Secondary Students' Perceptions of Instructional Approaches: Implications for Mathematics Learning

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In NSW, Australia, a new course, General Mathematics, has been introduced for the Higher School Certificate replacing the two lowest level courses. Twenty-five thousand students study this course each year. This article reports on a study of 95 General Mathematics students in six schools where they were asked to comment on their learning preferences. Many of the benefits of collaborative learning with spreadsheets, were perceived by only a small number of students in this study, as many students do not envisage benefits of small group learning or learning with spreadsheets. These results have implications for mathematics learning.

This paper reports on secondary students' perceptions of different instructional approaches and the implications for mathematics learning. In NSW, Australia there has been a recent change to the lower level end-of-school mathematics courses. The two lower level courses have been amalgamated into one course now called General Mathematics. Approximately 25 000 students study this course each year. The students are generally those who have studied the lower levels of mathematics up to year 10 but also include advanced students who believe that they will not need high levels of mathematics for their university study. The course contains sections on Financial Mathematics, Data Analysis, Measurement, Probability and Algebraic Modelling. The features of the syllabus are: (1) General Mathematics approaches specific mathematical skills through a range of applications that clearly demonstrate the need for and the use of these skills, (2) General Mathematics puts emphasis on the particular application of mathematics to finance and data analysis and reflects the uses of mathematics that are prevalent in modern society, and (3) the needs of individual students may be catered for through the wider range of applications (Board of Studies, 2001). Therefore, this syllabus focuses on mathematical skills and techniques that have direct application to everyday life rather than the more abstract approach taken by the higher level mathematics courses.

Literature Review

Numerous studies have reported many benefits of collaborative learning, with many definitive studies in the 1980's. Academically, collaborative learning develops higher level thinking skills (Webb, 1982); stimulates critical thinking; develops oral communication skills (Yager, Johnson & Johnson, 1985a); fosters metacognition in students (O'Donnell & Dansereau, 1992); creates an environment of active, involved, exploratory learning (Slavin, 1990); promotes higher achievement (Hagman & Hayes, 1986) increases student retention (Astin, 1977); enhances self-management skills (Resnick, 1987); fosters modelling of problem solving techniques by students' peers (Schunk & Hanson, 1985). Socially, collaborative learning fosters and develops interpersonal relationships (Johnson & Johnson, 1987); develops social interaction skills (Johnson, Johnson & Holubec, 1984); creates a stronger social support system (Cohen & Willis, 1985); builds more positive heterogeneous relationships (Webb, 1980);

establishes an atmosphere of cooperation and helping school wide (Deutsch, 1985); fosters team building and a team approach to problem solving (Johnson et al., 1984); creates environments where students can practice building leadership skills (Bean, 1996); and increases leadership skills of female students (Bean, 1996). Psychologically, collaborative learning builds self-esteem in students (Johnson & Johnson, 1989); encourages students to seek help and accept tutoring from their peers (Hertz-Lazarowitz, Kirkus, & Miller, 1992); significantly reduces classroom (Kessler, Price, & Wortman, 1985); and test anxiety (Johnson & Johnson, 1989).

The literature on the use of computers in learning is much more mixed. Despite the early promise, computers, at least in Australia, are not widely integrated into the secondary mathematics classroom. Nevertheless, following are advantages that computer technology like spreadsheets advocates as significant—exploration and independent inquiry, shared knowledge and collaborative learning, efficiency and organisation, analysing and studying information. Technology supports exploration, which helps students set achievable goals, form and test hypotheses, and makes discoveries of their own (Collins, 1990). Research studies, such as those carried out by Gregoire, Bracewell, & Laferriere (1996) and Heidmann, Waldman, & Moretti (1996) that focused on technology and students' motivation to learn, relied on self-reports of students' attitudes toward computers and found, in general, that most students considered computer activities to be highly motivating and interesting. Many successful users of technology-based materials say that students find strong motivation in the feeling that they are in control of their own learning (Arone & Grabowski, 1991; Relan, 1992) as sited in Robyler, Edwards, & Havrilukk, (1997). Current learning theories suggest that students need to construct their own knowledge (Newby, Stepich, Lehman, & Russell, 2000; Driscoll, 1994). Technology provides learning opportunities that support a highly interactive environment. This type of environment emphasises reflection and discussion with peers that aid in the construction of knowledge (Rodriguez, 1996; Valde, Bower, & Thomas, 1996).

