

Motivating Learning in Mathematics Through Collaborative Problem Solving: A Focus on Using Rich Tasks

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Abstract

This paper is based on the concept that lively and interactive math classes are possible by incorporating rich tasks to meet the needs of students operating at different levels in the classrooms. A study was carried out to find out the impact on learning and motivation of using rich tasks at secondary level in the maths class by incorporating co-operative learning. Qualitative research paradigm was opted for the study using an action research approach and the data were collected through two semi-structured interviews conducted at the onset of the research and after the intervention. Few important findings indicate that rich tasks demand different levels of challenge and extend opportunities to those students who need them.

Keywords: rich tasks, collaborative learning, cooperative learning, maths

Introduction

The best maths teachers have always encouraged their students to do more than learn by rote. In my opinion, mathematics is different from other subjects as it inculcates application of certain logical sequences that result in the culmination of a desirable solution to a problem. Cellis (1993) argues that with the change of mind-set of students in math classes,

teachers have no choice but to incorporate rigour in their classes, which were once considered to be dead classes. Introducing mathematics to students in a context that is meaningful or perhaps linked to other subjects is one way of doing this. This is supported by Sandra and Cynthia (2005) who believe that “The contexts in which mathematics is studied plays an important role in helping students understand not only how, when, and why particular concepts, procedures, and skills are used, but also what makes them significant and worth knowing” (pp. 1). It is a challenge for the teachers to cater to the needs of a class of twenty or thirty students or more. One way is through the introduction of rich tasks. A rich task is an activity that has all the essential features needed to meet the different learning needs of students. It should be simple enough to be approached by those who are not so mathematically able, yet at the same time allow for differentiation and extension. Piggott (2007) argues that what makes a task rich is the environment in which it is presented, which includes the sequences of questioning used by the teacher and the roles learners are expected to adopt.

It would be interesting to observe the impact of rich tasks in the light of collaborative group work. Collaborative learning in groups is seen as an integral part of the National Curriculum and some other program of study (Biott& Eason, 1994). Task groups offer opportunities for students to learn how to interact socially in situations where they feel they can act upon shared understandings of how to be co-operative. This study aimed to explore and investigate the effect of implementing collaborative learning methods in the teaching of mathematics through the use of rich learning tasks.

Literature Review

It is no secret that teachers currently are so burdened with increased workload and other professional demands that they have started using resources that direct the way their lessons run rather than supporting the way they desire to run their lessons. It has become increasingly difficult getting students connected to their mathematics learning and to appreciate its significance (O’Brien, 2005). Considering these challenges and to seek a solution to this commonly faced problem, it is worthwhile to look

at some key learning theories to help determine the qualities of an ideal classroom. There are three principle pedagogies used in a classroom.

In Constructivist learning, students are allowed to construct their own learning by actively participating in problem-solving and critical thinking. They construct their own knowledge by testing ideas and approaches based on their prior knowledge and experiences and applying these to a new situation. Jonassen (1994) proposes eight characteristics that differentiate constructivist learning environments and they imply that the teacher must adopt the role of a guide to the student, stimulating and provoking their critical thinking, analysis, and synthesis throughout the learning process.

In a study on Constructivist Learning Design project by Collay and Gagnon (1996), six important elements were highlighted to provoke thinking about planning for the learning of students: situations, groupings, bridge, questions, exhibitions, and reflections. Quite simply, the teacher presents a situation or a problem for students to work on, selects a method of grouping students and resources, builds a bridge between what students already know and what they expect to learn, encourages students to exhibit their findings, and finally reflects upon their achievements. The most crucial role of the teacher here as defined by Collay and Gagnon (1996) is that of assessment which must be carried out at every stage.

The term Student-centred learning was coined by Rogers (1965) and can be used interchangeably with terms such as active learning and participatory learning (Ginnis&Brandes, 1986) that suggest a system where the students are at the centre of all learning. They are encouraged to participate and take responsibility for their own learning which leads to self-fulfilment and helps them realise their true potential.

