Instructional Styles in the Teaching of Mathematics Thematically

Boris Handal
The University of Sydney
borishandal@optusnet.com.au

Janette Bobis
The University of Sydney
j. bobis@edfac.usyd.edu.au

ABSTRACT  This study explored different instructional styles in regard to the teaching of mathematics thematically. A hundred and twenty-two teachers were surveyed using a questionnaire and ten secondary mathematics teachers from New South Wales, Australia, were interviewed. The findings reveal that, in general, teachers opt for instructional styles that use applications of mathematics as a justification to teach in themes rather than using the theme as the context that should overarch the development of the lesson. It was also found that teachers shift among different teaching styles depending on the classroom context and opt for teaching mathematics via topics rather than in themes.

INTRODUCTION

In teaching and learning mathematics thematically, instruction is organised around thematic units or projects. Generally speaking, a thematic unit is a collection of learning experiences that assist students to relate their learning to an important question (Freeman & Sokoloff, 1996). Themes are the organisers of the mathematical curriculum, and concepts, skills and strategies are taught around a central theme that is intended to give meaning and direction to the learning process (Freeman & Sokoloff, 1995; Perfetti & Goldman, 1975).
The rationale for teaching mathematics thematically addresses situated-learning and constructivist concerns that the teaching of mathematics occurs within a context that is more meaningful to students than traditional mathematical instruction. It can be considered as a response to the need to humanise school mathematics (Clements, 1987). Its origins can be traced to Dewey’s (1938) progressive ideas on curriculum integration and to Bruner’s (1960) thoughts on the centrality and repetition of knowledge through the enactment of a spiral curriculum. The teaching of mathematics thematically is considered as belonging to the realm of situated learning because the content is embedded in themes that in turn serve as learning contexts (Henderson & Landesman, 1995). Situated learning is primarily concerned with the need to contextualise instruction since, by definition, all learning is situated. Learning is seen not as a matter of ingesting pre-existent knowledge but as a way of developing knowledge in meaningful and practice-bounded contexts (Putnam & Borko, 2000; Streibel, 1995). In turn, this situated perspective is associated with constructivist ideas of teaching and learning mathematics due to their shared interest for building mathematical knowledge within those contexts (Anderson Reder & Simon, 1996; Murphy, 1997). The thematic approach is also directly associated with constructivist ideas since it provides an environment where knowledge can be individually and socially constructed (Freeman & Sokoloff, 1995; Good & Brophy, 1994; Seely, 1995).
CHARACTERISTICS OF TEACHING AND LEARNING MATHEMATICS THEMATICALLY

Thematic units typically consist of three main elements: (a) facts and information, (b) topics and (c) themes. According to Freeman and Sokoloff (1995, p. 1):

Facts focus on basic information and narrowly defined ideas understood in discrete items. Topics provide a context for facts and information, and present a way of organizing discrete bits of information into classes of experience recognizable by scholars within traditional disciplines. Themes defined as broad existential questions, transcend disciplines, allowing learners to integrate the information and the topic within the full range of human experience.

A typical relationship among facts, topics and themes, as visualised by Freeman and Sokoloff (1995), is shown in Figure 1. The representation indicates that within a thematic unit, facts and topics are taught within the context of an overarching theme.
Figure 1. Structure of a Thematic Unit as visualised by Freeman and Sokoloff

Thematic instruction in mathematics is an umbrella term for a wide range of educational experiences that relate mathematics to real life situations (Handal, 2000). In those experiences, the real world serves as a representation of a mathematical concept or technique. This representation constitutes a movement from the concrete, "the every day world of things, problems, and applications of mathematics", to the abstract world, "mathematics symbols, operations and techniques", and/or vice versa (Schroeder & Lester, 1989, p. 33). In general, thematic instruction could best be characterised by (a) conceptual mathematization from the concrete to the abstract, (b) free production mainly in the form of projects and investigations, (c) interactive learning, (d) interdisciplinary learning, and (e) assessment based on constructivist principles and not on rote learning (Freudenthal, 1991, cited by De Lange, 1993).
Thematic instruction in mathematics might take different general orientations and emphases. For example, a topic is taught and subsequently is reinforced through applications of mathematics, although these applications are not very often integrated under a single central theme but beneath multiple small themes. This is the simplest form of teaching mathematics thematically. Another approach consists of discussing the mathematical implications of a theme, such as sports, followed by the teaching of mathematical concepts in examples related uniquely to the theme. For example, if the concept concerned is "rates", students would be asked to compare run and strike rates in cricket. A more sophisticated approach consists of introducing the thematic situation first, that is, a real-life problem, followed by a lesson structure that leads to the discovery of the mathematical concept concerned or to the building of a mathematical model.

