How does the use of Gamemaker software foster the development of creative problem – solving skills in boys?

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Abstract

Working individually and collaboratively, twenty-seven Year Five boys created computer games using a program authoring application. The aim of the project was to explore whether the Gamemaker application would foster the development of creative problem-solving skills. Over ten thirty-five minute lessons, boys were introduced to the Gamemaker package and challenged to produce a working computer game that could be played and evaluated by others in the class. Using video evidence, reflective journals and interviews, the study found that when boys construct computer games in a classroom that promotes risk taking, cooperative endeavour, competition and challenge, the process encourages individual and collaborative problem solving, and generates creative products. The use of technology to facilitate learning is well established. In the study, technology was also used to initiate and drive learning, amplifying the role that technology plays in boys'education.

Introduction

Boys in the Scotch College Junior School perform well above State and National averages in tests of literacy and numeracy. In general, these are tests of essential curriculum content and so are key indicators of success in specific learnt skills and with concrete learning scenarios. This study, however, began with the question, "How does the use of Gamemaker software foster the development of creative problem-solving skills in boys?". The evidence collected in various reflective journals and video records tested the hypothesis that if boys constructed their own computer games in a classroom that encouraged risk taking, cooperative endeavour, competition and challenge, they would create new products. These products represented tangible evidence not only of boys' creativity, but also of boys constructing meaning from the interaction with the gaming software and with other boys.

In this research, boys engaged with the software and with each other. They were challenged to find new and innovative ways of constructing the scenarios they put in front of their peers. They needed to explore consequences – action and reaction. In sum, they created a testable, visual experience from the world of their imagination, an experience built not solely on their own ideas, but with the collective ideas of others in the group. To start with, the boys formed a hypothesis (developed an idea for a video game), tested the hypothesis (playing their own and peers' games) and then reflected on their hypothesis (judging their own game via a student journal and interviews). This approach is typical of the protocols used in action research. In addition, action research was chosen as the method of investigation as it imbeds, for both students and the teacher, "the proviso that, if as a teacher I am dissatisfied with what is already going on, I have the confidence and resolution to attempt to change it" (McNiff, 1988, p. 50).

My research project investigated the extent to which boys with a range of academic abilities could articulate and share a variety of problem-solving strategies when working together on the

