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# Using an interactive whiteboard and a computer-programming tool to support the development of the key competencies in the New Zealand curriculum

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**Abstract**

*Does children's use of the software Scratch provide potential for the enhancement of key competencies as they work in pairs at the interactive whiteboard (IWB)? This article looks at how children using Scratch collaborated and managed their projects as they set about designing, constructing, testing and evaluating a game for others to play, a task that provided a sustained challenge over six weeks and beyond.*

*The findings showed that the key competencies of participating, contributing, and relating to others were enhanced by the collaborative use of Scratch at the IWB, and that creative and conceptual thinking processes were sustained. Children became increasingly adept at using Scratch, and some children, previously thought to have poor social skills, began to articulate their understandings to others. While a guiding and scaffolding role was evident in teachers' actions, close monitoring of group progress and direct input from teachers is required to keep the challenge high but achievable, and to extend children's knowledge and thinking as they use Scratch at the IWB.*

## Introduction

There is an expectation in New Zealand schools that children will be offered opportunities to explore information and communication technology (ICT) to open up new and different ways of learning through their curriculum experiences (Ministry of Education, 2007). It is contended that learners in the 21st century have different needs from those in prior generations, thus different expectations should be placed upon them (Hipkins, 2009).
Twenty-first century learners are expected to find out about and understand concepts, learn to problem-solve, work collaboratively and represent, negotiate, and communicate ideas in creative and critical ways (Ministry of Education, 2006). Therefore, it is anticipated that children in primary schools will learn to develop specific subject knowledge and "capabilities for living and lifelong learning." (Ministry of Education, 2007, p.12) The capabilities are designated as "key competencies" and include thinking, relating to others, participating and communicating, managing self and using language, symbols and texts (Ministry of Education, 2007). Key competencies are expected to better equip students to face challenges of the 21st century (Brough, 2008). This thrust is based on the premise that children need to be educated to function within a technology-saturated society (Mioduser, 2009). Perhaps these competencies can be developed in part, through the use of technology tools?

*The interactive whiteboard as a collaborative tool*

Warwick, Mercer, Kershner and Staarman (2010) noted that ICT tools can help children to design and develop representations, refine and interpret their thinking, and evoke dialogue in varied ways as a task is engaged in and reflected upon. They suggest that the interactive whiteboard has the potential to aid collective thinking and learning, and can become the focus for group collaborative work, providing children can and will support each other, understand the nature of what the task expects of them, and have a shared responsibility for the task itself.

This requires the teacher to orchestrate the learning environment and integrate the use of IWB features into a student-centred pedagogy (Harlow, Cowie & Heazlewood, 2010). An IWB enables the children and the teacher to access, and interact with, all the functions of a desktop computer (Murcia, 2010), but the benefit of the large screen is that it enables a space for problem solving collaboratively, since information can be easily shared and discussed in a public way (Wegerif & Dawes, 2004). Opportunities are available for learners to physically interact with the IWB itself, and it becomes a pedagogic space in which children can share their ideas and understandings with each other and the teacher.

*Scratch as a cognitive tool*

Scratch is a free graphical programming language (http://scratch.mit.edu/) that is designed to support and develop technological fluency (Resnick & Silverman, 2005). The software was created at the Massachusetts Institute of Technology's (MIT) Media Lab and has its developmental roots in the ideas and work of Seymour Papert (Papert, 1980; Harel & Papert, 1991) that led to the development of Logo and Technic Logo. Papert's ideas underpin the design of Scratch with one of its key aims being to provide "tinkerability" so that child programmers can put together, take apart, and recombine programming building blocks to build whatever they wish (Resnick, 2007).

The Scratch user interface is divided into three vertically divided areas. The left side of the screen contains graphic elements called blocks that are available under various categories such as Motion, Control, Looks, Sensing, etc. Each category of blocks is colour coded (e.g. motion blocks are dark blue) and blocks have particular shapes that allow them to be 'snapped' together with other blocks that are appropriately shaped.