Co-operative working involves a working environment where students work in co-operation with each other through the use of pair work and group work. This concept of learning has been supported by Bennet (1991), who argues that co-operative group endeavours provide students with social experiences such as receiving and giving explanations, sharing of knowledge between peers and tasks that provoke discussions through teacher facilitation.

These three principles require a change in the way things are done in a classroom so that students can work with a greater degree of independence. Any change can be made only at the teacher's discretion as s/he plays a central role in determining the running of a class. Friere (2001) in his New Basic Project states, "students learning to read and write is about learning to analyse the world around them while the principal task of teachers is to facilitate analysis of that world and the problems associated with the community" (p. 65). Hence, any pedagogy must be associated with the students' immediate surroundings and must help them analyse and engage with those surroundings.

To this end, Yeo (2007) stresses on the need for teachers to clarify the differences between various mathematical tasks such as project work, problem solving, real-life situations and so on, as each type of task has different pedagogical uses. According to The Professional Standards for Teaching Mathematics (1991), the classroom teacher is responsible for creating and using interactive and worthwhile tasks that allow students the opportunity to develop competence and understanding of key mathematical concepts to develop their interest in learning. Therefore, the emphasis is on the teacher to understand the differences in the teaching purposes of each task and choose the one that is most suitable for the class.

The initiative for this project was taken from the Rich Tasks that were developed by Education Queensland's new curriculum approach, which aimed at providing students with substantive, meaningful, and authentic learning practices. The rich tasks were one of the three conceptual pivots of the New Basics Framework adopted by most schools in Queensland in an attempt to "empower and encourage teachers, unclutter the curriculum, deliver fewer alienated students, prepare students for a future in an uncertain world, and position the classroom within the global village" (Queensland Curriculum, Assessment and Reporting Framework, 2003). Each task provides the students with investigations that require the integration of knowledge from other disciplines. It offers students an opportunity to investigate life-like situations specially while working in groups. Piggott (2007) reiterates that rich tasks give the learners an opportunity to develop and improve their mathematical skills to enable them to apply these in the real world.

The richness of a task is determined to a large extent by the context in which it is presented. The findings of a study carried out by three universities in Australia determined that the way task contexts are presented and the way they are introduced might have the potential to alienate some students. The research presented the need for consideration of “pedagogical issues related to focusing students’ attention on the goals of the activity, the modes of working, and the types of solutions that are valued” (Sullivan, Zevenbergen & Mousley, 2006, p. 108). The Cockcroft Report (1982) stated that mathematics teaching should include opportunities for problem solving and investigative work. The subsequent HMI document 1985 (as cited by Selinger, 2006) also recommended that practical work, problem solving, and investigative work should be incorporated as teaching strategies.

Methodology

Design

Choosing the research design is dependent on the choice of aims and objectives of the study. Sidhu (2000) rightly asserts that a combination of research approaches often give better results and it may be unwise to try to draw a stringent distinction between qualitative and quantitative studies. Owing to the nature of the research which is based on analysing students’ responses in interviews to open-ended questions, a qualitative method using action research approach was used.

Semi-structured interviews were used to analyse qualitatively to look into the responses of the students performing at different levels in the class. These responses were analysed with their performance on each end of task assessment sheet to develop a clearer understanding of the success of the method of teaching being studied.

Participants

The Advantage College (TAC) is a secondary school located in a mixed lower middle class area in London. As many of the high achieving students in the area opt not to attend this school, it means that the school

has spaces that are filled by ‘Over Aged Transfers’ (students transferred from another school to repeat a course of study), students from other boroughs, and twenty percent non-English students. The sample was taken from TAC and comprised a mixed ability year 9 set 4 class with a total of 20 students (7 girls and 13 boys), who performed at level 4 and 5 in mathematics. It was quite a few weeks after teaching this class that I felt I had begun to understand what level they were truly at and where I should pitch my lessons to ensure maximum learning. However, their class work and end of unit test results proved that they were not responding well to the more didactic teacher led style that I had adopted with them.

Measures

The research was carried out during the first half of the summer term at TAC through the introduction of an intervention of a maths project on ‘Building a Bridge’ extending over 6 lessons. This required students to work in groups to produce a final end product: the model of a bridge. At this time two new students were transferred into the class from another school. To investigate the issues under discussion, the data were collected using various tools.