Method

Six schools in comprising of 10 General Mathematics classes in Sydney, Australia were involved in the study. A total of 172 students (out of 211) participated in the larger study (see D'Souza & Wood, 2001; 2002 for details).The qualitative data analysed reported in this paper form part of this larger study that examined students' perceptions of various instructional approaches using different teaching styles for the content area of Financial Mathematics in the General Mathematics syllabus (D'Souza & Wood, 2002; D'Souza & Wood, 2001). We were particularly interested in the students' perceptions of learning in small groups (collaborative or cooperative learning) and their perceptions of learning using computer spreadsheets because the new syllabus emphasises the use of technology, such as spreadsheets, in the teaching of the Financial Mathematics component. This was not a statistically based study. However, the numbers of students have been included to give some idea of the distribution of responses.

Students were given an open-ended questionnaire about their learning preferences (see Appendix 1) after they had spent four classes working on activities developed by the researcher in collaborative, computer and computer supported collaborative environments. This questionnaire was administered by the teachers of each of the classes and students had to complete the questionnaire during class time (which took approximately 15-20min). Responses were received from 95 students, 51 female and 44 male. We did not attempt to group responses by gender or school. Instead, the responses were grouped according to: (a) Questions 1-5: Learning issues, social issues, equipment/style issues and (b) Questions 6-7: Preferred learning style and reasons.

There were some non-response to questions and many students put "not-applicable" or "don't know" possibly because students may not have used spreadsheets or collaborative learning methods in their classes. Most students had an opinion on whether they preferred to learn using collaborative techniques or using spreadsheets and consequently, the response rate for questions 6 and 7 was high. Since completing the questionnaire was voluntary, some students chose not to respond or to only respond to some questions. Those who did respond gave thoughtful and well-reasoned answers. The responses were grouped according to type of learning preferred and reason.

Results

Features of Collaborative Learning

Question 1 invited students to describe the features of collaborative learning that they liked. Grouping the responses, we see that 9 students listed the social aspects of group learning, 2 felt that they gained a better understanding, 8 found the different perspectives and opinions useful and 10 liked the peer support. On the negative side, 6 students liked nothing about collaborative learning and 11 did not know. One student liked "everything" about collaborative learning.

Question 2 asked students to say what they did not like about collaborative learning. Here three students mentioned assessment issues. They wanted to be assessed individually but were happy to work in groups. Ten students mentioned unequal workload. Twelve mentioned problems with task completion and one said it was boring. Nine students answered "nothing" which implied that they were happy with all aspects. Two students did not like "everything" and 9 did not know.

Question 5 asked students to nominate what they would change about collaborative learning and/or group structure. Again a large number of students replied "nothing". Another groups of students (6) made comments such as "get rid of it altogether", "learn better on your own". There were a variety of comments about the working or structure of the groups. Eight students commented on workload such as "make everyone work", "assign work to each student", others (7) said to make it more fun with one suggestion "add more fun props such as fake money". Four students suggested smaller groups, such as 2 or 3, and two students stated that the students should choose groups. One student stated "get people in my class to really work serious". This quote, and several others, reveal the difficulty concientious students have in some of the lower level mathematics classes.

Features of Computer Learning

There were two questions asking students what they liked and did not like about using spreadsheets to solve mathematical tasks. Here the "don't know" or "not applicable" response rate was high (32 for Q3 and 34 for Q4) as many students had not used computers in their mathematics work. Asked what they liked about using spreadsheets: the responses were: easy and straightforward (8), fast and efficient (4), ability to alter information (3), visible (multiple) representations (2), no different from pen and paper (2), nothing (4).

The responses to Q4 which asked what students do not like about using spreadsheets included: computer problems (eg starting and crashing) (4), complicated for simple tasks (3), boring (2), unfamiliarity with software causes difficulties (4), lack of computer access (1) have to learn another subject (eg computer studies) (1), nothing (4), everything (4). As stated previously 34 answered don't know (5) or not applicable (29).