On the right hand side of the Scratch interface is the Stage upon which are placed graphical elements called sprites. These sprites are then controlled by dragging blocks from the left hand area and dropping them into the central scripting (or programming) area (the third area) where they can be put together to form scripts (or stacks) that control the sprites and produce the actions and other effects desired by the programmer. The scripting area is intended for use like a physical desktop where you can move blocks around, assembling and disassembling stacks as you like, and you can even leave extra blocks or stacks lying around in case you need them later. The implied message is that it's OK to be a little messy and experimental, and tinkering is encouraged.

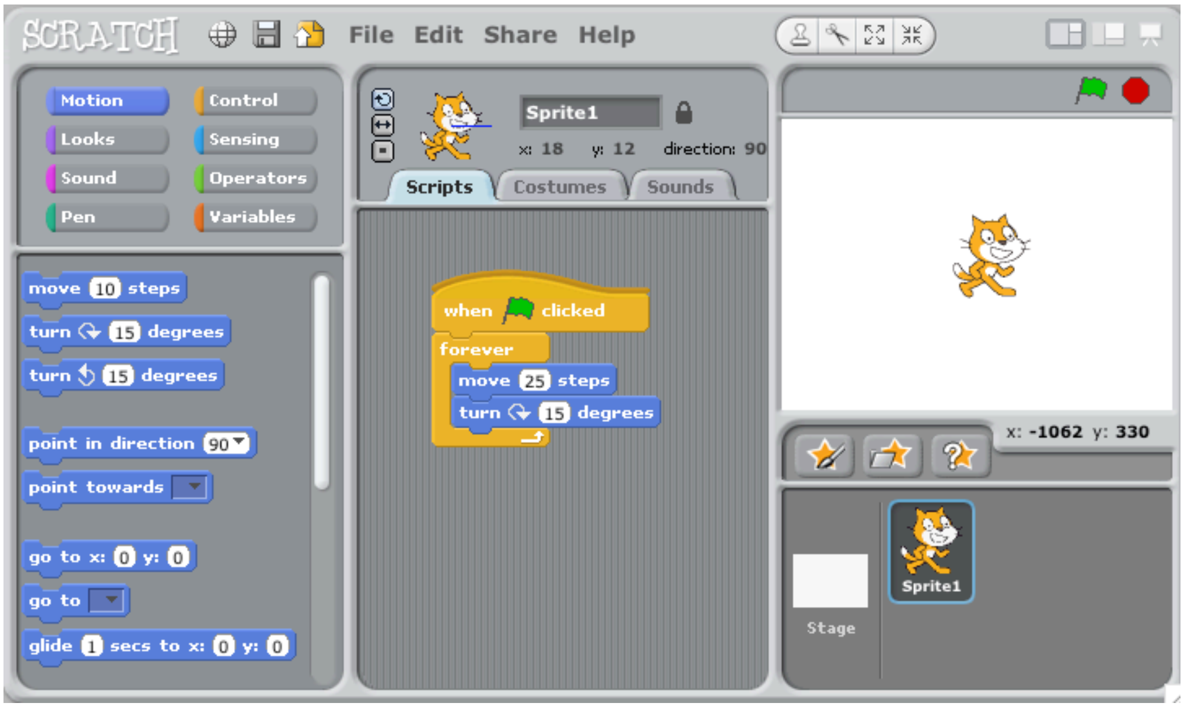

Figure 1: The Scratch user interface

A key feature of Scratch is that, unlike Logo and most programming languages that have their own text-based language and syntax that need to be learned and adhered to in order to create successful programs, Scratch uses drag-and-drop functionality that eliminates the need to write and remember code or syntax. Programming is done by physically manipulating blocks on screen and 'fatal' programming or syntax errors cannot happen, as the command blocks will not physically fit together unless they are logically and programmatically compatible. In this way, Scratch removes much of the frustration of learning to program, makes it quick and easy to have initial success and allows the child programmer to spend much more time on the logic and creative aspects of what they are trying to build. The program blocks in Scratch are capable of manipulating a variety of media and allow users to create their own interactive stories, animations, games, music, and art, and subsequently share their projects online if they wish. Scratch provides a playful learning environment that, although simple and easy to use, is capable of producing complex and sophisticated outcomes. It provides a context within which children can enjoy exploring and being creative with programming.