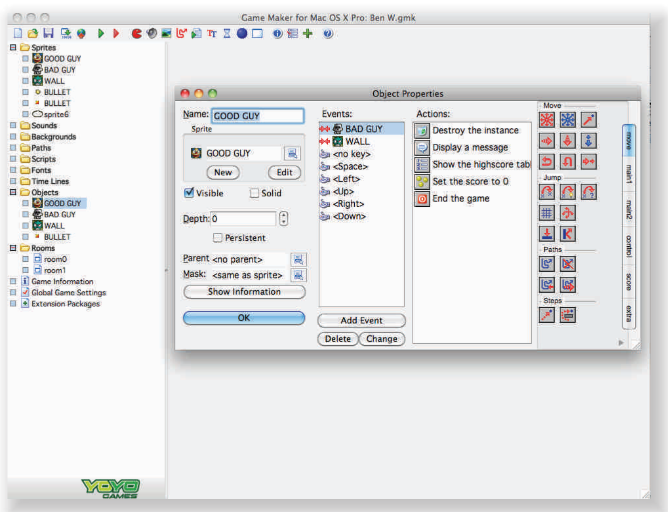

Figure 1: A typical Gamemaker screen with programming options

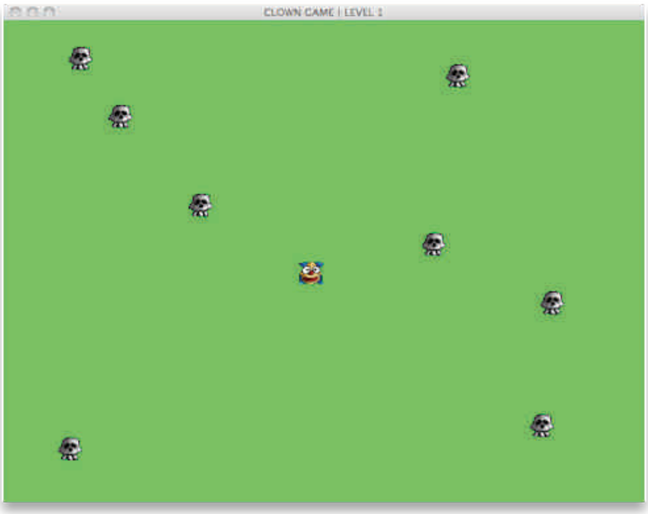

Figure 2: A basic game produced in Gamemaker

Gamemaker computer program. Gamemaker is a program that allows you to create computer games without writing computer code. It allows for drag and drop actions to create games with backgrounds, animated graphics, music and sound effects (see Figure 1). For more experienced game creators, there is a built-in programming language to allow for more sophisticated actions (see Figure 2 for a basic game produced by one of the participants and Figure 3 for a more advanced game produced by a different group of boys).

Figure 3: A more sophisticated game with an accompanying title page

Literature Review

There has been much written and spoken about the ways in which schools are killing creativity (Robinson, 2006). There has also been much discussion regarding the importance of students being able to learn effective problem-solving strategies, particularly as the problems that the world will face in the future are not necessarily known. This research analysed how the use of programming software, specifically Gamemaker, fosters the development of creative problem solving in boys.

Creativity has been defined from a variety of perspectives. The notion of creativity as the "production of effective novelty" is one that has been espoused by a number of writers (Aldous, 2007). Sir Ken Robinson (2009) has expanded the notion that to be creative, an idea must not only be original, but also have value. Indeed, he furthered the understanding by noting that, "to be creative, you actually have to do something. It involves putting your imagination to work to make something new, to come up with new solutions to problems, even to think of new problems or questions" (p. 67).

Many studies have looked at how creative thought develops in the brain. Aldous (2007) stated that there is evidence that creativity involves oscillating between thinking and feeling and moving between focused and defocused states of attention. It was not envisaged that this research would be able to identify creative thought, but it was hoped that it would be able to see the product of creative endeavour. However, the prime focus was on how creativity is an ability that everyone can develop and which can be fostered in anyone (Ferrari, Cachia & Punie, 2009). Learning in a creative manner, or creative learning, "involves understanding and new awareness, which allows the learner to go beyond notional acquisition, and focuses on thinking skills" (p. iii).

With this in mind, the Gamemaker software was chosen as the medium through which to analyse the development of creative problem-solving skills. As mentioned previously, Gamemaker allows for students to learn fundamental computer programming skills and then design their own games. Proponents for game design as a means to develop thinking skills emerged in the 1970s. Seymour Papert was the founder of the Massachusetts Institute of Technology (MIT) Artificial Intelligence Laboratory, Professor of Media Technology at MIT and creator of Logo, a programming language used by many schools in the 1980s. He noted that:

> It is one thing for a child to play a computer game; it's another thing altogether for a child to build his or her own game. This is where computers' real power as an educational tool lies. …It is in the computer's ability to facilitate and extend children's awesome natural ability and drive to construct, hypothesise, explore, experiment, evaluate, draw conclusions – in short to learn – all by themselves. (Papert, interviewed by Schwartz, 1999)

Papert also discussed how students' disengagement from school could result from it being too easy and, as such, boring. He noted how students, "talk about 'hard fun' and they don't mean it's fun in spite of being hard. They mean it's fun because it's hard". In addition, he stated that, "learning is essentially hard: it happens best when one is deeply engaged in hard and challenging activities" like computer programming (Papert, 1998, p. 88). He also added that programming differentiates learning for students because it allows for students to take charge of the process of learning. The students themselves, like professional game designers, make the important decisions.

In *Minds in Play – Computer Game Design as a Context for Children's Learning*, Yasmin Kafai chose a Year Four class to undertake a computer game design and creation unit. The Year Four students had to use the Logo software to design a game to teach Prep students about fractions. From her extensive analysis, she found that students actually learned about many things by making and playing games. The constructivist approach also allowed for individual styles to develop in game design as gender differences expressed themselves clearly in the choices of game themes and features (Kafai, 1995).

