NOTES ON GROUP-WORK BASED TUTORIALS IN A LARGE SERVICE TEACHING MODULE

Brien Nolan Eabhnat Ní Fhloinn

CASTeL, School of Mathematical Sciences, Dublin City University

We report on a teaching project that involved the use of peer-supported group-work tutorials in a large (n = 414) service teaching module in Dublin City University in the academic year 2010-11. We describe the background and motivation for the project, and its design and execution. This includes a corresponding tutor training element. We report on feedback on the tutorials obtained from students and tutors, and discuss the students' performance on the module assessments in the light of the group-work tutorials. We found little evidence of success in the project, and attempt to relate this to existing conceptual frameworks describing the effective implementation of group-work.

INTRODUCTION

The performance of third-level students in mathematics continues to be a cause for concern. We report here on a teaching project that sought to address these concerns by drawing on a teaching approach that has a firmly established conceptual framework. Likewise, the effectiveness of this approach – complex instruction (Cohen and Lotan, 1997) – has a strong evidence base. The project involved a new approach to the tutorial system for a large service teaching module taught in Dublin City University in the academic year 2010-11.

The module in question (MS136 - Business Mathematics) is taken by first year undergraduate students from a variety of degree programmes in business and economics. Roughly 400 students take this compulsory module each year (414 in 2010-11).

Our primary concerns relate to student achievement, in particular the persistently high failure rate. We also had concerns regarding the low rate of participation in tutorials, and speculated on the connection between the two, although there was no clear statistical association. (This is perhaps not hard to understand. Students may attend but not participate in a tutorial. Likewise, students could have passed the module without needing to attend tutorials.)

Our decision to implement a group-work format in tutorials was motivated by these concerns. This approach to cooperative learning is a well-established teaching method (Cohen, Manion and Morrison, 2006) that, crucially, was felt to present students with the *opportunity to learn*, in other words, circumstances that allow students to engage in and spend time on academic tasks (Hiebert and Grouws, 2007)

Of particular importance to this project was the keynote lecture of Boaler at MEI3 (Boaler, 2009) in which the *complex instruction* approach to cooperative learning was described. This strongly informed the conceptual framework underpinning this project. This framework is described below. We describe the development and implementation of the group-work tutorial system. We present data on the effectiveness of the group-work tutorials from different perspectives and summarise student feedback on the tutorials. We conclude with some reflections on the project, seen in the light of these results and the conceptual framework.

CONCEPTUAL FRAMEWORK

In third-level mathematics teaching, a distinction is frequently made between *service teaching* – the teaching of mathematics to students whose programme of study is not primarily mathematical in nature – and other mathematics teaching (that is, the teaching of mathematics to students enrolled on a programme that *is* primarily mathematical in nature). The importance of service teaching to mathematics departments in Ireland, both in terms of mission and sustainability of those departments, is reflected in the amount of associated research and development (e.g. Burke, Mac an Bhaird and O'Shea, 2012; Hoban, Finlayson and Nolan, 2011; Faulkner, 2009; Ní Fhloinn, 2009; Cleary, 2007; Gill and O'Donoghue, 2005). It has been claimed that the field of mathematics service teaching generally is under-theorised and under-researched, but efforts have begun in order to address this deficit (Gill and O'Donoghue 2007). We report here on a service teaching project. The work we describe is developmental in nature and seeks to improve the outcomes of the teaching of a particular module.

The project we describe involves the development and implementation of group-work based tutorials in a large service teaching module. We consider the group-work described below to be an example of *cooperative learning*: a structured, systematic instructional strategy in which small groups work together toward a common goal (Cooper and Mueck, 1990). Cohen (1994) specifies further a key part of this definition, that is, a situation in which students work together in a group small enough that everyone can participate on a collective task that has been clearly assigned.

The call for a move towards cooperative learning in mathematics can be traced back to at least the 1980's (Springer, Stanne and Donovan, 1999). As described in that paper, there is no single theoretical base for group-work as a pedagogical strategy, and a variety of conceptual frameworks exist that draw on a wide range of fields including philosophy of education, cognitive psychology, social psychology and humanist and feminist pedagogy (Springer et al., 1999, p. 24). We will appeal principally to the conceptual framework described by Cohen (1994) and elaborated further by Cohen and Lotan (1997).