Although, like its predecessor, Logo, Scratch is designed to help young learners more easily access and utilise the practical and intellectual tools of programming, for most children learning to program is not the overt purpose of using Scratch. Rather, it is an engaging tool that allows them to design and build interactive multimedia projects. This type of software has been described as a 'cognitive technology tool' in that it responds to a user's commands, and makes their actions apparent (Zbiek, Heid, Blume & Dick, 2007). Others (e.g. Miller & Glover, 2006; Wall, Higgins & Smith, 2005) suggest that the multi-modal and kinaesthetic possibilities offered by this type of environment can deepen learning and promote metacognition. In this study, we set out to explore the potential of Scratch to promote the development of key competencies as children worked to design and build a game for others to play.

*Games-based learning and thinking*

There is increasing research into the benefits of playing computer games for learning. The theory of games-based learning posits that children can develop new understanding by playing computer games (Gee, 2003: Prensky 2002). Robertson (2009) describes how computer games can allow several curricular areas to be explored, and learning enriched by the context within which a game is set. A game can also be a context for supporting traditional curriculum expectations such as, for example, reinforcing basic arithmetic facts.
Less work has been done from the constructionist perspective on the more complex challenge of creating a game for others to play (Robertson & Good, 2008). In a feasibility study on the use of Neverwinter Nights software these authors found the most important benefit was the strong motivational effect the process had on the game creators, and the bolstering of self-esteem. Participants indicated that they were using the software at home

to share with their family and friends. Their conclusion was that it would be worth exploring how computer game authoring could be used in the classroom to raise literacy standards and children's enjoyment of story making activities.

After studying the role of play in the pedagogy of ICT, Morgan and Kennewell (2005) suggest that the removal of the possibility of failure (as far as possible) by adopting a play-based approach and allowing children to learn from each other may help to counteract negative, confrontational and aggressive behaviour. They found that a play environment was valuable as a basis for reflection, leading to the development of an understanding of concepts and processes.

Scratch designers maintain that programming involves the creation of external representations of an individual's problem-solving processes, and therefore provides opportunities to reflect on one's own thinking, and even to think about thinking itself (Resnick, et al., 2009, p.62). Robertson (2009) outlines the process of learning during game making and offers suggestions to make this work in the classroom. She suggests that teachers devote some time to playing around with the software first and find another teacher to work with. It is essential to let the children play, and the teacher should not try to be the expert but the lead learner. The teacher has to be prepared to be flexible about the timetable as game making is absorbing and time consuming. With these ideas in mind we worked in a local primary school to see if children's use of Scratch at the IWB could enhance any of the key competencies.

## Method

The study involved two teachers, three researchers and 60 Year 5/6 children in a New Zealand city school. At the outset, teachers and researchers spent a day together to explore some of the potential of the Scratch program and to work out the research protocols, intentions, and processes. Researchers visited two classrooms of nine- and ten-year-old children for a period of six weeks each during 2010. The data included video recording one group of children (normally in pairs) working at the IWB for a period of one hour, one day each week for six weeks. Glover, Miller, Averis and Door (2007) suggested that conceptualisation is helped by concurrent verbalisation of thoughts, so audio recordings were made of children working together and of their conversations with the researchers about what they were doing and thinking.

Meetings were held with the teachers at the start and at the end of the study. Contributions to a blog from teachers and researchers were collected; the blog was set up for the purpose of discussing the progress of the classroom work. The teachers determined the context for the task as it fitted with their classroom planning. Data were analysed through a socio-cultural lens, drawing on the notion of the role that tools play in the mediation of human activity (Vygotsky, 1978). Although the tools provide opportunities to create new kinds of activity, it is the use of those tools that helps to develop thinking in alternative ways (Wertsch, 1998). The analysis included editing the videos to critical incidences to look for evidence that could elucidate one of our research questions: How can the use of the IWB/Scratch enhance the development of the key competencies?

*The classroom settings*

The IWB and several computers in each classroom were regarded as tools to support learning and were not regarded as the preserve of the teacher. All children had access to these tools at times and had some knowledge of how they could be operated.

The children in both classes were split into smaller ability groups for daily mathematics instruction, and it was in these groups and within the scheduled formal mathematics time that the children worked on their game development. In both classrooms there was an expectation that children would be able to help each other, share resources and take responsibility for managing themselves.

