fit within the New Zealand Ministry of Education technology framework (Te Kete Ipurangi, n.d.) with an emphasis on developing; problem solving, creativity, collaboration, technological principles and systems and the nature of technological practice.

The Lessons

The lessons were included as part of the students regular ICT class. This involved each class having two ninety minute lessons per week for one school term. The teaching was integrated into classes based on the New Zealand Ministry of Education Curriculum Framework, Technology Curriculum (Te Kete Ipurangi, n.d.). The lessons were designed to teach the key competencies including; information skills, problem-solving skills, self-management and competitive skills. The lessons built on prior and concurrent learning.

The learning experiences were embedded in everyday classrooms and the novelty factor controlled by introducing the experience as part of the daily school programme. No special attention was drawn to the event and it was presented as any other learning requirement in the school program.

[1] This can be obtained from the authors

Methods

The students completed an online questionnaire to collect demographic, previous exposure to playing computer games, perceptions about programming and their modality of learning (Fleming, 1995) before participating in the class. The game playing experience questions asked students to report on game playing frequency and the type of games platforms used. A five point Likert Scale was used to collect the data.

During 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 behavior was a result of the lesson and not other mitigating factors, the class teacher provided a rating of external factors. To collect this data the class teachers were given a class observation form with a five point Likert scale to measure each observed behavior for each student. The observation sheet included to definition and attributes of each behavior to observe.

At the end of the lessons the students were asked to complete a similar set of questions. In this questionnaire students were not asked to provide the demographic questions. Two open ended questions were added to ask the students:

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

It was considered likely that specific learning styles of individual students would affect their receptivity to the teaching methodology, so additional information about preferred learning style was sought. One method of understanding learning styles is the VARK questionnaire (Fleming, 1995). This method identifies four categories (or modalities) of learning; visual, auditory, reading/writing and kinesthetic. A visual learner tends to prefer information to be presented graphically, an aural learner would rather be told information or receive it aurally. A reading/writing learner tends to prefer the written word whereas a kinesthetic learner needs to personally experience the learning (usually through hands-on experience). To discern each student's modality of learning we provided students a seven point questionnaire based on Fleming's (op cit) model. Each answer was typical of one of the four modalities/modes of learning. The responses were then collated and the most frequently occurring mode identified as the learner's preferred learning style. If a preferred mode could not be clearly discerned, these students were identified as multimodal. The modality of learning uniquely identified provided categories into which the responses could be evaluated.

Data Analysis

Fifty two students completed the initial survey and forty nine of these students completed the second survey. The data obtained from the students that did not complete both surveys was not considered.

The most significant result from the study is how much fun students had. This conclusion was evident from the observations of the class teacher and from analysis of the self reported data at the end of the study. When asked if the students enjoyed the lessons 58% (average response 4.36) indicated that they enjoyed the lessons a lot and 24% reported that they enjoyed the lesson. This represents 82% of the students who completed the second survey reporting a positive experience, while only 2% of the students reported a negative experience. Moreover, 40% of the students indicated that the lessons were a lot better than the other lessons they have. A total of 64% indicated these lessons were better than their other lessons. The biggest challenge was getting the students to stop using Kodu Game Lab when the lessons had finished. This was an indicator identified by Squire (2003) that the tool is good for holding creative attention and learning.

The levels of observed enjoyment and engagement were also very high and the levels of observed boredom correspondingly low. Table 1 shows the results of the observed behavior - enjoyment. The amount of observed enjoyment is relatively close to the students' own reflection, which is very encouraging.

Table 1 – Percentage of Students exhibiting observed Enjoyment

Rating (n=52)	**1** ***Low***	**2**	**3**	**4**	**5** ***High***
Class 1	0%	0%	8%	13%	79%
Class 2	0%	1%	7%	8%	84%
Combined (Mean)	0%	0.3%	7%	10%	82%

Table 2 shows the results for observed engagement behavior.