The Gamemaker unit allowed for discussion amongst peers, and between peers and the teacher. A previous unit on Gamemaker revealed that students were just as likely to ask peers as the teacher for advice on computer programming and design. The element of education having a social construct is noted by many educationalists, including Vygotsky (1978), when he defined the zone of proximal development as:

> the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. (p. 86)

It can reasonably be argued that for students to reach their potential, they need a challenging task to facilitate this, echoing Papert's views about learning being essentially hard.

The decision to choose computer game design was a reflection on students' enjoyment in playing computer games. Papert (1996) noted that, "almost all kids find this an exciting thing to do because video games are important in their world. Besides, it is very challenging to make a video game. It leads you to reflect on yourself and interact with others" (p.12). Playing games as a means of educating boys is taking the soft option. Actually teaching programming is taking the hard option – boys were challenged in areas that they would not normally be involved in before or after this research.

In a report prepared for the NSW Department of Education and Training in Australia (2005), the authors identified that boys needed:

- purpose,
- relevance,
- evidence of progress in learning,
- competition,
- variety,
- action,
- to be given responsibility, and
- structure.

As such, the authors echoed the earlier work on boys' education of Biddulph (1998) and Lilico (2000). These eight characteristics of boy-focused education were also embraced in the present study, in particular:

- the use of computer game programming to which the boys could relate and see as purposeful,
- instant feedback about whether their coding was leading to a better game,
- the competitive element of the computer game construction, testing, and peer evaluation,
- provision of choice in the variety or style of game produced, and the way in which they could work alone or with others to develop their product,
- empowerment to produce a game for which they had total responsibility, and
- a classroom format that provided structure while at the same time giving boys some flexibility in the way in which they approached each task.

The test of the hypothesis – how does the use of Gamemaker software foster the development of creative problem-solving skills in boys – was to observe boys exhibiting and documenting these attributes in the Gamemaker exercise and then transferring these skills into other areas of the curriculum.

Research Context

Scotch College, Melbourne, Australia, is a non-selective boys' independent school with classes from Prep (5 year olds) to Year 12. The Junior School runs classes from Prep to Year 6 with an attendance of 430 boys. The ethos of the school is best described in its Memorandum and Articles of Association, which state that the College is required to provide for its students:

> An education of humane, scientific and general nature consistent with the teachings of Christianity…(and to) encourage each student to achieve the highest standard of which he is capable in all his activities.

Scotch College has a reputation for academic success, with over 50% of boys in Year 12 represented in the top 10% of Australian students of this age. As stated earlier, the Junior School profiles strongly in the NAPLAN (National Assessment Program for Literacy and Numeracy) Year 3 and Year 5 tests.

The school provides not only a climate that encourages the best academic performance, but also has a strong pastoral care program that provides comprehensive support for boys who have learning difficulties. Being a non-selective school means that there are several such boys in every class: boys who struggle with the basic elements of literacy and numeracy, and who may also have behavioural issues resulting from frustration with these learning difficulties. So, in addition to a number of very capable students, every classroom in the Junior School accommodates boys at the lower end of the academic spectrum as a result of learning and/or behavioural difficulties. I decided to use the 27 boys in my class for the study because, firstly, it contained a range of academic abilities to test out my action research and secondly, it was far more practical to use my class to organise ready access to the Year 5 laptops.

Letters of consent were completed by parents, which incorporated permission to include all data collected in a written report. Anonymity was protected by changing the boys' first names when being referenced in the report.

The Action

This unit of work using the Gamemaker computer software was undertaken with a class of 27 students over the course of a school term (10 weeks), teaching a double lesson (70 minutes) once each six-day cycle. Each boy used a Macbook Pro laptop with the necessary software installed, as did the teacher, who projected his screen onto an electronic whiteboard.