*The task*

One of the aspects of the study was to see if the use of Scratch and the IWB had the potential to enhance mathematical thinking, so the task was set in the scheduled mathematics time, and had a focus on a medieval theme (the current social studies topic).

Each maths group was charged with making a game about some aspect of medieval life for other children to play.

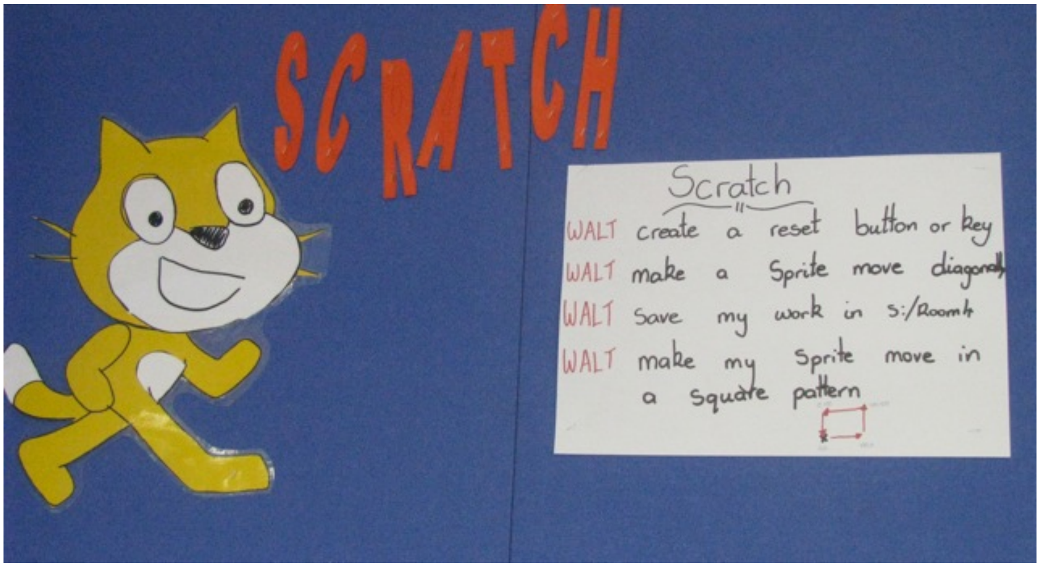


Figure 2: Introductory challenges

In both classrooms, after the teacher had introduced Scratch to the whole class (Figure 2), one maths group each day was able to work with the program for an hour, on one morning of the week, for the six-week period. Each day, a different pair of children from the designated group had sole use of the IWB for the development of a group game. The idea was that this work would be incremental, with each pair building on from the previous pairs' work. The rest of the group had the use of the computers in the classroom, where they could work alone or in pairs to create their own game. How children did this is shown in Figure 3 below.

