Perceptions of Challenging Tasks and Achievement by New Zealand Students

Chris Linsell
University of Otago College of Education
<chris.linsell@otago.ac.nz>

Marilyn Holmes
University of Otago College of Education
<marilyn.homes@otago.ac.nz>

Naomi Ingram
University of Otago College of Education
<naomi.ingram@otago.ac.nz>

Sharyn Livy
Monash University
<sharyn.livy@monash.edu>

Peter Sullivan
Monash University
<peter.sullivan@monash.edu>

This paper examines the learning by students who were participating in a project designed to promote persistence while working on mathematical tasks. We examined their learning of mathematics concepts and learning about the processes of engaging in mathematical tasks. There were substantial increases in students' knowledge of angles and also evidence that the students built on their prior knowledge, made connections between concepts, found the tasks rewarding, valued concrete materials and engaged in mathematical communication.

The classroom experiences that teachers select for their students are crucial for learning opportunities (Anthony & Walshaw, 2009; Sullivan, Clarke, & Clarke, 2012). Classroom experiences may be described on a continuum from "Memorization" to "Procedures without connections" to "Procedures with connections" to "Doing Mathematics" (Stein & Smith, 2011). Sullivan, Walker, Borcek, and Rennie (2015) proposed a lesson structure in which students would be engaged in doing mathematics through being presented with challenging tasks. The current study makes use of that lesson structure for the teaching of angles and addresses the research question, "To what extent do students learn mathematical concepts and processes through working on challenging tasks?"

Methods

Two hundred and eighty-one students from thirteen classes in New Zealand schools consented to take part in the study. The Year 5, 6 and 7 students (ages 9 to 12) were taught by their teachers, who were participating in The Encouraging Persistence Maintaining Challenge Collaboration during Term 4 of 2015 (Sullivan, Holmes, Ingram, Linsell, Livy, & McCormack, this issue). The students were presented with up to nine challenging tasks on the topic of angles over a period of six weeks. Two hundred students from eleven of the classes completed online pre and post assessments examining their knowledge of angles and also their views on learning mathematics. Some of the students also wrote reflections on each challenging task.

Students' knowledge

There was a highly significant difference between the pre assessment scores (M=3.4, SD=2.1) and post assessment scores (M=5.6, SD=2.5); $t(199)=-13.5$, $p = 0.000$, paired t-test. Furthermore, the proportion of students recording the correct response to the questions about angles improved between pre and post assessment for every question (see Table 1).

2016. In White, B., Chinnappan, M. & Trenholm, S. (Eds.). Opening up mathematics education research (Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia), pp. 661–664. Adelaide: MERGA.

Table 1
Pre and Post-assessment

Question	Proportion of students recording correct response		
	Pre-assessment %	Post-assessment %	Increase %
A: Angle size	50	72	22
B: Right angles	42	81	39
C: Internal right angles	8	55	47
D: Degrees for angles	45	58	13
E: Compass directions	49	56	7
F: Degrees for angles	36	58	22
G: Reflex angles	50	72	22
H: Clock angles	6	21	15
I: Angles in triangles	44	47	3
J: Angles in complete turns	8	22	14
K: Angles in triangles	4	21	17

Students' perceptions of challenging tasks

Students from eight of the classes reflected on each task and evaluated the level of challenge as either too easy, OK, or too hard (scored as 1, 2, or 3, see Table 2). They were also invited to write open-ended comments about each task at the conclusion of each lesson.

Table 2
Perceptions of Level of Challenge of Tasks

Task	Number of students	Mean level of challenge	SD
1: Angles and right angles	149	1.8	0.5
2: Internal right angles	146	1.9	0.6
3: Angles on clocks	149	1.7	0.6
4: Working out the size of angles	148	2.2	0.6
5: Angles and compass bearings	132	1.9	0.6
6: Comparing angle sizes	141	1.7	0.6
7: Angles in triangles	85	2.0	0.6
8: Angles in quadrilaterals	70	2.4	0.7
9: Angles and parallel lines	27	2.0	0.8

Students who evaluated a task as being too easy consistently commented that a task was fun and also often commented that they were learning from it even though they had evaluated it as being too easy, e.g., "I found it easy because I learnt what acute means." Students who evaluated a task as being OK also emphasised how much fun the task was and that they were learning from engaging in it, e.g., "A bit challenging but FUN!" and, "I started to understand it better as it went on." Students who evaluated a task as being too hard often commented that they did not understand the question, but their comments also indicated that they were

persisting and learning, e.g., “I didn't understand that task that well but it helped when someone showed us what was in the triangle on the second day: I understood it more.”

Question C: Internal right angles

Question C (see Figure 1) had the largest gain in achievement of 47%, from 8% to 55%.

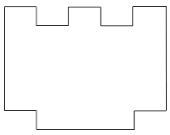

Figure 1. Question C: How many internal right angles are in this shape?