Boys were introduced to basic programming in the initial five lessons with strategies and techniques demonstrated on the electronic whiteboard. The final five lessons involved the boys designing, creating and refining their own games. All research was done during regular class time, although a number of boys chose to undertake independent research and improvement at home.

Data Collection

Csikszentmihalyi (1999) argued that creativity occurs when an individual (a student) interacts with a socio-cultural setting (the classroom and teacher) within the domain (programming with Gamemaker). He went on to state that the outcomes arising from this interaction are judged by members of the field (at a classroom level, this will be the students and their teacher). This human dimension of creativity lends itself to qualitative methodologies of 'measurement'. Indeed, in trying to form quantitative questions, there is a risk that some of the elements of creativity will be missed in the 'numbers'.

Within this composite of individual, social context, and learning domain, several researchers have identified nine climate dimensions for creativity and innovation (Isaksen & Lauer, 2001; Isaksen et.al., 2001). These are:

- Challenge
- Freedom
- Trust/Openness
- Idea Time
- Playfulness/Humour
- Risk-Taking
- Idea Support
- Debate
- Conflict

These nine climate dimensions are more fully explained in Appendix A.

These dimensions are best addressed through qualitative measures such as classroom videos, one-to-one and group interviews, pre- and post-testing, student journals, and a teacher reflective journal. The pre- and post-tests appear in Appendix B: Gamemaker Unit Pre- and Post-Test.

The pre-test sought information that gave a starting point with respect to the boys' understanding of problem solving. The post-test sought to establish any changes in their understanding of, and strategies used in, problem solving. It could be argued that the pre- and post-tests did not directly, by themselves, give much evidence towards the research question – the development of creative problem-solving skills. However, these tests were looking for evidence that the boys were more aware of what was involved in problem solving. The games produced by the boys, their journal entries and interview comments, and teacher journal reflections provided the evidence for creativity, while the test questions revealed an increased awareness of the strategies needed to tackle problems and the way in which those strategies could then be applied elsewhere.

The reliability of the data came from the range of data sources used. The triangulation of the data gathered from formal pre- and post-testing, interviews, questionnaires, classroom observation in other contexts, and videotapes provided a substantial body of evidence to develop and support the hypothesis of this action research. In addition, two colleagues acted as critical friends by providing insights into the research process, particularly in regard to my action research. They also checked over my work to ensure that important areas were addressed properly and provided validation of the work and process undertaken.

Data Analysis

The key to answering the research question was the extent to which the data could be used to support one or more hypotheses. In a study such as this, it was necessary to use multiple sources of data to provide a broad base of evidence for a particular position.

To ensure the validity of the data, specific questions addressing the focus of the action research were included in the pre- and post-testing and in the interview process. The specific questions that elicited the most telling understandings from the boys in the pre- and post-tests were:

- Problem solving includes many different skills. How do you go about problem solving in a computer game?
- If you have ever made your own computer game, did you have to use problem-solving skills? If so, describe the situation.
- Do you think that learning basic programming skills in Gamemaker has helped you in problem solving? If so, how? (post-test only)

In the answers to the pre-test, there was no evidence that the boys could articulate problem-solving strategies in a computer game situation. In fact, none of the boys had even undertaken any form of game programming. However, after the ten units of the course, the post-test comments indicated a more sophisticated approach to problem solving, not just in relation to computer programming, but also to other aspects of the curriculum.

After looking through the video footage, the pre- and post-tests, the teacher journal and the boys' journals, the analysis of results showed a clear link between boys' creativity and the necessary climates for creativity as identified by Isaksen et al (2001). The nine climate dimensions for creativity identified by Isaksen were grouped into three key elements for ease of discussion and analysis. There was some overlap between climates, on occasion:

Social Construct For Learning

This subheading encompassed the climates of trust/openness, playfulness/humour, idea support, debate and conflict. The social construct for learning, as a necessary and beneficial part of the boys' learning and creating, reflected Papert's thoughts that making a video game, whilst being a very challenging task, also "leads you to reflect on yourself and interact with others" (Papert, 1996).