Pre and post interviews. Interviewing involves the collection of data through direct interaction between individuals seeking information on the part of one and supplying information on the part of the other. Focus group interviews were used for the study to bring several different perspectives into contact. Two semi-structured interview guidelines were developed for pre and post intervention interviews of half hour each. Taking into consideration the ethical dimension of interviews, the teacher took verbal permission from the students before recording the interview. The participants for both interviews were the same and comprised a group of 6 students: 3 from level 4 and 5 each. Equal representation ensured a more fair assessment of the intervention and demonstrated how effective it was in extending the more able students while making maths more accessible to the weaker students.

Assessment sheets. The plenary at the end of each lesson included an assessment sheet that each student had to fill out. Each assessment sheet was aimed at putting the maths knowledge gained during each lesson

to the test. The assessments were short and designed in such a way that they enabled the teacher to get a fair idea of their understanding of each lesson. This served as a record for the study and the teacher made sure to share the overall progress with the students the next day.

Teacher notes. As per regular teaching practice, a detailed record was maintained of any observations made during each lesson. This helped the teacher generate targets to take forward into the next lesson.

The intervention-a project. For the intervention, a six-hour module was designed and detailed six lesson plans were developed for which worksheets and tasks were adapted from Graham, Sharp and Maull (1999) for use in the class. Various techniques and strategies were employed in this project to turn challenges and problems into favourable learning conditions.

The rich tasks. Resek, Kysh, and Hsu (nd.) believe that a class could be made more effective if students wrestle with content that is challenging, but accessible to them. Moreover, students could all begin with the same rich problem, but those who solve it quickly work on questions that will deepen their understanding, and those who find it difficult will receive help from others.

Procedure

All these aspects were kept in mind as the teacher was essentially interested in doing activities which the students would find interesting and learn some new concepts that would be appealing to their visual and kinesthetic sense. Hence, the teacher chose to introduce a project on 'Building a bridge' using materials which were quite accessible such as cards, elastic strings, paper clips etc. This activity, it was presumed, would pull together various mathematical ideas such as scaling, pythagoras' theorem and trigonometry, plotting a curve from experimental data, using calculators, working in groups, and predicting the length of the string used for the bridge. The project was extended over a period of six lessons and the students were expected to live up to the roles assigned to them in their groups. The teacher facilitated group discussions when needed.

Results, Findings and Discussions

Interviews

The focus of this interview was to reveal why students acted so disinterested during mathematics lessons and to gain an insight into what they thought could be done to make lessons more interesting. The purpose behind the interview was two-fold: determining what key elements should ascertain the pattern of each lesson and seeking students' opinion on working as groups. To this end, it was important also to understand how their working relationships with each other would determine their productivity. During the interview an interesting comment was by made by Trudie (pseudonym).

“Yes it (project) would be more fun than doing questions from a textbook maybe. If it’s fun I will remember I think.”

Coming from a student like Trudie, who produced excellent work when motivated, the teacher tried to consider what other options she had available for classwork. This perception coincides with Yeo (2007) who asserts that sometimes teachers who use textbooks as a source of maths problems to be solved in class do not realise that this is not the kind of problem solving that constitutes the theme of many school curricula. All six of the students who were interviewed expressed their feelings for mathematics in very negative terms. One student very vehemently stated:

“Maths classes are boring. I hate figures and many a times figures are confusing for me—even the maths questions are hard. I am not interested.”

When offered project-work as an alternative to traditional methods of learning, all showed enthusiasm and were inclined to take more interest if they thought that they were enjoying the lessons. A student said:

“If I am able to use the equations and calculations to tasks outside the class that would be fun.”

The idea of learning mathematics differently seemed secondary in significance to the availability of the opportunity of working in groups.

However, the responses received mostly were very positive and in favour of this small planned intervention.