Task 2 challenged students to *Draw two different closed shapes that have exactly 6 internal right angles. Write a description of each of your shapes so that someone else could draw the shape from your description*. Students’ comments indicated that during Task 2 they had learnt about closed shapes and internal angles, e.g., “At the start I didn't know what closed shape was and making a different shape but at the end I knew what to do because I knew what a closed shape was” and “After confirming that internal angles are the angles on the inside everything becomes simple”. Furthermore, they were building on the knowledge that they had gained from the previous task, e.g., “It was okay today doing this lesson because it helped that yesterday I learnt a lot about right angles. I also think I learnt a lot by doing the description and using 90° turns and angles.” Comments also indicated that concrete materials were important for their learning, e.g., “It was easier to use sticks because you got to fiddle with the sticks.” Describing the shapes was clearly the most difficult aspect of the task for the students, e.g., “I found it very fun making all the different shapes but when I did the description it was harder to get the right words to make it easier for the reader to understand. I need to work on making clear descriptions.” Comments were very similar between those students who answered Question C correctly in the post-test and those who did not, except that those who were unsuccessful made more comments indicating difficulties, e.g., “I was confused.”

Question H: Clock angles

Question H (see Figure 7) had a gain in achievement of 15%, from 6% to 21%.

Figure 7. Question H: This clock shows 5 o'clock. What is the size of the smaller angle between the minute and hour hands?

Task 3 also made use of the context of clocks but did not require students to calculate angles in degrees. Students were informed that *I know that the minute hand of the clock is on 2. The hands make an acute angle* and challenged to answer *What might be the time? (Give as many answers as you can).* Students’ comments indicated that during Task 3 they had learnt about classifying angles, e.g., “I hadn't learnt the obtuse and acute angles before but I quickly got the hang of it” and also about telling the time on analogue clocks, e.g., “It took me a while to work out how the clock hands positioned, then it became easy.” Students were also clearly involved in generalising, e.g., “Having a pattern seriously helps! After realising that each activity would have 6 answers (except the last one) it's really easy.” Again, use of concrete materials helped

them with the task, e.g., "It helped a lot having a clock to rotate." Task 4 required students to calculate the size of angles by using fractions of 360º but made use of a context of geometrical shapes meeting about a point. Students were informed that *In a circle there are 360 degrees* and challenged to *Work out the exact size of as many of the angles in this shape as you can. Explain how you worked them out.* During Task 4 their comments indicated that they had learnt about calculating angles in degrees, e.g., "Even though it was a bit easy but it still helped me to learn more about angles and degrees." Interpreting the question and explaining the answers appeared to be the most challenging aspects, e.g., "Confusing at the start until I knew how to do it" and "The angles were easy but explaining the things was hard." Comments were very similar between those students who answered Question H correctly in the post-test and those who did not, except that those who were unsuccessful again emphasised the difficulty of the task.

Discussion and Conclusions

There were substantial gains in achievement on all assessment items, clearly demonstrating that students' knowledge of angles increased through engagement in challenging tasks. Anthony and Walshaw's (2009) summary of effective pedagogical practices includes suggestions that teachers should provide opportunities for students to build on their thinking, make connections, use mathematical language, use concrete materials as tools, and engage in worthwhile tasks. The assessment items that showed the greatest gains in achievement were those that used a context that was the same as one of the challenging tasks. After engaging in doing mathematics in a particular context it appears that students were able to solve similar problems in that context, but when attempting an assessment item in a different context students were not so able to solve the problem. Students' comments showed that during the challenging tasks they were building on their prior learning and making connections between concepts but our data showed little evidence of students being able to make new connections during an assessment. Students' comments during the challenging tasks also showed that they valued being given access to concrete materials, and used mathematical language even though they found this aspect of the tasks particularly challenging. Overwhelmingly, they found engagement in the tasks worthwhile and enjoyable, and in the words of one student, "It was more fun than Minecraft."

References

Anthony, G., & Walshaw, M. (2009). *Effective pedagogy in mathematics - Educational practices series* (Vol. 19). Brussels: International Academy of Education.

Stein, M. K., & Smith, M. (2011). *5 Practices for Orchestrating Productive Mathematics Discussions*. Reston, VA National Council of Teachers of Mathematics.

Sullivan, P., Clarke, D., & Clarke, B. (2012). *Teaching with tasks for effective mathematics learning*: Springer Science & Business Media.

Sullivan, P., Holmes, M., Ingram, N., Linsell, C., Livy, S., & McCormack, M. (this issue). The intent and processes of a professional learning initiative seeking to foster discussion around innovative approaches to teaching. In XXXX (Ed.), *Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia*. Adelaide: MERGA.

Sullivan, P., Walker, N., Borcek, C., & Rennie, M. (2015). Exploring a Structure for Mathematics Lessons that Foster Problem Solving and Reasoning. In M. Marshman, V. Geiger & A. Bennison (Eds.), *Mathematics education in the margins (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia)*. Sunshine Coast: MERGA.