Challenge

Linked with Papert's view of computer programming providing "hard fun" and being a real challenge, the results, in particular the boys' comments, showed a definite link to Vygotsky's zone of proximal development. This will be elaborated in the discussion of results section. The climate of risk taking was included in this element.

Enjoyment

This subheading included the aspect of playfulness/humour and the fact the boys had the autonomy and resources to make decisions about their learning, in other words, freedom.

Another factor that was not obvious in Isaksen's nine dimensions was student *self-organisation* – the ability of a boy to identify a sequence of tasks, which are prioritised, in order to reach a goal. This element will be discussed in light of the boys' journals and teacher observation.

Discussion of Results

"Today me and Stephen made a front cover for our game, but implementing it in our game was very difficult. Joel showed Stephen while I was trying to find out how, when you land on an enemy vertically they die but if you touch them horizontally, you die. Joel was trying to find the same thing but unfortunately when he did find out how, it had over 30 steps involved so we decided not to use it."

(Adam – student journal)

Two boys from one group, Adam and Stephen, in collaboration with another boy, Joel, identified that their task was **challenging** and that they would need to take risks in order to produce a game that works. Their engagement with this task, both in and out of class, illustrated the **enjoyment** they gained from this challenge notwithstanding the fact that the ultimate goal required the individual steps to be **organised** very carefully.

Social Construct For Learning

Vygotsky (1978) and Papert (1996) have both identified the critical nature of a social learning environment. This study reinforced those findings as can be seen in the following quotes:

"You had helpers and you had a choice on what game you would like to produce."

(Campbell – student journal)

Campbell noted that the final decision of the direction of his game relied upon collaboration with others. Soren felt confident enough, without being asked, to assist with the development of another game:

"I improved Peter's game by making new levels and better guys and lots of things. We also made a front page. Sometimes Peter would work on his own game so at the end we would decide which one was better."

(Soren – student journal)

There was also a reciprocal relationship between the social, the challenge and the risk taking. Having observed peers' games (social), boys were then motivated to improve their own games (challenge and risk taking). As Cameron notes in two quotes from his daily journal reflection:

"I enjoyed playing other people's games to see what they were thinking and what their ideas were...

...I think problem solving means working together as a team to solve a problem. Once you solve a problem, there is always another problem."

(Cameron – student journal)

Cameron's reflection also identified that new questions arise as a result of solving existing problems. Cameron was not alone in his enthusiasm for celebrating others' success:

"The game that stood out for me was Adam and Stephen's because all the levels from start to finish were challenging and there was always a special way to complete the level without dying"

(Phillip – student journal)

Challenge

Isaksen (2001) defined risk taking as going out on a limb without fear of being criticised. Michael identified a problem, chose what he thought was an appropriate response, which did not work. Undeterred, he found a different set of programming strategies that did work. And then, with no further input from others, he identified future strategies to help improve his game:

"For some reason my invisible object didn't obey my programming so when the bad guy collided with the invisible object it went right through and off the game but I fixed the problem by inserting a sprite-tree so there was a picture of a tree and that worked.

What I need to do in Gamemaker:

- **turn the background around**
- **make a repetitive pathway for my other cars**
- **make another room."**

(Michael – student journal)

The boys had difficulty identifying the programming problems that they encountered in their written journals. However, the teacher journal noted many times the willingness of the boys to take risks in attempting to solve their problems. To start with, only 4 of the 27 boys actually gave up on their original games because they could not find a solution to their particular programming problems. All of the other boys completed their initial task successfully with help from other boys, online tutorials, teacher assistance and experimenting with alternative programming.

Stephen noted the joy gained from solving a problem because, as Papert would refer to, it was hard:

> "I liked that my game that we had gravity and I'm really proud because it is hard to make."
>
> (Stephen – student journal)

Enjoyment

Papert (1996) referred to the excitement that kids found in video games. Isaksen also identified the climate of playfulness/humour in a creative working environment. Below, Stephen captured both Papert and Isaksen in his post-test comment:

> "I really enjoyed the sensation of making a real working game"
>
> (Stephen – post test)

The freedom to choose added to the enjoyment of the task, as Joel noted:

> "I liked especially in the Gamemaker project having the ability to choose what game you want to do, so it didn't limit our ideas".
>
> (Joel – post-test)

The teacher journal noted that every time the boys undertook their task of creating and refining a game, the classroom buzz was one of excitement that you only hear when boys are totally engaged in their learning and participating in a collaborative learning adventure.