Post Interviews

The post-interviews were carried out with the purpose of understanding the effectiveness of the intervention methods that had been used, that is, rich tasks through group work. It was also to learn how students compared this new teaching style to a more conventional didactic teaching style. The results suggested that rich tasks become more productive if students are placed in groups. They are expected to be responsible for the learning of all their members. The students communicated their thinking with others and good mathematical arguments and explanations emerged. They shared their work with others and presented their ideas without hesitation. Often when students are placed together for pair work, they have expressed displeasure by saying, “We don’t get along. I can’t sit with him.” To prevent this from happening, the teacher with the help of the students grouped them ensuring productive teams. At times they expressed dislike for some team members.

Assessment Sheets

The value that assessments can have for learning has been recognised by many experts in this field. Jones and Tanner (2000) opine that assessments are a strong means of informing teachers of their teaching and students of their learning. This is supported by Gillies (2007) who believes that teachers can only make constructive changes to the learning process if they are able to successfully understand what methods help students learn and eventually achieve success. When planning assessments, the teacher included a variety of questions to address all the main objectives for the students’ mathematical development. Prior to each lesson, the objectives and expectations for the completion of the tasks were shared. The percentage of correct responses on the assessment sheets and students’ positive comments and feedback mirror both the significance of the learning achieved as well as the sense of autonomy and independence experienced by them as a result of being grouped (Millis & Cottell, 1998; Selinger, 2006; Zevenbergen, Sullivan, & Mousley, 2003).

Teacher Notes

The teacher maintained notes during and after the class to maintain a record of student learning and to make adjustments in the following lessons. The teacher's task was also to observe students' behaviour in groups and their ability to manage their resources and focus on producing a result as set down in criteria for performance. Assigning roles to students meant that everybody would need to stay on the task and fulfil what their role expected from them. There was an intrinsic pressure on them to do so, as otherwise they would let down their groups. For example, at one point while the class was measuring angles and their related stretched lengths, a facilitator of a group said she was giving up. The teacher allowed the students to sort out the group work dynamics to create a more congenial environment. On another occasion, the group had to be rearranged. However, there is much research done on the part friendship plays in supporting social and cognitive development leading to motivation and autonomy with the work. The teacher observed that students had automatically assigned jobs to each other or chosen what they felt they could do best. Being quite low achievers in mathematics and poor communicators, some of the students especially, the 'gatekeepers' found it quite challenging to summarise the findings and needed support. The teacher initially observed very little interaction and collaboration within groups. Except for one or two groups, the others were not seeking or giving help (Brown & Dowling, 1998; Hanco, 1999). The teacher prompted participation by phrasing out questions very clearly and leaving them with the groups to discuss.

Classrooms are dynamic organizations involving a number of different dimensions. These include interaction between students and teachers, attitudes and behaviour, the physical organization of activities, and curriculum. As these are interdependent changes two of these, namely activities and physical organization are of relevance to this study. This implies:

1. Students will work in groups where a high level of co-operation is ideal. Learning is more student-centred and requires students to be more constructive. This also necessitates that their social skills need

to be well-developed as they learn to discuss, share resources and ideas, and are able to resolve conflicts amicably (Flewlling, nd.; Herbert, 1990).

2. As students use a wide range of resources working on negotiated tasks, the role of the teacher will change from being in the forefront to partners in helping students construct knowledge, and understanding from their learning experiences (Gillies, 2007).
3. Schools will be expected to be more student-centred, and will provide appropriate training to teachers and other staff.

Conclusion

This small scale investigation was carried out to study the impact on learning and motivation by using rich tasks in the presence of co-operative learning. The results of the study showed that using rich tasks in class provided:

1. Motivation and enthusiasm.
2. Different levels of challenge despite the learner's level.
3. Extension opportunities to those who needed and demanded them.
4. Opportunities for collaboration and discussion in the form of group work.
5. Encouragement to learners to develop confidence and independence and to become critical thinkers.

At the same time, the teacher played a very crucial role in ensuring that the group tasks were relevant and discovery-based, and the groups were well-structured so that the students cooperated and contributed to each other's learning. Assessments were perhaps the most powerful tool employed to understand the effectiveness of a change in teaching strategy. It determined any improvement or changes needed to be made to the existing teaching practice. This is important as research indicates that

teachers can become committed to using new practices only after they have used them in their classes and observed change in the achievement of students (Guskey, 2002; Warfield, Wood & Lehman, 2005).

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