Thus group-work is now well established as a teaching approach (Cohen, Manion and Morrison, 2006), and its credentials as an approach that underpins successful teaching and learning can be said to be equally well established. In relation to the use of group-work in primary and second level education, "meta-analyses have consistently reported that cooperation has favorable effects on achievement and productivity, psychological health and self-esteem, inter-group attitudes, and attitudes toward learning" (Springer et al, 1999, p. 23). This meta-analysis reports similarly positive outcomes in relation to cooperative learning of science, mathematics, engineering and technology at third level: "The magnitude of the effects reported … supports more widespread implementation of small-group learning in undergraduate SMET" (Springer et al, 1999, p. 21).

A list of advantages of group-work in teaching is offered by Cohen et al (2006, p.199): nineteen different features are identified. Group-work is noted as a characteristic of mathematics teaching in countries rated as high achieving in the 1995 and 1999 TIMSS mathematics assessments (Conway and Sloane, 2005). It noteworthy that group-work was not found to be a feature of Irish mathematics classrooms in a study carried out before the introduction of Project Maths (Lyons, Lynch, Close, Sheerin and Boland, 2003).

Cooperative learning is at the heart of the work of Elizabeth Cohen and colleagues that seeks to embed an equitable approach to teaching in heterogeneous classrooms. An important element of this work has been the drive to establish the conditions for productive learning in small groups (Cohen 1994). This has led to the notion of *complex instruction*, the nature of which is outlined in (Lotan, 1997). This overview article begins with the following definition:

> Complex instruction is a pedagogical approach that enables teachers to teach at a high intellectual level in academically, linguistically, racially, ethnically as well as socially heterogeneous classrooms (p.15).

This approach entails a combination of a specialised curriculum based on open-ended tasks, cooperative student groups and a set of organisational arrangements that seek to maximize the benefits of cooperative learning for students. These arrangements include the structuring and assigning of roles within the groups, but relate more importantly to the role of the teacher. A crucial part of this role is to maximise the number of interactions between students. Given the sociological origins and intent of complex instruction, it is important to realise that this refers to *all* students, and particular teaching strategies are described that seek to meet this aim by addressing issues of status within student groups. These strategies are the adoption of a multiple-ability orientation, and assigning competence to low-status students. In adopting the former, teachers "widen their own and their students' conception of 'smarts'" (Lotan, 1997, p.23). Teachers assign competence to low-status students when they draw particular attention to the contributions of such students and thereby elevate the status of these students within the group (Lotan, 1997, p.23).

Drawing on work of sociologist Charles Perrow on organisational structure, Cohen, Lotan and Holthuis (1997) posit three propositions that form a framework describing conditions for productive cooperative learning. The first of these is that when working on open-ended tasks, "…the extent to which students talk and work together will be related to organisational effectiveness" (Cohen et al, 1997, p. 33). Thus the teacher should seek to maximise task-related interaction between the students, described as *lateral relations.* Recognising that open-ended tasks lead to uncertainty on the part of students, the second proposition asserts that "…the more frequently the teacher uses direct supervision, the lower will be the rate of lateral relations among students" (Cohen et al, 1997, p. 34). The notion of direct supervision, and its obverse, *delegation of authority*, is important here. Direct supervision refers to such teacher actions as informing, instructing or defining; disciplining; asking a factual question. Actions such as stimulating higher-order thinking, making connections, talking about multiple abilities and assigning competence lie outside the domain of direct supervision. Thirdly, the authors note the link between the number of different tasks on which different student groups are engaged and the opportunity for the teacher to delegate authority.

Combining these propositions allows the authors to present a summary theoretical framework:

> differentiation → delegation of authority → lateral relations → effectiveness (Cohen et al, 1997, p. 35)

This article concludes by presenting evidence that supports this framework in terms of the existence of the appropriate correlations based on observations of a total of 50 different classes. Further discussion of the effectiveness of complex instruction is presented in the four chapters of Part V of Cohen and Lotan (1997). See also (Boaler and Staples 2008), and an account of the effectiveness of this approach to teaching in (Boaler 2009).

