Scaffolding and Problem Posing: Supporting Student Engagement in a Microworlds Environment

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This paper presents an account of a classroom teacher's actions with students when using LOGO. The paper focuses on a pedagogical approach aimed at engaging students in transdisciplinary tasks. Using the LOGO environment as a teaching tool, students were engaged in a task where the teacher's role was to scaffold students with 'nearly-enough' information for them to continue with the task. Problem posing and scaffolding were central to the teaching approaches adopted by the teacher.

When using ICTs in the classroom to support numeracy learning, the teacher can take a number of roles. From my perspective, I value and implement two teaching approaches – scaffolding and problem posing. I find that these create learning environments where students are encouraged to move beyond their comfort zone and into deeper learning without me appearing to be in control. This allows students to feel an ownership of their learning. I draw from Vygotsky and constructivist writers (Bruner, 1989; Jaworski, 1990) to see that scaffolding is an approach where support is given to students in order that they are pushed and challenged in their learning. Masters and Yelland (2002) support this approach in the use of ICTs in classrooms. I also see it as important that students have a sense of control over what they need to learn. This is particularly the case when using ICTs as there is considerable diversity in students' knowledge and skills. As such, problem posing becomes important since students are able to pose problems that they need to solve which may be very different depending on their pre-existing knowledges. There is an existing body of research that validates this approach (English, 1996, 1998; Stoyanova, 2000).

In this paper, I present a personal account of my teaching when working with students using Microworlds, and how through problem posing and scaffolding, I seek to foster an environment were students are actively involved in their learning and where deep learning is central to my objectives.

Background and Task

The classroom is a multi-age setting with fifty-six ten to thirteen-year-olds in a senior primary class (Yr 5-7). It is a team teaching space. The students had access to fifteen computers so that each pair could use the same computer for the duration of the task. One half of the double teaching space was arranged so that as students worked at their computers they could see a central screen on which the students and I would demonstrate using a data projector.

The task described here was for the students to construct a dynamic model of the solar system using the Microworlds program. The culminating activity was for them to present their models at an exhibition at the end of the semester, thus setting a tangible outcome for them. For the Solar System task, students were asked to construct a linear model so that, with one click, the turtle (disguised as a spacecraft) would move from the centre of the sun and proceed to the outer planets, stopping to draw each of the planets using two scales: one for planet size, and another for distance from the sun. The task would require students to build knowledge of the LOGO language through a series of smaller programming tasks. Students were asked to do all of the programming before adding the effects afforded by the Microworlds drawing centre and other graphic and multimedia enhancement tools.

Scaffolding Knowledge: The Need to "Nest" Knowledge and Skills

Students were given a two-week period to complete the solar system model. During the whole two-week period each pair was able to access their computer for ten to twelve hours. Prior to this they spent seven weeks working through a series of mini projects that were designed to build the prerequisite conceptual knowledge and procedural expertise necessary for the successful completion of the solar system model. Each mini-task had the same operational structure as the major task. That is, the task had a clearly articulated product, and the students were responsible for the process. Each mini-task developed an understanding of mathematical concepts as well as LOGO programming skills. As a suite of tasks, the mini-tasks provided a movement from the less complex to the more complex in terms of conceptual content and Logo skills. In both conceptual and procedural terms, the mini-tasks were 'nested' within the major solar system project. Ownership of learning required engagement with tasks, and continued engagement was dependent on frequent opportunities for success.

The first two mini-tasks involved comparing the size of the Sun and the planets. The activities dealt with conceptual items such as scale and features of circles including diameter radius circumference and pi. The students were required to create scale drawings of the Earth on the classroom floor using chalk and a blackboard compass, and a 'drawing' of the Sun at the same scale using a line marker on the oval.

'Visit the Sun', mini-task three, was the first activity involving Microworlds. It was simple: program the turtle to move from Earth (a blue circle in the top left of the screen) to the Sun (a yellow circle in the top right of the screen) where the turtle would turn around and return stopping on Earth. I asked: "Who would like to have a go?", and of course every student did. Enthusiasm was high. However, as most students finished drawing and filling the two circles using the drawing tools, the atmosphere changed from one of fearless adventuring to hesitating beguilement. Just how did one make the turtle move? Phantom-like, I visited a few pairs and suggested, just loudly enough so that the neighbouring pair would hear, the forward (fd) command. In response to student requests for the appropriate number of turtle steps to travel, I suggested a trial and error method as I breezed across the room to another pair. And so, with careful "seeding" from me, the buzz of problem solving proceeded with students totally engaged with the task sharing ideas within and across pairs, and experiencing their first taste of success with Logo programming.