Preferred Learning Style

The last two questions pertained to preferred learning style and here is where the students indicated strong preferences. Many expressed their views very strongly. The issues of confidence, learning, and social aspects identified in the literature are evident.

Table 1 shows that more students favour groups over individual learning but not by much. Twelve students suggest that a bit of both is the most beneficial. There were several comments that testing and assessment should be individual. This reflects the NSW system where rank in class is critical to the university entrance rank. Good students do not want their mark reduced by weaker classmates.

Table 1
If Given the Opportunity, Would You Prefer to Work/Learn Collaboratively in Groups or Individually by Yourself? Why/Why Not?

Quotes	Number of responses
Individual—I trust myself	10
Individual—I learn more	11
By myself because some people don't cooperate	4
In groups—I feel more confident	10
In groups because I can talk to my friends	3
Work/learn collaboratively because it's more fun and you learn a lot better	15
A bit of both. While learning in a group can be fun and more educational, sometimes it's good to be able to work out the answer yourself.	12
Work in groups to learn so we can help each other and get different opinions but test and assessments should be done by ourselves.	3
In groups—to break the monotony of it	3

Table 2 shows the grouped responses to the question as to whether students would prefer spreadsheets or pencil and paper. We see that only 13 students favoured spreadsheets and 16 students thought both were appropriate. Many students who preferred pen-and-paper particularly mentioned the fact that you could see your working step by step. Many also believed that pencil-and-paper methods were easier.

Table 2
If Given the Opportunity, Would You Prefer to Work/Learn Using Spreadsheets or Using Traditional Pen-And-Paper Methods by Yourself? Why/Why Not?

Quotes	Number of responses
Pen and paper are reliable/less time consuming/see step-by-step	6
Pen and paper—easier	11
Pencil and paper because computers are too hard to operate	7
Pencil and paper—you can't take a computer into an exam	1
I don't really mind	7
I would use spreadsheets as I know from past experience that I work better with computers compared with pen-and-paper method.	6
Spreadsheets—get to use computers—more fun	5
Spreadsheets—where the future is headed	2
Both—you always need to keep using your head, we can't always rely on machine but then again machines are quicker and neater	2
Both—it depends on the problem	7

Summary of Findings

The study has the potential to be significant as it considers the perceptions of less mathematically inclined secondary students, a group not often the subject of research. These findings are valid and also significant in that while the syllabus recommends the use of spreadsheets, the students' response to the use of spreadsheets does not support the findings of the relevant literature. It is also noteworthy that many students did not like collaborative learning. Again, this is contrary to much of the literature suggesting social benefits, and raises the question whether this is indicative of lower level secondary students, or whether it was the result of other factors.

Implications

Implications for Technology Education

As a result of this study, a number of implications for secondary mathematics teaching and learning arise. This study highlights the need for adequate computer resources, support and training when implementing new curricula. The use of software such as *Microsoft Excel* requires time to learn. The package initially interferes with mathematics learning. Preference for learning using individual pen-and-paper methods by a majority of students implies that students feel that they learn better using traditional teaching methods. An implication for this is that, over time and with adequate technological, pedagogical support and training, changing teaching and learning methodologies to include computer supported collaborative learning methods may receive less resistance from students as well as teachers.

Implications for Collaborative Learning Methods

A number of students in this study indicated that they found the collaborative activities (during the study) were interesting and enjoyable, and a number of students thought the collaborative activities improved their mathematical understanding. It must be noted that some students made contrary statements. Several students expressed an extreme dislike to collaborative learning methods. A variety of learning strategies is thus called for, to best meet the needs of all students. It was also seen that collaborative groups do not always function effectively, and instructors employing collaborative learning methods must pay constant attention to minimising factors that contribute to such ineffectiveness, and addressing problems where they occur.

The most comprehensive conclusion that can be reached from this study is in the area of individual student preferences for different styles of learning. Given the differences in preferred learning styles, it is difficult to design teaching and learning programs. This makes the role of the teacher problematic. There is a temptation to stay with the status quo that students are trained for in mathematics.