Self-Organisation

At the conclusion of the programming sessions, the boys wrote their reflective journals. One of the questions asked the boys to identify what they needed to do to next in terms of programming. Ultimately, those games that were enjoyed and admired most by the boys, as reflected in a popular vote, were those games that they identified in their comments as the most challenging. More than half of the responses specifically referred to the challenge of the game being the determining factor in their choice of favourite game.

The most popular games were produced by boys whose programs and reflections best demonstrated that they had thought through the structure and sequence of their game. Here are the words of the boys who overlaid the organisational dimension to enhance the creative dimension of their games:

> "Today we didn't make that many changes into our game directly, but we did set things up for next session."
>
> (Adam – student journal)

Joel provided an elegant summary of his group's organisation approach:

> "What we need to achieve:
> - ? New level
> - ? End screen
> - Check all properties and commands
> - Get Year Six to play game and ask for feedback
> - Check error messages
> - (If heaps of time left and is easy, make scoreboard)"
>
> (Joel – student journal)

Joel used the question mark to identify items that would require further assistance to solve. For an eleven year old, this was a fairly sophisticated analysis of the organisational imperatives of a problem-solving task.

However, not all of the challenges could be completed successfully. As Phillip noted in an interview:

> "We still hadn't solved the glitch problem so we tried making our good guys and bad guys smaller but that didn't work either. So, we looked up a tutorial on how to fix it and surprisingly that didn't work so we gave up.
>
> Today, I learnt how to make different sounds when you press any key thanks to Stephen."
>
> (Phillip – student interview)

Despite this apparent failure, the boys in the group still demonstrated the social element, the challenge, the enjoyment and moreover, despite their perceived failure, they chose to solve a different problem with the help of peers.

Transferability

One of the questions in the post-test asked the boys:

> "Do you think that learning basic programming skills in Gamemaker has helped you in problem solving? If so, how?"

Out of these four elements addressed previously, the boys identified that what had emerged from this activity had relevance elsewhere in their learning. Indeed, there was evidence from the boys themselves that the skills that they had picked up from this activity transferred to other elements of their school life:

> "Yes it has. It has taught me new ways to solve problems in and out of Gamemaker. I've actually used it in a Maths problem."
>
> (Joel – post-test)

"Solving problems on Gamemaker helped me a lot in Maths because usually I rush through my work but problem solving on Gamemaker helped me slow down."

(Phillip – post-test)

"Yes definitely it has made me more self reliant in problem solving and to think about problems more."

(Adam – post-test)

"Yes it has showed me that there are lots of different ways to solve one problem."

(Stephen – post-test)

"Yes because I have realised how important trial and error is."

(Douglas – post-test)

Conclusion

The creation of new ideas requires that we couple thinking strategies that are critical, systematic, and analytical with those that are creative, intuitive, divergent and lateral (Lavonen, Meisalo and Lattu, 2001). The work of Lavonen et al. embraced Cattell's (1967, summarised by Cherry, 2012) concepts of fluid and crystallized intelligence.

Fluid intelligence is defined as "the ability to perceive relationships independent of previous practice or instruction concerning those relationships". It involves being able to think or reason under novel conditions, conditions such as those that exist when the boys construct the solution to a problem in Gamemaker. Crystallised intelligence involves knowledge that comes from prior learning and past experiences. In partnership, these two dimensions of intelligence provide the tools for dealing with the spectrum of learning tasks that we undertake. (Lavonen, J.M., Meisalo, V.P., & Lattu, M., 2001)

The present study supports this contention that creative ideas, in the form of computer games, arise from a combination of innovative and imaginative approaches, collaborative exploration of ill-defined, complex and meaningful problems, together with a systematic and logical approach to a final outcome.