Table 2 – Percentage of Students exhibiting observed Engagement

Rating (n=52)	**1** ***Low***	**2**	**3**	**4**	**5** ***High***
Class 1	0%	0%	2%	13%	86%
Class 2	0%	0%	6%	8%	83%
Combined (Mean)	0%	0%	4%	12%	84%

Conversely the levels of observed boredom and frustration and were significantly lower than reported boredom levels obtained in the study by Larson & Richards (1991).The sample of Larson and Richards (1991) found that students experience differing levels of boredom while participating in different classes. Helpfully, the levels of boredom reported in similar subjects like Science, Math or Typing were notably higher than was observed in this study. A percentage of the effect can be attributed to the game play in a computing context.

Table 3 shows the results of the observed boredom behavior. Table 4 shows the results of the observed frustration behavior.

Table 3 – Percentage of Students exhibiting observed Boredom

Rating (n=52)	**1** ***Low***	**2**	**3**	**4**	**5** ***High***
Class 1	72%	10%	2%	0%	0%
Class 2	80%	3%	9%	0%	8%
Combined (Mean)	83%	7%	6%	0%	5%

Table 4 – Percentage of Students exhibiting observed Frustration

Rating (n=52)	**1** ***Low***	**2**	**3**	**4**	**5** ***High***
Class 1	61%	9%	18%	1%	1%
Class 2	64%	3%	16%	1%	16%
Combined (Mean)	66%	6%	17%	1%	10%

The students were also observed in high levels of peer teaching and collaboration illustrated by Tables 5 & 6. The differences between the amounts of observed collaboration in the two classes may be explained by some of the students sharing personal computers. It is possible that the significant differences in observed peer teaching and collaboration in the two classes could be due to the different types of students or assessment methods and standards. The much higher levels of observed collaboration in Class 2 may also be explained by some of the students sharing personal computers.

Table 5 – Percentage of students exhibiting observed Peer Teaching

Rating (n=52)	**1** ***Low***	**2**	**3**	**4**	**5** ***High***
Class 1	15%	9%	33%	5%	33%
Class 2	3%	3%	17%	14%	63%
Combined (Mean)	8%	6%	25%	10%	51%

Table 6 – Percentage of students exhibiting observed Collaboration

Rating (n=52)	**1** ***Low***	**2**	**3**	**4**	**5** ***High***
Class 1	26%	10%	22%	3%	24%
Class 2	2%	1%	22%	31%	53%
Combined (Mean)	13%	6%	24%	14%	43%

The Class 1 teacher identified two individual students who were usually noticeably disruptive in other classes yet were observed to be continuously focused and engaged in every lesson. The Class 2 teacher identified three individual students who were usually very quiet in class were more vocal and confident throughout these lessons. Moreover, several students in this class indicated they would download the software so they could use it at home.

The other finding is that through using Kodu Game Lab the students changed their opinions about programming, programmers or their career choice. Through comparing the data collected in pre and post surveys we identified 48% (n=42) who changed their opinion from a positive or neutral view to a negative one to any of the following questions;

- I am interested in computer programming,
- I would like to be computer programmer one day,
- I could be good at programming, or
- I am similar to people who are really good with computers and technology.

One of the most difficult challenges for eight students was the compatibility of the software with four legacy computers. Although the students were told that this was beta software, this did not negate the frustration they experienced when the software crashed multiple times in a single class. Therefore, the levels of frustration with the lessons were hard to accurately measure during the sessions where these computers were used as the students could have been frustrated with the learning or the software crashing (or both).

Although some students experienced moderate levels of frustration with the computer hardware, they still reported an overall positive experience which further indicated the quality of experience was and the motivational value. This was evident from the post-test response to the open-ended questions where 87% indicating a positive experience (through using words like awesome, fun and cool) to the first question and 77% of the students reported a positive experience (also through using words like awesome, fun and cool when completing the second question).

