Making Connections Between Simulated and "Real" Worlds: Young Children Interpreting Computer Representations

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This paper explores the way in which six young children (6 year olds) interpreted and made sense of screen-based images on a computer. The participants were asked to interpret a screen image as they were introduced to a construction-based software program. Some of the children could not make links between the screen images and the intended three-dimensional (3D) representations. The participants who were able to make these connections tended to relate the screen objects to life-like images or used analogies to describe concepts associated with depth perception, perspective and orientation.

Recent innovations in Information Communication Technology (ICT) have placed an increasing emphasis on video technology as animation and three-dimensional (3D) simulations become more "lifelike." In this information age students are required to process and interpret pictures and images with increasing regularity. Since most aspects of mathematics are image-based (Wheatley & Brown, 1997) it is important to evaluate the effectiveness of new technologies on students' mathematical development as they spend increasing amounts of time on computers (and playing computer games).

It is evident that these technologies are playing an influential role in school-based curricula, information retrieval, communication and home entertainment. As the technology becomes more sophisticated, greater demands will be placed on the user's ability to interpret information and construct understandings from the visual displays generated from the computer-based environments. Since various types of imagery play a significant role in the learning of school mathematics (Presmeg, 1995) we would expect that such "developments" might have an impact on the way in which mathematics is delivered in the future. To date, most research associated with way students interpret visual stimulus, whilst engaged in computer-based activities, has been restricted to mathematical understandings associated with 2D representations. Moreover, these studies have not involved young children who are establishing foundation understandings of 2D and 3D space. Since many young children are being exposed to—and are motivated to play with—computer-based environments on a regular basis, more attention needs to be focused on the impact such technologies have on these students' learning.

There has been an extensive body of literature that highlights the benefits computer-based activities have on children's problem-solving skills (Betz, 1995-96), cognitive development (Fatouros, 1995) and creative thinking (Rieber, Smith & Noah, 1998). Other researchers have argued that computer games improve spatial visualisation (McGlurg, 1992) and mathematical reasoning (Stone & Stone, 1998). As a result of the changing habits of children's leisure and entertainment preferences, considerable attention has also been devoted to the type of skills that are developed by playing computer games. Greenfield (1984), for example, proposed that the use of computer games promoted hand-eye coordination and spatial skills.

Not surprisingly, Amory, Naicker, Vincent and Adams (1999) found that students preferred to play with 3-D adventure games that required the use of visualisation and

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challenged the user to employ a range of problem-solving skills. Such games involve 3D-like representations of background and foreground scenes with the user manipulating keyboard commands or other peripherals to navigate a character through scenes that are becoming increasingly lifelike. We could speculate that current trends in advertising could influence young children to play entertainment games more than educational games in the future. Today, popular television shows and movies are closely linked to entertainment games (eg., the Pokemon cartoon series is linked to Nintendo games while the latest Star Wars movie has software programs that simulate battle scenes from Episode 1).

Even with today's technology, which may be obsolete within two years, the user is able to move a character with precision in a simulated environment that is quite detailed. These images have structure, depth, perspective and flow seamlessly from one scene to another. We could hypothesise that some of the realistic flight-simulations developed for the training of pilots will be available to the general public (and will be inexpensive) within a few short years. As these developments become available there will be a need to monitor the extent to which these technologies influence the user's spatial development. Since young children are becoming increasingly exposed to simulated environments that require the interpretation of visual displays—more research is required in this area. At present, we are trying to fit new technologies to existing curricula rather than reconceptualizing curricula with the addition of technology.

Most studies that have attempted to gain insights into the way in which users engage in ICT contexts have been with high-school students or adults (Lowrie, in press). Few studies have been conducted with young children who are developing foundation spatial skills. One study that did involve young children (Lowrie, 1998) revealed that some students had difficulty relating the screen-based representations to real contexts. These students were not able to interpret the cues that provided information about the pictorial depth of the image and consequently could not go beyond 2D interpretations on the screen. This study extends our understanding of how young children make sense of 3D-like images in computer-based environments that require a high degree of visual processing.

Method

The Participants

Six students (6 year olds) were selected to participate in a problem-solving task that was intended to monitor their spatial and visual understandings as they completed an activity that required the interpretation of 3D-like representations on a computer screen. The investigation took place in a primary school in a large rural city in New South Wales

The Activity

The activity required the participants to interpret the template from a Lego construction program (Lego Group, 1998) titled *The Knight's Kingdom.* For approximately 20 minutes each participant was able to move building blocks onto a background and construct designs of their choice. The children were encouraged to click on icons (including buttons that could rotate blocks, change the orientation constructions, change perspective, move between close-up and wide-angle views, and change the colour of blocks). The present study is concerned with the manner in which the students made sense of the screen template and not their success in constructing models. At all times the children were encouraged to verbalise their thinking as they attempted to understand how to move through the program and construct models. The author took the view that the children should learn to use the program by promoting guided discovery and modelling through active inquiry.