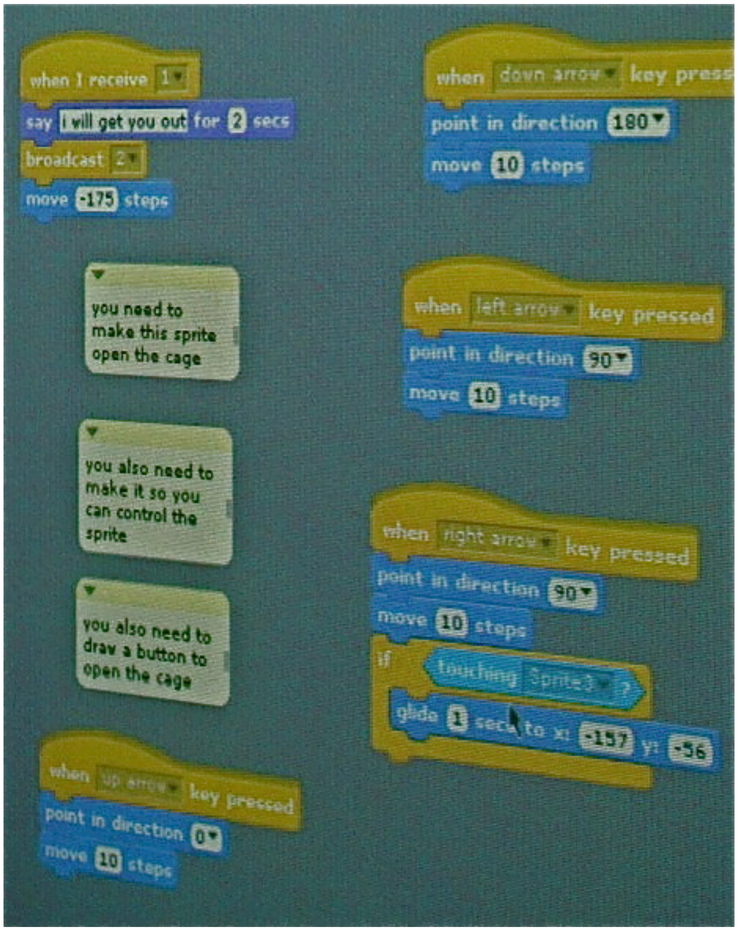


Figure 3: Shows a sample of the messages children left for the next pair of game developers. This is how the children working on the game could tell the next pair what needed to be done next.

The design brief specified a description of the game, who the characters would be, what the characters would and would not able to do, what the player(s) had to do, any obstacles or challenges in the game (there had to be at least one), and what levels of difficulty there would be for the player. In addition, each child or pair was to design his/her own game. These design briefs (group and individual/pair) were completed on paper and children were expected to refer to these as the days went by. After three weeks, teachers held a class-share session where a spokesperson from each group used the IWB to present the group game to the class. At the end of the six weeks, three children in one class prepared their own talks and presented their work to a school assembly. The games were to be assessed at the end of the period to see if all the conditions had been met: that is, that the game suited the intended purpose, and was easy and fun to play. The children were expected to save both the group and individual games each day they worked on them.

**Findings**

*Managing self – an authentic task, motivation to learn, resilience*

With Scratch as the medium, the children were engaged with something that had meaning for them – their own invented medieval world where personal characters and scenarios were designed and created to achieve a goal they had determined. The children's self-esteem and intrinsic wish to succeed was boosted by their involvement in the task. Scratch seemed to engage all of them, albeit at different levels. There were those who took a very active role in designing the group game and those who were more engaged in the actual programming for construction of the game. Some children were happy to work with a new partner every time they had a turn at the group game development sessions. Others were content to work alone on developing their own games and not be an active participant in the group activity at the IWB. Many of the children maintained their interest and focus on working with Scratch and the IWB for quite long periods of time (45 minutes or so) without teacher intervention. Each teacher reported that during any available time before or during other school activities, many children spent time on their personal projects or worked on the group game.

*Participating, contributing, and relating to others – classroom culture*

Children were observed to work at the IWB in a collaborative and co-operative way. They were all involved and it seemed to come naturally to them to take turns with handling the pen, ensuring that everyone had a turn to speak, and was involved in the decision making about their project. On reflection, however, this culture had been set up by one of the teachers who had said that, "One person has the pen and one person does the typing. You need to share your ideas." In the other classroom children were observed to notice when someone had not had a turn, and would ask, “David, do you want a turn?” and encourage the shy ones in the group to take a pen and go up to the IWB.

The decision-making about Scratch included which sprites to use, which variables needed changing, and what programming attributes they might try. An example of the dialogue as two Year 6 children worked on their group game may be seen in Figure 4:

| **Child** | **Dialogue** | **Processes** |
|---|---|---|
| C | He needs to think… | Thinking about what the *sprite* would be saying. |
| G | …how will I get out of this jungle? | Offers a *speech bubble* suggestion. |
| C | ‘How will I get out’. So once he’s done that he needs to be able to move. So I go to *control*. I need to go ‘If the right arrow …’ | Uses suggestion. Thinks about next action, and plans what *control* to use. |
| G | I think it’s in ‘*motion*’? | Offers a *control* suggestion. |
| C | No… *motion*, yes. He needs to *glide* one second. He is over there [in the cage]. He needs to be able to get across… | Uses suggestion, chooses a *motion*, and plans where the sprite will move to. |
| G | Don’t we need a bridge? | Spots a problem, suggests an addition to the *background*. |
| C | We will need a bridge, good thinking! So we need to go into pen…[starts to draw a bridge] | Commends thinking and plans how to make this happen by drawing. |

Figure 4: An example of children’s decision-making dialogue

In Figure 4, one child (C) was in charge of the IWB pen, and although he had more experience with the blocks, he accepted the suggestions of the other child (G) and commended him for having a good idea.