From the study we also found that the preferred modality of learning had some influence on student engagement with this technology. The modality of learning may be considered a moderating variable that requires consideration in any general statements to be made regarding outcomes. 41% of the students who reported high and very high levels of enjoyment were students who identified as having kinesthetic modalities of learning. 26% of the students who reported high or very high levels of enjoyment were students who identified as having aural/ auditory modalities of learning. The other finding was that some students (24%) identified as using multiple modalities of learning or used different modalities of learning for solving different types of problems.

The students were asked to produce a functional application at the end of the lessons and 97% of the students were able to attain this outcome. Moreover, the students had acquired the key terminology used in programming. This is a significant result when compared with observational data collected from students of the same age using syntax based programming languages. When compared to the students in the initial pilot study, the levels of engagement and enjoyment were higher and students found it easier to grasp the key programming concepts when using Kodu Game Lab.

Although the reported amount of game use was very high (31% playing computer games every day and 44% 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.

These findings are consistent with the findings of Rosas et al (2003) in that this tool provided the potential to increase motivation, enhance attention, and concentration. Most importantly the students had fun and this finding supports the earlier work of Squire (2003; 2008), Prensky (2001) and Shaffer et al (2005). However, 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).

Discussion

The choice to embed the learning experiences in everyday classrooms and not to distinguish the experience from any other in the standard daily school program gave the best control on any novelty factors introduced into the study. On going research that is to follow the use of Kodu over two more semesters can provide further data on the novelty factor and to allow the development metrics for measuring the gain in knowledge by the sample groups.

This introductory study has confirmed the findings of others (see Sections 1 & 2 above) that fun has direct impact on learning in environments that are carefully designed. In addition the provision of fully integrated game development platform with fewer end user constraints differentiates this study from others. It showed that students were more likely to give additional time to learning and that an enriched game experience assisted in overcoming a number of frustrations that arose from both the software service and the challenge of programming.

The value of using a Kodu Game Lab to introduce programming concepts to middle school students is observable. While the results have been convincing, the study was limited in scope and served as an initial exploration. Therefore, to make any broad generalizations the study is ongoing and further development of metrics, benchmarks and scope is to be implemented for two more semesters. Moreover, there is an opportunity to consider the use of this tool to teach subjects other disciplines such as science, social studies and statistics.

Conclusions

From the data collected by asking the students their responses and systematic observation of their behavior in class, it is apparent that in this situation the use of computer games was effective for engaging the students in learning. When compared to similar students that were taught more traditional programming languages (C++, Java) the levels of enjoyment, engagement were observed as being significantly higher. Conversely, levels of boredom or frustration were observed as being significantly lower.

From the observations of the class teachers students learnt what programming means. They also did their learning with higher motivation levels. Students had the embedded feedback of producing a working and functional game that built confidence and a sense of achievement in classroom learning. This demonstrated (although was not measured as a research objective) that specific learning outcomes had taken place in line with the curriculum objectives.

Acknowledgement

This research was conducted under the auspices of the Waiariki Institute of Technology Research Committee ethical standards. The authors would like to acknowledge the support of the staff and students at Rotorua Intermediate School for whom this report would not have been possible. We would also like to acknowledge the support and assistance of Microsoft Research's FUSE Labs.

References

Anderson, C. A., Berkowitz, Donnerstein, E., Rowell Huesmann, L ., Johnson, J. D., Linz, D., Malamuth, N. M. & Wartella, E. (2003) *The influence of media violence on youth, Psychological Science in the Public Interest*, *4*(3), 81-110

Bailey, M. W., Coleman, C. L., & Davidson, J. W. (2008) Defense against the dark arts. *SIGCSE '08: Proceedings of the 39th SIGCSE technical symposium on computer science education, 315-319*

Dann, W. Cooper, S. & Pausch, R. (2009) *Learning to program with Alice, Second Edition, Upper Saddle River, NJ, Pearson.*

Gee, J. P. (2003) *What video games have to teach us about learning and literacy*. New York, NY: Palgrave Macmillan.

Griffiths, M. (2002) The educational benefits of video games*, Education and Health*, *20*(3), 47-51.