In brief, guidelines are vague and only reveal general principles on how to proceed with teaching mathematics thematically. These guidelines suggest more use of co-operative learning, use of concrete materials, discussion, guided discovery (Henderson & Landesman, 1995), formulating and solving a problem, data gathering, practical work, alternative interactional patterns in the classroom, fieldwork and use of technology (Abrantes, 1993). As Seely (1995) and Freeman and Sokoloff (1995) have argued, a broad range of constructivist practices like those mentioned above are necessary to effectively implement the teaching of mathematics thematically.
THE JUNIOR SECONDARY STANDARD MATHEMATICS COURSE

In New South Wales (NSW), Australia, the Years 9 and 10 Mathematics Syllabus consists of the Advanced, Intermediate, and Standard courses. The main feature of the Standard course is the introduction of teaching mathematics thematically as a mandatory instructional strategy at the junior secondary level (Board of Studies NSW, 1996; Hunter, 1996). In the previous General Syllabus (Secondary Schools Board NSW, 1983) the use of themes was optional. The Standard course consists of eight themes and ten topics. The themes include: (a) Mathematics of our Environment, (b) Mathematics involving Food, (c) Mathematics in the Workplace, (d) Building Design, (e) Mathematics involving Sports, and (e) Mathematics in the Community, (f) Handcrafts, and (g) Tourism and Hospitality. Each theme is organised into sub-themes. For example, the theme Mathematics involving Sports includes the sub-themes: (a) Sporting Venues, (b) Sporting Costs, and (c) Performance in Sport.

The Standard course curriculum document makes it very clear that the thematic component of the course should be enacted accordingly, that is, the theme must be considered as the main idea around which the mathematical content is taught (Board of Studies NSW, 1996, p. 19):

Teachers may wish to teach a theme by first teaching some or all the mathematical content and then reinforcing this content within the context of the theme. Alternatively, teachers may wish to teach the theme and emphasise the mathematical skills when
appropriate. This does not imply that teachers must follow a particular sequence when teaching each theme. However students must be provided with the opportunities to acquire the mathematical knowledge, understanding and skills in the context of each theme [emphasis added].

TEACHING STYLES IN THEMATIC MATHEMATICS

Generally speaking, the literature reveals that teachers enact three teaching styles when dealing with a thematic unit (Blum, 1991; Galbraith, Blum, & Huntley, 1998; Handal, 2000; White & Hastings, 2000). In the first style, the teacher intends to reach the mathematical content objectives of a particular thematic unit or lesson through an entirely content based lesson and consequently no applications of mathematics are presented in class. In this form, rote learning and drill are the predominant approach to learning. The second teaching style is characterised by applications of mathematics but in a restricted dimension. Typically, the teacher begins the lesson with the introduction of a mathematical concept and later presents applications of mathematics as a way to practice the already taught mathematical concept. Applications of mathematics in this second style are not related to each other and are used not to elicit mathematical ideas from a real life situation but as a way to justify the applicational goals of a thematic unit. This style represents the most basic form of teaching mathematics thematically since in a theme all applications are to be related to each other and must revolve around a central idea (Freeman & Sokoloff, 1996). In the third teaching style, the teacher is engaged with mathematical modelling. This is thought to be the most difficult and complex style of
teaching thematically (Blum, 1991; Galbraith et al., 1998; Handal, 2000; White & Hastings, 2000). A teacher operating in this style typically begins from a real-life situation involving experiential and hands-on activities that eventually lead to the formalization of the mathematical concept involved. Presented as discrete "styles", no evidence suggests how prevalent each style is or if one is more effective.

The study reported here is part of a larger investigation concerned with the beliefs and practices of secondary mathematics teachers who were required to teach mathematics thematically. The findings reported in this paper deal only with the research component concerned with the teaching styles utilised by these teachers. More specifically, the study intended to identify which factors determine teachers’ choice of instructional styles in the teaching of mathematics thematically and whether the styles chosen were in accordance with those required by curriculum documents.

**METHODOLOGY**

The study combined both quantitative and qualitatively research techniques. A blending of techniques is recommended on studies about teachers’ instructional behaviour because there is a need to elicit a broad range of teachers’ responses and to secure triangulation of data.