In the Gamemaker unit, the boys with the most creative games were the most organised. Creativity and logic needed to be combined for these boys to produce the most popular, challenging and innovative games. The starting point for the programming exercise was for the boys to think up ideas for a game. For the ideas to become useful, the boys needed to think of a list of what was required to bring the ideas to a desired outcome, do their own study to improve their learning and evaluate their work on their own. This formed a feedback loop, the same loop that underpins action research. Even in this immersion in creativity, the systems approach/action research approach was integral to the process, but it is important to note that it arose out of creativity – out of the ideas of the boys.

They discovered, without teacher direction, systems theory with learning loops that helped remodel and reshape their ideas into valuable outcomes.

The boys recognised that if they were not logical, the process did not work as well. Without this combination of imagination and logic, all they ended up with was an incomplete game with major programming flaws. By using a feedback loop, boys played around with their programming and often found solutions by themselves, which they could then share with others. In particular, the use of online help sites proved to be beneficial. Boys looked at the advice and remodelled their programming to include the necessary steps.

Looking at the experiences of the boys through their journaling, it appears that the Gamemaker activity brought the two different styles of intelligence together, perhaps in a form more powerful than many other learning activities. It allowed for learning from the teacher of how to undertake basic programming. The boys were then encouraged to learn from other sources about how to solve programming issues. However, the activity was open ended enough for boys to look back at their own games and evaluate their overall merit, perhaps after comparing them to a peer's work. By being able to bring their own ideas and those of others to what they already know, the process enabled problem-solving strategies to develop in boys, as well as embedding the creativity side to such thinking.

Attitudinal, cognitive and experiential factors are important elements of problem solving (Lavonen et al. op. cit.). In the Gamemaker activity, boys undertook tasks that they found engaging, motivating, and interesting; tasks that required them to push the boundaries of their current cognitive experiences, yet in a mutually supportive and non-judgmental environment. Arguably, the learning context for the boys in this study was authentic in that the tasks were ill-defined, complex, had multiple solutions, required self-direction and the identification of the resources necessary to complete the task, but were often made much easier through collaboration.

Providing the initial instruction in the use of the programming language in Gamemaker was important to streamline the development of the creative elements of the final games. It is interesting to speculate on what the boys might have achieved without this more formal introduction. The question of whether this formal introduction to gaming protocols produced the series of similar game styles observed in this study is not answered here. Typically slower learners may have experienced significant difficulties if they had been required to learn the programming language for themselves in addition to creating a viable final game.

While the teacher took on the role of tutor for boys experiencing difficulties, for the most part the boys resolved issues by working with other boys and with online tutorials accessed outside of class. The boys were sufficiently engaged with the task to spend significant periods of their own time searching for strategies that could be implemented in their programs.

One interesting finding emerging from this study was the extent to which students can adapt to a different learning environment.

Those boys who have struggled with more conventional classroom tasks were able to complete this project without having to risk being highlighted as 'slow learners' or boys who have difficulty persisting with a hard task. Indeed, four of the boys who struggled with other aspects of their learning were able to produce games that were highly regarded by others. Off-task behaviour that had been apparent in some other learning situations was never an issue when the class was immersed in Gamemaker activities.

This study began with the question, “How does the use of Gamemaker software foster the development of creative problem-solving skills in boys?”. The evidence here and in various reflective journals and video records supports the hypothesis that when boys construct their own computer games in a classroom that encourages risk taking, cooperative endeavour, competition and challenge, they do create new products. These products represent tangible evidence not only of boys' creativity, but also of boys constructing meaning from the interaction with the gaming software and with other boys. Without the gaming software, these elements of creativity and constructing meaning would not emerge.

Implications for Future Practice

Did the attributes and skills that the boys gained through this activity emerge anywhere else in their learning? The issue of transferability is one that can be difficult to see. It may be a tenuous link, but what I saw from some of the boys in their improved approach to problem solving, particularly in Mathematics later in the year, may well have been due to their experiences solving problems in Gamemaker. As mentioned in the previous section, many of the boys could identify and articulate how the Gamemaker experience improved their ability to solve problems in other areas of the curriculum. The recommendation I take from these comments is that I need to undertake the Gamemaker unit of work earlier in the year so that I can look for transferability over a greater period of time.