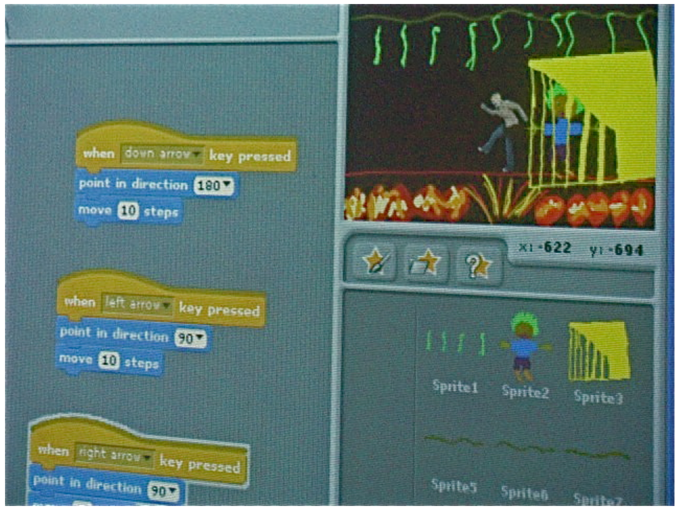


Figure 5: Getting the prisoner out of the cage. This image relates to the dialogue recorded in Figure 4 above and Figure 7 below.

The children connected with others who were also developing games, sometimes checking their scripts to help them to be more effective or efficient. Children were often rewarded by positive comments (more often whoops of joy!) from their peers and their teacher when they 'got something right' and the sprites operated the way they envisaged. If a problem emerged, then someone was usually able to make a useful suggestion about a possible way forward. Children were also able to get ideas from the Scratch cards available from the website (Figure 6):


Figure 6: Some Scratch cards available from the website

*Use of language, symbols and text – alternative ways of expression*

Working with Scratch and the IWB helped some children to demonstrate their abilities in ways that had hitherto been unavailable to them. One boy, for example, who exhibited autistic tendencies, demonstrated that he was now able to successfully contribute to a group because he was interested in the power of the programming tool. His involvement with other children in the class began to increase after he wrote a list of 15 things that could be done with Scratch (he had accomplished all these tasks himself) and pinned it to the wall above the computers. The tasks included; make a sprite disappear when a button is pressed; try to make your sprite dance by switching costumes; and make your character throw a ball at a target.

Another boy, who had been formally assessed as having ‘low’ mathematical ability, showed evidence of leadership skills as he established himself as one of the class Scratch programming experts who could be consulted for help. On one occasion, he demonstrated his knowledge of co-ordinates, and his understanding of that idea enabled him to teach others how to program sprites in certain ways. One very shy girl who initially was not very confident in class, came to realise that she could “do Scratch” when her personal game was admired by others, and she was asked to contribute to a presentation of work in Scratch to a school assembly. Her teacher remarked how she had become more involved and was making contributions to other class activities as well.

*Thinking revealed – unexpected results*

Most children were able to take advantage of the “low floor” (easy to get started) and “high ceiling” (could develop more sophisticated programming techniques and effects) embedded in Scratch (Resnick, et al., 2009). They demonstrated perseverance, were motivated to problem solve and responded positively to exploring Scratch in ways that were not usually evident in their regular classroom activities. The data shows that several children, rather unexpectedly, had the disposition to tackle conceptually new and difficult challenges within Scratch. The scores for some children in conventional tests were belied by their observed problem solving capabilities. The example in Figure 7 below is of two Year 6 children of average ability working on the group game:

| Child | Dialogue – to get prisoner out of cage and free to start the maze game | Thinking Process |
|---|---|---|
| T | We should make him [the rescuer] say, "I am going to get you out!" | Generates idea |
| G | So we need to broadcast. When I receive broadcast one…. [creates the script]. | Conceptualises |
| T | You want me to push restart now? The prisoner will say, "How will I get out?" and the rescuer will say, "I will get you out!" Then we'll make him move ten steps. | Uses idea to inform action and thinks forward |
| G | Then when he touches the cage, it will be destroyed? | Generates idea |
| T | Why don't we just like make it to go up and there's like a button outside that when he touches it, there will be a chain out there and it will lift up. | Suggests alternative solution |
| G | He can just pull it up. | Builds on idea |
| G | Now try it… why does he walk backwards? Try it again. Yes, he walks backwards! | Observes relationship between concepts |
| T | Maybe we have to take that [a control] out? Tries it again. | Conceptualises |
| G | Go sprite 3 and he uses sensing. So when he touches it, if touching sprite 14 (cage) when green flag if touching sprite 14… how do we make it go up? I know what we could do. We could import a script from something else – like the jetpack girl – she already has a script that makes her go up. We get this [he finds a script] | Expresses knowledge with relevant concepts / Draws on personal knowledge |
| T | We could use x and y make it move to the coordinates we set. | Suggests alternative solution |
| G | There, that will be close enough, we need to repeat it twice | Uses idea to inform action and thinks forward |

Figure 7: Shows an example of problem solving dialogue

In Figure 7, the children think of and try out several ways to lift the cage, exhibiting creative and conceptual thinking processes, but in the end a child (C) with less ability (according to standardised test results) comes up with the solution on another day (Figure 8):

| | | |
|---|---|---|
| C | How we do it is when that [rescuer] touches the button it *broadcasts one* and when the gate [sprite 14] receives *broadcast one* it lifts up. | Details action that lifts cage |

Figure 8: Shows an example of how the problem was solved

Some children had downloaded Scratch to their home computers and were bringing to class evidence of new ideas they had tried at home. Some children developed a fluency in reading and understanding scripts quickly and offered suggestions for script improvement to others both publicly and privately.

Scratch offered each child complex layers of opportunities for investigation. They could choose, for example, to include measurement and geometric concepts such as length, co-ordinates, and angles to develop the desired movements and effects they wished to portray. It was the choice of tools embedded in Scratch that led to differentiated pathways and problems. We observed that several children displayed resilience (Johnston-Wilder & Lee, 2010) when working with Scratch, as they sought to explore and deepen their understanding of how to resolve issues that arose. When the software/system went down a couple of times while the children were working, they were quite unfazed and simply set about restarting in a no-fuss matter-of-fact way. They did not need, nor ask for, help to do this. If the system crashed and the children had not recently saved the last iteration of their programming they set about recreating it.

During the class-share sessions, when each group presented their game to the class, children from other groups asked questions about the game being presented and offered suggestions from their own experiences. This was an excellent way for the teacher to gather formative assessment data and offer guidance and support to each group. In Figure 9, the teacher asked one pair from a group to explain what they had worked on that week, knowing they had had some difficulties:

| Child | Dialogue |
|---|---|
| A | We tried to work out how to get the witch to follow the [computer] mouse. |
| Teacher | Does it work now? Make it full screen and show us – that's right, you had trouble making the witch to follow didn't you? How do you move that character? |
| B | Last week we tried to move the witch to follow Harry because Harry has to go with these two. We are going to delete the background and make a different background – it will not be a dark colour – [it will be] a maze. |
| G [not in the group] | I know how to make the witch follow Harry – you just say 'forever' because when you press space she moves 10 steps once. She will follow Harry then [A and B start to set this script up]. |
| B | Is that in *control*? |
| G | Yes, you don't have to hold it; you just need to press it. |
| Teacher | What are you doing now? Explain it to us. |
| B | Now she's trying to move Harry. |
| G | When you're moving Harry you don't want 'forever' because then you just keep moving it forever and you don't want that. |
| B | True. |

Figure 9: An example of a class sharing session

In Figure 9, the pair working on the game explain what they want to do and someone from the class (G) offers an idea (with a caution) to make this happen. They start to set up this action shown in (Figure 10) below:


Figure 10: Follow mouse control

**Discussion**

Teachers noticed that certain children showed increased self-esteem from being involved in the group game. Bandura (1997) proposed that a belief in one's capability to organise and execute the courses of action required to produce given attainments was central to the mechanism of personal agency. These children showed that they believed they could undertake the task and that what they contributed would have the desired effect and be used by other children – a sense of self-efficacy, which was not evident when they were involved in normal classroom activities.