**Questionnaire Component of the Study**
A questionnaire was designed in consultation with teachers, policy makers, textbook writers and senior academics in mathematics education. The purpose of the questionnaire was to identify teachers’ level of engagement with each of the three teaching styles depicted in the literature and described earlier in this paper. These teaching styles were presented via different teaching scenarios and were represented by the hypothetical teachers, Robin, Ashley and Lee. Participants were asked to indicate to what degree the scenarios resembled their own teaching styles when teaching mathematics thematically. Seven choices of response for each of the three scenarios were presented on a Likert-type scale varying in their degree and agreement to the item. The minimum score was 1 and the maximum score was 7 (Handal, Bobis, & Grimison, 2001). The questionnaire also had an open-ended response section that was designed to elicit more information about why teachers were using particular teaching practices.

**Sample and procedure**

Six questionnaires were mailed to each of the 69 high schools in metropolitan Sydney offering the Standard Course. A letter addressed to the principal asked that the questionnaires be given to the teachers of the Standard Course in the school. All schools were contacted by telephone in the following weeks to encourage the completion and return of the questionnaires. One hundred and twenty-two teachers from 44 schools returned the questionnaires. This represented 62% of the total number of targeted schools and approximately 52% of the total number of Standard Course teachers in the schools sampled.
**Interview Component of the Study**

The purpose of the interview component of the study was to explore teachers’ teaching styles in regard to their teaching of mathematics thematically. Ten teachers of the Standard course who were living in the Metropolitan area were selected from questionnaire respondents who indicated their willingness to be interviewed as a follow-up to the questionnaire. The final 10 teachers were selected on the basis of achieving an equal representation of gender, academic qualifications, socio-economic teaching area, years of experience and faculty position.

**RESULTS AND DISCUSSION**

**Quantitative Results**

Questionnaire results indicate a support for the first \((M = 4.95; \text{S.D.} = 1.74)\) and second teaching styles \((M = 5.14; \text{S.D.} = 1.53)\), as opposed to the third style \((M = 3.34; \text{S.D.} = 1.79)\). The results suggest that by supporting the first and second teaching styles teachers practice a compromise version of the constructivist goals on which teaching mathematics thematically was designed. The low support for the third teaching style suggests that teachers tended to operate in a more traditional style.
Qualitative Results

The analysis of teachers’ responses in the interview component of the study regarding their teaching styles confirmed the existence of the three main teaching styles. As discussed earlier, the first teaching style is characterised by drill and repetitive exercises, while the second style consists of a combination of rote learning and word problems. In turn, the third style makes greater use of modelling experiences and hands-on activities in learning mathematics thematically.

Responses during the interviews revealed three related styles in teaching mathematics thematically in the Standard course. In the first style, teachers tended to use textbooks written before the 1996 Standard course was introduced, and consequently based the thematic lesson or unit on topics only. Teaching thematically was therefore reduced to a few examples at the end of the unit or chapter showing isolated applications of mathematics instead of using a theme as a unifying idea. A teacher using this style was typically convinced that students like mathematics taught more according to topics than themes. This was the simplest of all the thematic styles because themes were just simple illustrations of a mathematical concept.

The second style can be split into two sub-styles and focused more on applications of mathematics organised around a central theme. In the first sub-style, a typical lesson would consist of a topic being taught in isolation followed by applications of mathematics related to a single theme. A teacher interviewed called this style "teaching
topics in themes”. A typical lesson would commence with the teaching of basic skills and later teachers would introduce examples of real-life mathematics related only to the theme. One teacher explained that she operated in this sub-style because she believed that “it’s better for the students to actually spend more time on improving their basic skills and then applying those skills to themes rather than just concentrate on themes”.

The second sub-style is a variant of the first except that the theme is presented early as the central idea of the lesson. In this sub-style the teacher may use the theme to unfold the learning scene to motivate the class. Alternatively, the teacher may pose a thematic problem at the beginning of the lesson and then conduct a brainstorming activity to elicit mathematical procedures and ideas from the students. Gradually the teacher becomes more direct in his or her teaching and begins to introduce the mathematical content and procedures. Essentially, the theme is used as a generative idea to increase participation. A broad range of depth in the theme itself and in the mathematical content can be observed when teachers operate in this style. For example, teachers can use the theme simply as a motivator to teach basic skills to justify their observance of the curriculum. Consequently this approach can turn into merely teaching a topic in the name of a theme. Alternatively, the theme can be used as a powerful generator of ideas that can go beyond the disciplinary limits of the subject. This second sub-style obviously requires more preparation, pedagogical skill, effort and resources.