Implication for Mathematics Learning

Students in Year 11 at secondary school have thought about their preferred ways of learning and have had this shaped by years of teaching. This is illustrated by a quote "I prefer traditional pencil-and-paper methods—I have always done it that way". Many students have not had experience of learning mathematics in groups or with spreadsheets. For those who have been taught by those methods, the success is not always apparent. Some of the comments indicate that group work was not successful due to lack of cooperation and unequal workload. With computers, some of the students were frustrated by inadequate computer resources and by having to learn how to use software as well as learn the mathematics.

So what do we need to do? If we want students to use software in their mathematics at university or out in the workforce, we should explain why we are introducing them to mathematical computing. We should do this gently with the knowledge that many of our students will not previously have used computers for their mathematics study, many lack confidence in the use of computers and may have strong preferences for individual work with pen-and-paper. We should also consider introducing students to small group learning techniques and study groups as this will help them with the development of teamwork skills for the workplace and with their study throughout university where a more collaborative rather than competitive environment is fostered. Many of the small group collaborative techniques are especially good for international students and students whose first language is not English as students are required to communicate with each other. It is important for teachers to communicate well with students to explain why small groups are used. Excellent support materials are also needed.

Conclusion

This study points to the obvious variation in students' perceptions of instructional approaches. Within the classroom, close monitoring of students' learning can enable all students to benefit while beyond the classroom, particularly in secondary schools that are in transition from traditional to computer supported approaches, students may need help in making sense of the differences in their experiences and their teachers' expectations across their learning settings. The use of spreadsheets in the Financial

Mathematics component of the General Mathematics syllabus should be a valuable practical and cognitive tool for students. Students have opinions and pre-conceived ideas on how to learn mathematics even if they have not been taught by a particular method. This study demonstrated that some students are resistant to learning mathematics using computers. Many of the benefits of collaborative learning and learning with spreadsheets, as identified in the literature, were perceived by only a small number of students in this study. There are multiple student learning outcomes at risk when using computers in mathematics - acquiring new information, developing specialised computer skills for working with spreadsheets, reasoning and problem-solving abilities. Many of our students do not envisage benefits of small group learning or learning with spreadsheets. If schools encourage these styles of learning, then teaching and learning should reflect this and explicitly teach students the skills of learning in groups and how to use appropriate computer software. This is particularly important for students who generally lack confidence in mathematics. Assisting them to broaden their learning preferences may be the most important aspect of their learning.

References

Astin, A. W. (1977). *Four critical years: Effects of college beliefs, attitudes and knowledge.* San Francisco, CA: Jossey-Bass.

Bean, J. (1996). *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom.* San Francisco, CA: Jossey-Bass.

Board of Studies. (2001). *An introduction to General Mathematics Stage 6 in the new HSC*. Sydney, NSW: Board of Studies.

Cohen, S., & Willis, T. (1985). Stress and social support and the buffering hypothesis. *Psychological Bulletin, 98,* 310–357.

Collins, A. (1990). The role of computer technology in restructuring schools. In K. Sheingold & M. S. Tucker (Eds.), *Restructuring for learning with technology*. New York: Center for Technology in Education, Bank Street College of Education, and National Center on Education and the Economy.

D’Souza, S. M., & Wood, L. N. (2001). Investigating the effects of using spreadsheets in a collaborative learning environment. In W. Yang, S. Chu, & J. Chuan (Eds.), *Proceedings of the Sixth Asian Technology Conference in Mathematics* (pp. 261–270), Melbourne: University of Melbourne, and ATCM Inc.

D’Souza, S. M., & Wood, L. N. (2002). Using CSCL methods in secondary mathematics, In B. Barton, K. C. Irwin, M. Pfannkuch, & M. O. J. Thomas (Eds.), Mathematics Education in the South Pacific (pp. 244-251). Sydney: MERGA.

Deutsch, M. (1985). Distributive Justice: A social psychological perspective. New Haven, CN: Yale University Press.

Driscoll, M. P. (1994). Psychology of learning for instruction. Boston, MA: Allyn & Bacon.