*ICT /IWB – the potential for key competency development*

The characteristics of Scratch and the IWB afforded children particular learning possibilities, particularly with reference to the key competencies. The learning context was influenced by the physical, cognitive, and cultural contexts within which they were set. Working at the desktop computers provided a private or paired space for the children to explore their ideas, which they subsequently brought to the group game when it was their turn at the IWB. The large screen of the IWB made sharing possible and generated many of the benefits of group work. There was evidence that the children were exploring the narrative of programming (Robertson & Good, 2008) in Scratch. In doing so, they expanded their vocabularies in ways that would not have been possible without it. The language expansion, in turn, helped to focus the dialogue when children developed their game on the IWB, used the IWB to demonstrate their thinking to others, or participated in the class-share sessions.

The children in this study used the IWB space to co-construct knowledge (Somekh & Haldane, 2007) as they participated in socially shared cognition (Hennessy, Deaney, Ruthven, & Winterbottom, 2007), adding their contributions to the class conversations in the class-share sessions. The IWB was pivotal in supporting the development of task-related talk, where reasoning and justifying was supported by the artefacts and programs that were being created. The Scratch software and the IWB helped participants to construct and/or co-construct dynamic representations of their original plans. There was a definite sense of co-ownership within the class and respect for what other children had contributed.

*The role of the teacher*

The research indicated that regular teacher intervention and monitoring of children's progress is required to support deeper learning, (Warwick, et al., 2010). The development of the group game was sometimes slow – on some days the subsequent pair of game designers were not briefed about the previous day's progress made by the programmers. Their tendency was to delete earlier work because they were either not aware of what had been programmed, or did not recognise it as being progress according to their conception of the design brief.

When the design brief was not referred to for a period, a program decision that was not going to lead to success would have to be changed back to what had gone before. Without some sort of group feedback, process, or written description, the game creation did not always develop as far as it might have. Direct teacher input enhanced the children's progress with game development, with the development of the key competency of thinking skills, and metacognitive skills.

**Conclusion**

When children are design partners the experience can be an intensively engaging way for them to practice their creative and conceptual thinking skills. With scaffolding by the teacher this can also lead to the development of metacognitive thinking skills, especially when children work in groups to develop their own game. The teachers had orchestrated the learning environment to ensure that the use of Scratch on the IWB provided opportunities for collaboration within groups that may normally not have chosen to work together, so there was a need for children to be able to explain their thinking and reflect on other's thinking to make decisions for the way ahead. Students who were adjudged to have differing capabilities were able to come together to work on problems with evident success.
The technical features of both the IWB and Scratch, such as the ability to combine images, text and sound, and to create and control sprites, seemed to contribute to the processing of information in very accessible ways for a diverse range of learners (Carter, 2002; Sessoms, 2007). Scratch proved to be a useful cognitive tool to reveal children's thinking and to challenge them to explore this rewarding yet sometimes frustrating environment. The IWB allowed opportunities for the teachers to informally assess the children's development of the key competencies in action. Their emerging mathematical understanding and technological thinking became more readily accessible, as children peeled back more layers of their thinking for teachers and others to see. Scratch enhanced the children's perceptions of their problem solving abilities by allowing them to use visual cues and deductive reasoning. Scratch and the IWB offered different but intersecting affordances to create powerful public and private thinking spaces, and an alternative way for children to learn and relate to others. The teachers were impressed by the positive *social* changes they observed in some children, and they attributed these changes to their exploration of Scratch.

This study showed that Scratch and the IWB not only had the potential to enhance key competencies but also to uncover previously hidden qualities, such as self-efficacy and leadership skills in some children. This finding raises questions about conventional assessments being used to judge children's capabilities. The children were implicitly exploring mathematics ideas, displaying their knowledge of medieval times, and using technological processes of planning and generating and testing their designs. Children were also benefiting from collaborating and even the most timid child participated in, or 'basked in reflected glory' as the group game was presented. They had begun to evaluate each other's games early on in the design process, and came to this process from an informed game designer and user perspective. If learners in the 21st century have different needs to those in prior generations, perhaps different learning environments and assessment criteria need to be employed.

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