Next, we seek to draw connections between the notion of delegation of authority as described above and a teaching and learning strategy that emphasises questioning and prompting of students (Watson and Mason, 1998). This strategy seeks to engender mathematical thinking capacities in students. These capacities are listed, and include such activities as exemplifying, generalising, justifying and explaining. The teaching approach involves the use of explicitly given questions (generally open or leading questions) and prompts designed to lead the student to engage in a particular form of mathematical thinking. For example, for the capacities of "Exemplifying/Specialising", we find

> Give me one or more examples of .. / Is .. an example of ..? / Find a counterexample of … (Watson and Mason, 1998, p.8)

We take the view that in asking such questions and offering associated prompts, the teacher is not engaging in direct instruction, and so is delegating authority. Thus, appealing to the framework described above, this approach to teaching should support effective group-work.

Finally, we note the importance of ground rules (or cooperative norms) for group-work and of assigning roles within groups (Cohen et al 2006, Cohen 1994).

THE TEACHING PROJECT

Overview

The project involved developing and implementing a peer-supported group-work tutorial system for the first year module MS136 (Business Mathematics). Post-graduate tutors, peer tutors and the module coordinator/lecturer (BN) provided the teaching for these tutorials. Students were assigned to a specific group in a particular tutorial, and were given a different role each week. The majority of groups contained four students; a small number contained three, with at most seven groups in each tutorial. Preparatory work was assigned and attendance/participation was compulsory: continuous assessment marks were awarded for participation in the tutorials. A training workshop for tutors was developed and delivered, and the curriculum for the module was adapted to the new tutorial regime.

The module

MS136 is an introductory level calculus module, closer to Ordinary Level Leaving Certificate (LC) mathematics than Higher Level. The module includes procedural content in the context of business and economics, and an element that seeks to develop students' mathematical thinking capacities. This is a service course taught to some 400 students on 11 different programmes. The mathematical prerequisite is grade D3 or higher in either Ordinary or

Higher Level LC mathematics. Students attend two lectures and one tutorial for each of the 12 weeks of Semester One. Assessment is in the form of two multiple-choice in-class tests given in weeks 7 and 12 (7.5% each), and one terminal written exam (85%). The module suffers from persistently high failure rates (30-35%) and low levels of lecture and tutorial attendance.

A peer-supported group-work tutorial programme was introduced in 2010-11. This included an amendment of the assessment schedule: 5% of the total for the module was awarded for attendance and participation in the tutorials, leaving 5% for each of the two multiple-choice in-class tests. Many key aspects of the module were unchanged: the same lecturer, syllabus, examination and class-test structure and content remained in place from previous years.

Tutor training

The importance of teacher preparation for the implementation of group-work is emphasised by both Cohen, Manion and Morrison (2006) and Lotan, Cohen and Morphew (1997). In developing a training workshop for the group-work tutors, we were cognisant of the principles of effective group-work as laid out above. Thus we sought to address the key issue of encouraging participation on the part of students during the tutorials.

The training workshop was developed by a project team comprising the authors and three experienced post-graduate mathematics tutors from DCU. A SWOT analysis on group-work was carried out in July 2010 which led to basing the training workshop on the five elements discussed below. These were developed over July/August 2010 and delivered to the group-work tutors at the beginning of the academic year 2010-11.

Introduction to group-work tutorials

This element of the training workshop involved a discussion of the basic principles of and rationale for group-work. We discussed how group-work benefits students and outlined the role of the tutor in group-work tutorials.

The first tutorial

This part of the workshop was designed to enable the tutors to introduce their students to group-work. This was done by having the tutors themselves experience the activities scheduled for the first tutorial. In order to translate the principles of the *Introduction to Group-work Tutorials* to a meaningful experience, the tutors engaged in three activities: an ice-breaker that allowed students to introduce themselves to one another; a communication task that sought to build an appreciation of the importance of working cooperatively and a personalities task that sought to build an appreciation of the need for awareness and respectful communication with other group members. (In the tutorials themselves, the first tutorial also included an exposition of the ground rules for group-work.)

Case study of group-work

In this session, tutors read and took part in a structured discussion based on a fictional account of a (mildly) dysfunctional group. This built on previous work of one of the authors using case studies in tutor training (Nolan, 2008). This seeks to confront prospective teachers with some of the issues that they may encounter in the classroom. The students discuss these issues and potential resolutions, and thereby prepare for similar situations that arise in their teaching. The issues in this case relate to the group failing to adhere to the ground rules for group-work.