The third teaching style is more investigative in nature. A teacher operating in this style would use the theme as a way to discover and model knowledge in open-ended activities.
Students ideally begin their learning through hands-on activities and later work through examples to identify and eventually generate the mathematical idea. This is probably the most elaborate type of teaching thematically and requires complex teaching expertise. As a result of this style of teaching students would probably be engaged in research assignments and mini-projects. The assessment is usually more complex than just paper-and-pencil tests. One teacher committed to this style described their faculty’s approach:

What we try to do at our school is create projects or mini-assignments within class time where students work at their own pace. We do try to provide a few prerequisites beforehand… We try to do it within class time.

Analysis of teachers’ responses on the open-ended section of the questionnaire revealed that they switch between styles depending on the learning context. Teachers’ responses show that they usually do not teach solely according to one style but move back and forth from one to the other. Typical of these comments were: "A combination of the first two is usually the way to go", "I’m a bit of each at different times", "It is important to use many different strategies", and "A combination of all of the above techniques". The decision to adopt a particular teaching style seemed to depend on the need to cater for all learning styles, the nature of the topic or "what is to be taught", the type of students and time restraints in moving to more innovative teaching styles.

Interviewees’ responses shed more light into this interactive process. This oscillating movement between teaching styles may even occur within one single lesson. Often
teachers have to revert from complex to more simple styles in order to revisit basic skills. It appears from the interviewees’ responses that the most frequent style is the first sub-style of "teaching themes in topics". In general, teachers’ choice of each style depends on several factors. One factor is their personal attitude toward teaching mathematics thematically. Very often the attitude like/dislike is a function of the complexity of a particular style. Another factor is the teacher’s feeling of self-competence of teaching in a particular thematic style. Teachers’ judgement of students’ ability to handle the abstractness or complexity of the theme and its mathematical content is an additional significant factor in choosing a particular thematic style. Usually this is a powerful deterrent to teaching thematically, particularly when the teacher realises that classroom management problems such as discipline and class noise levels may arise in open-ended tasks.

Linked to the factors presented above is the teacher’s expectation of the level of motivation that the theme can generate among students. In addition, a teacher may feel very competent to teach through topics but not thematically, or vice versa, and this realisation can determine the teacher’s choice of teaching style. Generally, as some head teachers suggested, mathematics teachers are very traditional in their teaching and are very unwilling to change. Another factor affecting the selection of a particular style was the capacity of the mathematical concept to fit in with the theme context since some mathematical concepts are more difficult than others to teach within a theme. For some forms of content, a teacher may prefer to begin from the theme and then move to the basic skills, while other types of content require the inverse procedure. Last but not least,
teachers’ technical knowledge of the theme itself emerged as an important factor in undertaking a theme because some self-research and independent study was needed. For example, a theme concerning building design requires drawing skills that may be challenging to some teachers. In conclusion, these findings show that there are many factors that a teacher considers when deciding as to what teaching style to adopt. In general, opting for a more complex style is considered by teachers to be risky and more challenging.

CONCLUSION

Based on both quantitative and qualitative data, it was possible to identify three teaching styles associated with the teaching of mathematics thematically. The first style of instruction was concerned with teaching via topics with an emphasis on procedural learning. The second style was found to have an association with two individual sub-styles. In the first sub-style, themes were used to provide a context for a particular topic but in a very structured way. In the second sub-style, themes were used as the learning context of the lesson and as a generative idea. The third style made use of themes to model and investigate a particular aspect of reality. This was considered the most complex style of teaching thematically and was rarely used among Standard teachers because it required students to be proficient in both numeracy and literacy. It also required a high level of pedagogical skills on the part of the teacher. The predominance of these styles suggests that the teaching of mathematics thematically in the Standard
course is being implemented mostly in its simplest form—via topics with emphasis on procedural teaching.

In general, teachers seemed to shift constantly among styles but still gravitate between the simplicity of the first style and the first sub-style of the second teaching style. This fluctuating movement between teaching styles may even occur very often within one single lesson. Teachers repeatedly have to revert from complex to more simple styles in order to revisit basic skills. These factors are important because they help to understand the reasons as to why teachers are generally resistant to teach mathematics thematically. These factors show that there are many forces that a teacher considers in deciding a more complex style of thematic teaching and that, in general, opting for a more complex style is risky and challenging for most teachers.

REFERENCES


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