Applying Pedagogical Heat

To facilitate numeracy learning, I needed to make some pedagogical moves that went beyond simple exposition followed by student practice. I needed to ensure students were appropriately challenged, that they had clear guidelines, that they had enough time for genuine exploration, that they received appropriate support when they needed it, and that they enjoyed success, frequently. I maintain that these pedagogical moves are critical for successful numeracy learning.

The students were given parameters of what their solar system model should look like. The criteria for the model were clearly articulated, and posted as a chart for student reference. The moves students needed to make to produce the model were less clearly defined, however. Students were given responsibility for working out how to produce the final product. The subsequent control of the process enabled students to claim ownership of the enterprise.

Ownership and control are only possible with careful teacher facilitation. I needed to provide just the right amount of support to help students to the next step, and then the support needed to be carefully withdrawn. Enkenberg (1994) refers to this process as 'scaffolding and fading'. In the solar system task, such scaffolding and fading applied to the whole group as well as individual pairs. At many points throughout the task, my intervention was necessary to guide the whole group to the next step. Wherever possible I encouraged students to share a successful strategy that a pair may have used as a way of providing the support necessary.

I used the process of problem posing and seeding often across the seven mini-tasks and the solar system task. It was very important to work this way because the success the students experienced was far richer when they had "solved the problem themselves". They had a level of ownership that teacher exposition as opposed to seeding, could not have provided. Obviously, students' knowledge increased over time, but there was always something new to learn in each of the tasks.

Problem posing and seeding is not the end of the pedagogical story, rather it is the beginning. In the 'Visit the Sun' activity many students were using the command centre to program in a 'command-at-time' manner, while receiving instant feedback from the run window. Some students were attempting to estimate or calculate the total number of steps to write one command to take them all the way to the sun. Other students had managed the turn and had returned to Earth. They were looking for ways to make their programming look more elegant and perform more efficiently. Johnson (2000) has discussed elegance and efficiency in terms of students' higher-level outcomes. Other students had not moved beyond drawing (and redrawing) the circles with the graphic tools. Needless to say, these students were nearing frustration and required a different kind of scaffolding. This range of approaches to problem solving was evident in all the mini-tasks, and necessitated the next stage of the scaffolding, which involved stopping all students and moving them away from their computers to a space in front of the data projector. This gathering would usually occur at fifteen to twenty-minute intervals. The bulk of these ten-minute sessions were spent celebrating successful programs, which also acted as models for those students who needed the inspiration.

An important part of these short whole-group sessions was to finish with a challenge that would "raise the bar". In demonstrating with the computer, I used multiple representations, where I would work at the front of the class using traditional tools (chalk, models, etc) and have students working on a computer connected to a data projector that displayed their work. I see this as important since all students could make multiple connections between the various representations and processes being modelled. I always adopted the strategy of students using the ICTs, as I believe it exemplifies student-centred learning. In the case of 'Visit the Sun' I modelled on the board how the process worked, while students presented a short demonstration using the data projector on how to program colours, showing how a turtle could be instructed to turn around when it passed over a particular colour. Students were then challenged to make their "Visit the Sun" programs more efficient using programmed colours. In a similar session during the mini-task "Control Freak", students modelled how to program buttons to make their programs more efficient; during the mini-task "Frogger", students were shown how a procedure could be one element inside another procedure, and in the final solar system task, a session similar to this would have demonstrated how to move from one page to the next while keeping count of turtle steps where one turtle step represents one million kilometres. In this way, new mathematical concepts and LOGO structures were introduced and consolidated. During these sessions, as well as while the students were at their machines, I would clearly articulate how the students were expected to work: "You must talk to each other.", "It's okay to get help from another pair.", "Getting help isn't the same as copying — copying doesn't involve understanding." Sharing knowledge is an integral part of the learning experience.

Overall, the success of the strategies used with this unit of work was evident in the quality of the work produced by the students and their engagement with the tasks. The strategies were highly relevant for the diversity in my classroom. For example, one high needs student who would not engage with learning, would not take his recess breaks but would remain in class, working on his project. Many stories exist that suggest that the strategies engaged students, produced high quality products and fostered deep learning of many mathematical concepts and processes.

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