Ground rules, conflict resolution and grading

The fourth element of the workshop involved a discussion of the ground rules for the tutorials devised by the project team. Advice on resolving difficulties between group members was also given, and post graduate tutors were instructed on their role in grading students. Grading was based on a 'tick' system. Students were instructed to (i) carry out preparatory work for the tutorial; (ii) arrive on time and (iii) engage with the worksheet and their group during the tutorial. A failure on the part of the student in any one of these resulted in a tick against the student. Full marks were awarded if a student had no ticks; half marks if there was one tick, and no marks if there were two. Leniency was promoted within this system.

Questioning skills for group-work

The final part of the workshop involved a session developing tutors' questioning skills. This was based on the work of Watson and Mason described above (Watson and Mason, 1998). Included here was a video case study that allowed the tutors to critique the questioning approach taken by a tutor in a fictional setting.

Ground rules

The following ground rules for group-work tutorials were devised by the project team. These were informed by the SWOT analysis of July 2010, which in turn was informed by the research literature on group-work, in particular the discussions of Cohen, Manion and Morrison (2006) and Cohen and Lotan (1997). In summary, these rules stipulate: (i) active participation; (ii) mutual respect; (iii) talking and listening equally; (iv) no-one is finished until everyone is finished; (v) giving answers is not helping – give explanations when helping; (vi) call the tutor for group questions only; (vii) arrive on time; (viii) carry out assigned preparatory work; (ix) adhere to your role.

The guiding principal of these ground rules was that they must engender discussion on the part of the students. Likewise, we see these ground rules (cooperative norms in the language of Cohen (1994)) as an effort to adopt the perspective of complex instruction that organisational arrangements are central to effective cooperative learning.

The peer tutors

There is an extensive literature on peer tutoring in third level mathematics which is beyond the scope of the present article. Here, peer tutoring describes the involvement of second year students in tutoring their first year peers. The project was advertised in April 2010, and the tutors were recruited in August 2010. The only qualification was that the prospective tutor must have passed the module MS136 in the academic year 2009-10. Twelve second year students participated in the project. They were paid the hourly undergraduate demonstrator rate for this work. The tutors took part in the training workshop in September 2010.

Tutorial structure

Each of the 414 students enrolled in the module was assigned to a one-hour weekly tutorial based on their programme timetable. They were then randomly assigned to a group of four within their tutorial. (A small number of groups had only three members.) There were either six or seven groups in each tutorial. Teaching was provided by one postgraduate tutor or academic staff member, and one or two peer tutors. Each student was assigned a colour code: red, yellow, purple, green (R, Y, P, G). Tutorial worksheets were available on Moodle at least one week before tutorials. Each question was assigned to two of R/Y/P/G: these questions were to be attempted by those students in advance of the tutorial. In tutorials, students were asked to discuss questions and to work together and with tutors to develop complete solutions. The first tutorial, as described above, formed an important part of the teaching.

The group roles comprised chair, recorder and ordinary members, and rotated weekly. The role of the chair was to ensure that the group adhered to the Ground Rules and kept to the tutor's time-keeping guidelines. The recorder was asked to keep a legible version of the group's work on each tutorial sheet question. They also had the task of providing the other members of the group with a copy of these solutions within one day of the tutorial. Ordinary members were given the task of co-operating with the recorder in providing solutions to their assigned exercises. All students had the task of working cooperatively on the worksheets.

We note that this structure was significantly different to that of previous years, where attendance was not compulsory, and tutorials focussed on students working individually or in *ad hoc* groups with the assistance of the tutor.

Curriculum

The syllabus of MS136 had been devised in cooperation with client Schools in DCU over the course of several years. Thus the project did not entail any revision of the syllabus. For the group-work tutorials, questions that sought to promote student interaction were included. Thus the following four question types were included: definitions; example generation; true or false questions; procedural questions. (All four question types appeared in the terminal examination: the example generation and true or false questions formed a compulsory question worth 25% of the total.) The first type question type could be described as "take out your notes and look something up". The second and third question types were of crucial importance to the project. It was with these that we hoped to engender meaningful lateral interactions on the part of the students. Watson and Mason (2005) have written extensively on the use of example generation in learning mathematics. We claim that questions of these two types had not previously been encountered by the students in the context of mathematics. We base this conclusion on our knowledge of the nature of textbooks, assessment material and the approach to teaching and learning in Irish secondary schools. See for example (O'Keeffe and O'Donoghue, 2009), (Lyons et al., 2003) and (State Examinations Commision, 2005). We anticipated difficulties with these questions by spending lecture time on a discussion of their nature and strategies for answering them. We note that while the more conceptual questions played an important role in relation to engendering cooperative work, the procedural questions played an equally important role in terms of the module learning outcomes.