Figure 1. A representation of the screen image encountered at the beginning of the problem-solving activity

This screen image was quite dynamic in the sense that an object could be manipulated in a number of ways that provided the user with a 360 degree view of the scene. The opportunities for *active play* allowed the participants to gain an understanding of how background scenes and objects were represented. It also allowed the participants the opportunity to "play" first and to experiment with different screen views and construction options in a supportive manner. The instructional component of the session was interactive in the sense that the students were encouraged to ask questions about the program's features and build their own models using the construction facilities of the program. This is in line with Lesh's (2000) notion of *representational fluency* which encourages the user to develop increasingly powerful conceptual understandings by adapting (refining, revising, extending, integrating and differentiating) existing ideas and schemes. Although the interviews were relatively open-ended in nature, questions were posed in order to monitor the students' understandings of depth perception and the structure of 2D-3D shape. Consequently, the major focus of the study was to determine the extent the students were able to interpret screen-based images and relate these images to objects in their environment.

Results

The children's interpretations of the screen-based representation were quite diverse. Three of the participants had considerable difficulty in recognising that the images had depth and were intended to represent a life-like scene. The children had difficulty interpreting depth cues on the screen and tended to recognise the objects as 2D shapes. By contrast, the other three participants were able to relate the objects to life-like images and relate the images to personal lived experiences. These children had little trouble recognising that the images represented 3D objects.

Difficulties in Interpreting Images.

Three of the six children involved in this activity found it difficult to make links between the screen images and the intended representations. When initially questioned about the screen representation presented in Figure 1 Carmel was unable to interpret that the background images represented buildings. When asked to describe what these objects were she responded, "they are [pointing to the objects] shapes. Some are rectangles and some are pointy triangles." She went on to comment "some of the shapes look like they are floating in the air." Even when Carmel was encouraged to examine other parts of the screen (for example, the Lego base that represented the ground) she did not appreciate that the shapes represented buildings. Carmel appeared to be viewing all objects and images without perspective or depth and thus only "viewing" the screen in two dimensions.

Carmel was the only student who was unable to recognise that the background objects were buildings in a city. Neil immediately identified these background images as a cityscape that had "some buildings taller than others." Neil was able to identify the ground and the sky and also recognised that it would be possible to build other structures in front of the buildings. Nevertheless, he was not able to justify why the buildings appeared to be so small.

> If I build something in front of these buildings they will go to the top [of the screen] and will be bigger than these buildings [pointing to the background]. (Neil)

With the exception of Carmel, all of the other children interviewed were able to reason that the buildings appeared to be small because they were so far away. Neil, however, was unable to consider depth or notions of diminishing line in his reasoning. When Neil began to explore the functions of the program he used the mouse to hit the arrow keys. These keys allowed the user to view objects from a number of perspectives. The students were particularly fascinated with the "up" and "down" arrow as they allowed the user to view buildings from varying heights. Neil appeared to become quite confused when using this particular function. He commented that:

> Everything [the buildings] changes shape. If I click here [the down arrow] it becomes high but if I hit here [the up arrow] it becomes so small. The more I click the smaller it comes. (Neil)

He did not seem to appreciate that the view and not the objects were changing.

The other student in this cohort who struggled to make sense of the images presented on the screen was Sandy. Sandy was not able to reason that the buildings could possibly be a considerable distance away. Like Neil, Sandy had difficulty in appreciating the conventions that take the flatness away from the computer screen. In another situation, she was encouraged to click on the rotation button and comment on what happened. The screen view could be rotated 30^0 clockwise or counter-clockwise with one "click" of this icon. She too seemed to think that the objects were changing rather than the manner in which they were viewed. After some time using this function she commented, "Now I see what it does—It lets you walk around the building." Interestingly, this interpretation did not require Sandy to interpret any depth perception—it involved the recognition that the particular object remained the same despite the fact that it looked different from various elevations.

Sophisticated Interpretations of Images.

The other three students who engaged in this activity immediately recognised that the background images represented buildings from a cityscape. They were also able to make judgements about the size of the buildings and why they appeared to be smaller than constructions they were creating. Both Rachael and Carl were able to articulate why the buildings looked like they did.

> You can only see the front of the buildings [because] they are so far away. They look small but they are probably very tall. If you got closer you would be able to see some parts of the sides [of the buildings]. It's like when you draw a picture you have to be careful about how tall you draw things. (Rachael)

> It's like drawing a picture. This is the front of the picture taken from above the ground. If you drew it from the side it would look different. (Carl)

It seems to be the case that Rachael is indicating that the template is in perspective and has taken for granted some of the assumed conventions that are required to interpret links between 2D and 3D representations. Interestingly, Rachael was quite anxious to test her theory and soon clicked on one of the icon buttons that enabled her to view the screen in a more interactive manner. Similarly, Carl wanted to see if you could see what the buildings would look like from side on. Both of these children recognised that the background scene represented a life-like scene and were anxious to explore the "world." Interestingly, these two children scored highly on the spatial ability measure and commented that they had played with Lego Blocks at home.