Gregoire, R., Bracewell, R., & Laferriere, T. (1996). The contribution of new technologies to learning and teaching in elementary and secondary schools. Quebec: Laval University and McGill University.

Hagman, J., & Hayes, J. (1986). Cooperative learning: Effects of task, reward, and group size on individual achievement (Technical Report 704, Scientific Coordination Office, US Army Research Institute for the Behavioural Sciences) ERIC Document No. 278720.

Heidmann, W., Waldman, W. D., & Moretti, F. A. (1996). Using multimedia in the classroom: Catalyst for educational change, Proceedings of the Thirteenth International Conference on Technology and Education (pp. 300–302), New Orleans, Louisiana, Grand Prairie, TX.

Hertz-Lazarowitz, R., Kirkus, V., & Miller, N., (1992). An overview of the theoretical anatomy of cooperation in the classroom. In R. Hertz-Lazarowitz (Ed.), Interaction in cooperative groups: The theoretical anatomy of group learning (pp. 3–4). Cambridge, MA: Cambridge University Press.

Johnson, D.W., Johnson, R.T., & Holubec, E.J., (1984). Cooperation in the classroom. Edina, MN: Interaction Book Co.

Johnson, R. T., & Johnson, D. W., (1987). Learning together and alone: Cooperative, competitive and individualistic learning. Englewood Cliffs, NJ: Prentice Hall.

Johnson, R. T., & Johnson, D. W., (1989). Cooperation and competition theory and research. Edina, MN: Interaction Book Co.

Kessler, R., Price, R., & Wortman, C. (1985). Social factors in psychopathology: Stress, social support and coping processes. *Annual Review of Psychology, 36,* 351–372.

Newby, T. J., Stepich, D.A., Lehman, J. D., & Russell, J. D. (2000). Instructional technology for teaching and learning. Englewood Cliffs, NJ: Prentice-Hall.

O'Donnell, A. M., & Dansereau, D. F. (1992). Scripted cooperation in student dyads: A method for analyzing and enhancing academic learning and performance. In R. Hertz-Lazarowitz, & N. Miller (Eds.), Interaction in cooperative groups: The theoretical anatomy of group learning (pp. 120–141). Cambridge, MA: Cambridge University Press.

Resnick, L. B. (1987). Education and learning to think. Washington, DC: National Academy Press.

Roblyer, M. D., Edwards, J. & Havrilukk, M. A. (1997). Integrating educational technology into teaching. Upper Saddle River, NJ: Prentice-Hall.

Rodriguez, S. (1996). Preparing preservice teachers to use technology: Issues and strategies. *Tech Trend for Leaders in Education and Training, 41*(4), 18–22.

Schunk, D., & Hanson, A., (1985), Peer models: Influence on children's self-efficacy and achievement, *Journal of Educational Psychology, 77*(3), 313.

Slavin, R. E. (1990). Research on cooperative learning: Consensus and controversy. *Educational Leadership, 47*, 52-54.

Valde, R., Bower, R., & Thomas, R. A. (1996). Developing preservice teacher's computer competencies. *Journal of Technology and Teacher Education, 4*(2), 83–90.

Webb, N. M., (1980). An analysis of group interaction and mathematical errors in heterogeneous ability groups, *British Journal of Educational Psychology, 50,* 266–276.

Webb, N. M., (1982). Group composition, group interaction and achievement in small groups. *Journal of Educational Psychology, 74*(4), 475-484.

Yager, S., Johnson, D. W., & Johnson, R., (1985a). Oral discussion, groups-to-individual transfer and achievement in cooperative learning groups. *Journal of Educational Psychology, 77*(1), 60–66.

Appendix 1

Open-Ended Questions

1. What do you like about collaborative problem solving?
2. What do you not like about collaborative problem solving?
3. What do you like about using spreadsheets to solve mathematical problems?
4. What do you not like about using spreadsheets to solve mathematical problems?
5. What would you change about collaborative learning and/or the group structure?
6. If given the opportunity, would you prefer to work/learn collaboratively in groups or individually by yourself? Why/Why not?
7. If given the opportunity, would you prefer to work/learn using spreadsheets or using traditional pen-and-paper methods by yourself? Why/Why not?