RESULTS

We note two points. First, our implementation of group-work sought to draw on the ideas of complex instruction, but we do not claim that it provides an example of this teaching approach. This has implications for the data gathered in the course of the project. We did not seek to carry out classroom observations or measure the correlation between the instances of lateral relations and effectiveness. Second, our principal aim with this teaching project was to increase the effectiveness of the module in the narrowly defined terms of assessment marks. The results we present seek to address this, and seek to understand the impact of the group-work tutorials through the use of a student survey, and through the authors' reflections on the project seen through the lens of the conceptual framework described above.

Attendance and participation

We recall the grading system used in the tutorials. Each student attended ten tutorials during the course of the module, and was awarded a mark of 0, 0.5 or 1 for each. These marks were totalled, and scaled to the 5% of the module total that was awarded for attendance and participation in tutorials. The spread of marks is summarised in Table 1.

These results indicate a high level of attendance and participation in the tutorials, and show what can be taken to be success in this regard. Nearly 63% of students earned a mark of 80% or higher. However it is of concern that even with the reward of marks that are not contingent on procedural ability in mathematical tasks, some 9% of students failed to earn marks in even one of the ten tutorials. It was exceptionally rare that a student who attended a tutorial did not earn a mark, so these marks correspond to students who did not attend any tutorials.

Examination results

There was a significant decline in exam performance in the module. Summary statistics are represented in Table 2, comparing the examination results with those of the corresponding examination from the previous academic year. The sharp decline is evident.

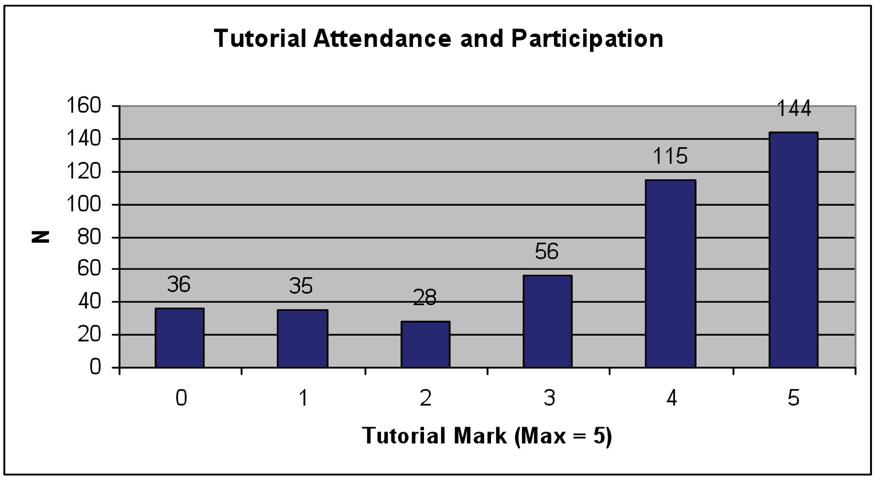

Table 1: Summary of marks for tutorial attendance and participation

	N	Mean	Median	Mode	Standard Deviation
2009-10	387	51	52	43	23.2
2010-11	379	40	38	26	18.6

Table 2: Summary statistics for examination results.

Correlations

We recall the breakdown of marks for the module: 5% for tutorials, 10% for in-class multiple-choice tests and 85% for the written examination. In Table 3, we present the correlation coefficients for the following pairs of marks: tutorial mark ("tutorial") and overall module total ("total"); tutorial mark and written exam mark ("exam") and tutorial mark and class test mark ("test"). We note a positive correlation in all three cases. There appears to be a strong short-term gain: successful participation in the tutorials is strongly associated with the class tests that take place during the teaching period of the semester. However this association falls off sharply when we compare the tutorial mark with the exam mark.

Correlated Marks	Tutorial vs Total	Tutorial vs Exam	Tutorial vs Test
Pearson's R	0.52	0.39	0.77

Table 3: Correlation of tutorial and other assessment marks

Survey results

Students who had taken the module were asked to complete an online survey on the tutorial system in the second semester of 2010-11. Following a familiar pattern, participation in this survey was very low (10% response rate). The survey contained ten statements with responses called for on a Likert scale offering options from *strongly agree* to *strongly disagree*. We summarise responses from the five questions we found to be of most interest.