Guzdial, M., & Soloway, E. (2002) Teaching the Nintendo generation to program: Preparing a new strategy for teaching introductory programming. Communications of the ACM, *45*(4), 17-21.

Hayes, E. R. & King, E. M. (2009) Not just a dollhouse: what The Sims2 can teach us about women's IT learning, *On the Horizon*, *17*(1), 60-69

Stolee, K. T & Fristoe, T. (2011) Expressing computer science concepts through Kodu game lab. *Proceedings of the 42nd ACM technical symposium on Computer science education* (SIGCSE '11). ACM, New York, NY, USA, 99-104.

Kodu Curriculum: Xbox Controller, Retrieved December 12, 2010, from http://csamarktng.vo.msecnd.net/kodu/pdf/kodu_curriculum_Xbox_controller.pdf

Kodu Game Lab, Retrieved December 10, 2010, from http://fuse.microsoft.com/project/kodu.aspx

Larson, R. W., & Richards, M. H. (1991) Boredom in the middle school years: Blaming schools versus blaming students, *American Journal of Education*, *99*, 418-443

MacLaurin, M. (2009) Kodu: end-user programming and design for games*, FDG '09 Proceedings of the 4th International Conference on Foundations of Digital Games*, DOI=http://doi.acm.org/10.1145/1536513.1536516

Meerbaum-Salant, O., Armoni, M., & Ben-Ari, M. (2010) Learning Computer Science Concepts with Scratch, *ICER '10 Proceedings of the Sixth international workshop on Computing education research*, 69-76.

Overmars, M. (2004) Teaching computer science through game design, *Compute*r, *37*(4), 81-83, Prensky, M. (2001*) Digital Game-Based learning*, New York, NY: McGraw-Hill.

Prensky, M. (2002) The motivation of gameplay: The real twenty-first century learning revolution, *On the horizon*, *10*(1), 5-11.

Resnick, M., Maloney, J., Monroy-Hernandez, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B., & Kafai, Y. (2009) Scratch: Programming for all. *Communications of the ACM*, ACM, 42, 11, 60-67.

Rosas, R., Nussbaum, M. Cumsille, P., Marianov, V., Correa, M., Flores, P., Grau, V. Lagos, F., Lopez, X., Lopez, V., Rodriguez, & P. Salina, M. (2003) Beyond Nintendo: design and assessment of educational video games for first and second grade students, *Computers and Education*, 40. 71-94.

Shaffer, D. W., Squire, K. D., Halverson, R. & Gee, J. P. (2005) Video games and the future of learning. *Phi Delta Kappan*, *87*(2), 104–111.

Skinner, E. A., & Belmont, M. J. (1993) Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology*, *85*(4), 571-581.

Squire, K. (2003) Video games in education. *International Journal of Intelligent Simulations and Gaming*, 2. 1.

Squire, K. (2008) Educating the fighter: buttonmashing, seeing, being. In *Beyond Fun*, Drew Davidson (Ed.). ETC Press, Pittsburgh, PA, 27-42

Fleming, N. D. (1995) I'm different; not dumb. Modes of presentation (VARK) in the tertiary classroom, in Zelmer,A., (ed.) Research and Development in Higher Education, *Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia (HERDSA)*, HERDSA, 18, 308-313

Strasburger, V. C., & Donnerstien, E. (1999) Children, Adolescents and the Media: Issues and Solutions, *Paediatrics*, I(1), 129-139

Te Kete Ipurangi. Retrieved December 12, 2010, from http://www.tki.org.nz/r/technology/curriculum/contents_e.php

Wiedenbeck, S. (2005) Factors affecting the success of non-majors in learning to program. *Proceedings of the first international workshop on Computing education research* (ICER '05). ACM, New York, NY, USA, 13-24. DOI=10.1145/1089786.1089788

Wurtzel, A., & Lometti, G. (1984) Researching television violence, *Society*, *21*(6), 22-30