Contemporary software packages such a Minecraft offer similar (and perhaps more popular and 'relevant') options for good learning to that of Gamemaker. Minecraft includes child-initiated projects, engagement, challenging and open-ended tasks, multiple solutions, and significant opportunities for collaboration both within a specific game and in an online (multiplayer/developer) environment. Minecraft lends itself to a range of abilities as it requires no sophisticated programming knowledge but nevertheless requires higher order creative and critical thinking to produce scenarios of the highest calibre. As such, this is a possible area for further action research. Indeed, it could be worthwhile to compare the relative strengths of Gamemaker and Minecraft in terms of the benefits for boys in terms of fostering creative problem solving.

Reflection Statement

The major benefit for a teacher undertaking action research is that it forces you to critically analyse your own work for effectiveness, student engagement and the outcomes you wish to achieve. In addition, it allows for the discussion of unexpected outcomes – both positive and negative. The challenge for the future is to use the systems approach feedback loop essential to action research to further refine the Gamemaker unit of work. Perhaps the most rewarding section was almost the hardest, reflecting on the work of Vygotsky, Papert and on other research relating to the development of creativity. Trying to get the boys to reflect on their work in written form was initially a particularly tough task. Many of the boys didn't identify any problems that they encountered – even after I pointed them out! However, by modelling and sharing good examples, the boys became proficient at self reflection on their work. Hopefully, the boys will be able to transfer this skill to other areas of the curriculum.

Having undertaken this action research, I feel justified in pushing for this Gamemaker unit of study to be permanently included in the Year Five curriculum. The hurdle is trying to find enough time to teach the unit properly, whilst not neglecting other core subjects.

I was very fortunate to have a particularly helpful critical friend in Dr Peter Lewis. He was never too critical and often suggested previous research to read, which always proved beneficial. In addition, his help in discussing how the project should progress made me think very deeply on what it was I actually wanting the boys to achieve. I was also lucky to have another critical friend in Dr Peter Coutis, who helped me organise my research and findings in a far more logical structure. And finally, thank you to my supervisor Margot Long, whose advice was both constructive and sage. She could not have been more thoughtful in her counsel.

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Appendix A

Explanation of terms or Isaksen and Lauer's Nine Climate Dimensions for Creativity and Innovation

Several researchers have identified nine climate dimensions for creativity and innovation (Isaksen & Lauer, 2001; Isaksen et.al., 2001). These are:

- Challenge - the task is engaging and meaningful.
- Freedom - boys have autonomy and resources to make decisions about their learning.
- Trust/Openness - boys are open and frank with other boys and the teacher. There is mutual respect and support.
- Idea Time - boys have time to generate, explore, and develop programming ideas and produce quality products.
- Playfulness/Humour - the classroom is purposeful, easy-going, and is a fun place to be.
- Risk-Taking - boys can go out on a limb without fear of being criticised.
- Idea Support - innovative and/or different solutions are encouraged. Suggestions are not dismissed without due consideration and consultation.
- Debate - boys put different and perhaps competing ideas. These are constructively discussed.
- Conflict - boys and the teacher accept and deal with diversity. Power struggles are minimised and the emotional tension is low.

Appendix B

Gamemaker Unit Pre- and Post-Test

Computer Games and Problem Solving

Name: ______________________________

1. Name two or three of your favourite computer games
2. What do you like about each of these games?
3. What makes you want to play these games again and again?
4. Problem solving includes many different skills. How do you go about problem solving in a computer game?
5. If you have ever made your own computer game, did you have to use problem solving skills? If so, describe the situation.

Computer Games and Problem Solving

1. *(Only as Post-Test)*
   Do you think that learning basic programming skills in Gamemaker has helped you in problem solving? If so, how?
2. *(Only as Post-Test)*
   What did you enjoy about the Gamemaker rotations?
3. *(Only as Post-Test)*
   How could the Gamemaker rotations be improved?