Within a short time Rachael was able to achieve "close-up" and "far-away" views of the cityscape by moving the mouse and using the appropriate function keys. She commented that:

> The building looked tall when you get up close. They do not get bigger even though they look big now [as she moved to a close-up view]. It's like real life. If you get close to a tall building and look up it looks really high but smaller from a long way off. (Rachael)

This response indicated that Rachael was developing an understanding of perspective. She appreciated that the screen images resembled life-like images by using directional functions from the program to explain her reasoning.

Samual also used these functions to explain his reasoning about the position of objects on the screen. He used analogies to describe the changing images of the background scene.

> When you go up it is like flying in a helicopter. You get to look down from in the sky like you are a bird. (Samual)

Samual enjoyed moving between the different screen elevations available in the program (different bird's-eye and front-view elevations). He reasoned, "things look different from far away and close up" and was quite motivated to test the limits of the program. For example, he wanted to see how high he would be able to go.

> If I can go high enough everything look(s) really small. They would look like ants...but really the just look smaller because you are so far away. (Samual)

It was evident that he was able to appreciate that the screen representations were dynamic in nature. By contrast, Neil had become confused when attempting to use the directional arrows on the screen. He had assumed that he was modifying the structure of his design because the image on the screen continually changed. The children who were able to relate the screen representations to life-like experiences were more successful in addressing concepts associated with perspective and orientation. Samual's analogies that were related to helicopters, birds and ants articulated a high level of spatial reasoning.

Conclusion

Generally, the students who participated in the activity were able to interpret at least some of the spatial and depth cues embedded in the screen image. Only one student was unable to recognise that the background scene represented a cityscape. Nevertheless, it needs to be recognised that three of the six children had difficulty providing any detail about the spatial orientation of the background scene. It may be the case that the students' familiarity of using Lego Blocks or other concrete manipulatives helped them to decipher spatial information more easily than those students who had difficulty interpreting the screen images. Another possibility is that these children had been exposed to computer or entertainment games that required the spatial interpretation of information on a more regular basis. It was evident that some of the children were able to perceive and interpret the screen images more easily than others. These findings are consistent with earlier studies that examined the way in which photographs are perceived. Serpell (1976) argued that particular depth cues needed to be addressed and the absence of others ignored when viewing both drawings and photographs. Serpell argued that it is only a western convention that teaches us to suspend the information that indicates flatness, and focus our attention on weaker pictorial depth cues (Presmeg, 1985). Such conventions take time to develop and need to be adjusted regularly when attempting to perceive images represented on computer screens. It could be argued that at least two of the children described in this study were unable to perceive the cues that provided information about the pictorial depth of the image—and that these children had not be challenged to consider such representations adequately in the past. In other words, they had not been specifically taught these conventions or had not been exposed to situations that allowed them to construct ideas about links between 2D and 3D representations.

The present study has revealed that some young children are unable to make connections between familiar real-life objects and the way in which these objects are represented on a computer screen. At this point in their physical and cognitive development they cannot appreciate that 3D objects need to be represented in a particular 2D form in order to look "3D in nature." Moreover, these students' understanding of diminishing line and depth perception have not been sufficiently developed to interpret depth cues.

Importantly, the children who were able to interpret images and relationships between objects within the screen environment often used specific function keys on the program (including arrow keys to project close-up or wide-angle perspectives) in order to describe or reinforce their reasoning. These facilities provided opportunities for the children to explain relatively sophisticated concepts associated with direction, position and perspective. On the other hand, these program function keys confused the children who were having difficulty interpreting the screen images. It seemed to be the case that these children were unable to appreciate that the objects had not changed but rather the perspective from which the objects were viewed. Consequently, the function keys either supported or hindered the participants depending on their capacity to interpret the simulated computer environment.

The participants who were able to make connections between 2D and 3D space also used analogies associated with familiar real-life experiences to describe highly visual and spatial arrangements. These analogies and concrete life-like representations helped the children make sense of these relatively unfamiliar screen environments. These findings further support the notion that young children need to develop and establish connections in the 3D world before effectively making connections across simulated screen environments.

Implications

From a teaching and learning perspective a number of implications can be drawn from the present study. First, screen-based representations of "real" objects are not easily interpreted by young children. Although the graphic images displayed through computers are becoming increasingly detailed and life-like, students with emerging concepts of depth perception cannot always make the connections between screen and 3D worlds. The explicit teaching of 2D and 3D concepts should be developed concurrently so that children are provided with opportunities to make connections between 2D and 3D space. For example, encouraging children to consider the restrictions involved in interpreting photographs and identifying cues that limit depth perception could be introduced from the early years of school—and may have direct links to limitations involved in interpreting images displayed on computer screens.

Second, construction-based computer programs provide opportunities for children to view and manipulate 2D and 3D objects with flexibility and precision. Moreover, these programs allow the user to change the perspective and orientation of objects with ease. Foundation spatial concepts can be enhanced in such environments. Finally, it seems advantageous to relate students' emerging development of perspective and elevation concepts to analogies in life-like contexts. Although teachers often use terms like "birds-eye view" to explain different viewpoints, relevant comparisons should be encouraged as new concepts are introduced.

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