I found the maths tutorials helpful in terms of learning the course material: 50% of students gave responses in the *disagree* categories.

I found the maths tutorials helpful in terms of passing the exam: here, 55% of students gave a response in the *disagree* categories.

The tutors in my tutorial were helpful: There was a more equal split here, with 40% disagreeing or disagreeing strongly and 43% agreeing or agreeing strongly.

Apart from learning maths, there are advantages to having group-work tutorials: Here, we found that 78% of students either agreed or agreed strongly with this statement.

Overall, the group-work tutorials for maths are a good idea and should be continued. Again, an even split, with 48% in the *disagree* categories and 50% in the *agree* categories.

DISCUSSION

As we have seen, the outcomes of the project were very mixed. Inasmuch as the principal aim was to address the high failure rate in the module, the examination results point to a failure of the project. In fact the decline in the examination results was so extreme that other sources of an explanation for this drop were sought. These were found: we hypothesised that the decline was due to examination questions that may have been considered ‘unpredictable’ by students.

We also see mixed results in relation to the students’ attitudes to the group-work tutorials. However, one positive outcome was the students’ recognition of benefits other than learning maths of the group-work tutorials. This is perhaps reflective of the wider sociological and personal development benefits of cooperative learning (Springer, Stanne and Donovan, 1999). One area of success of the project was the high rate of participation in the group-work tutorials. This high rate associated with short-term procedural competence as seen in the correlation between participation in the group-work tutorials and marks in in-class tests.

Based on feedback from the tutors, and on the first author’s experience working as a tutor, we note that this success reflects the observation that a significant amount of cooperative learning did indeed take place in the tutorials. Likewise, the predicted difficulties arose in relation to withdrawal from the group by individuals, or its domination by others. Tutors also reported the difficulty of adhering to the principles of complex instruction, mainly in terms of acting in ways that embodied delegation of authority and refraining from direct instruction. This is perhaps unsurprising given Cohen and Lotan’s (1997) description of the intensive professional development needs of teachers who seek to undertake complex instruction.

The tutors as a whole also reported that students spent a disproportionate amount of time on the example generation and true/false questions. This may have been at the cost of developing their procedural competence. This observation is reinforced by data from the Maths Learning Centre (which provides a drop-in service that students can attend for one-to-one assistance with mathematics) which shows that 33% of the students in MS136 attended a drop-in session during the semester, making a total of 352 visits between them. These students primarily asked for help with the “example generation” and “true or false” questions. Anecdotally, with the former, their greatest struggle seemed to be the fact that there could be more than one correct answer when asked for an example; with the latter, the true/false questions demanded a fuller understanding of the material than many students appeared to have. In terms of the operation of the tutorials, frequent complaints included the fact that other group members were “slowing them down” so that their group did not finish the full tutorial sheet by the end of the tutorial; that they felt embarrassed and under pressure when they were unable to contribute anything to the group for the questions they were meant to have attempted in advance; and that not all group members were pulling their weight, regardless of the structures in place. This speaks to a shortcoming in terms of the tutors’ ability to adopt a multiple ability orientation and to assign competence to students in the appropriate way (Lotan 1997).

We speculate that the mathematical thinking exercises may have ‘distracted’ students from what could be described as more pragmatic and strategic examination preparation. Asking students to engage in mathematical thinking is asking them for a long-term commitment (Mason, Burton and Stacey, 1982): a 12 week, one hour per week programme that follows (for many students) 12 years of direct instruction is likely not sufficient for students to adopt the dispositions that underpin the benefits of mathematical thinking.

REFERENCES

Boaler, J. (2009). Equity and high achievement: the case of Railside School. In D. Corcoran, T. Dooley, S. Close, and R. Ward (Eds.), *Proceedings of the Third National Conference on Mathematics Education MEI3* (pp.2 -19). Dublin: MEI.

Boaler, J & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of Railside School. *Teachers' College Record. 110*(3), 608-645.

Burke, G., Mac an Bhaird, C. and O'Shea, A. (2012). Monitoring students' engagement with mathematics at third-level. In P. van Kampen, B. Nolan, O. Finlayson, (Eds.), *ESTABLISH | SMEC 2012 Teaching at the heart of Learning*, (pp. 50-53). Dublin: Dublin City University.

Cleary, J. (2007). Diagnostic resting: An evaluation 1998 – 2007. In S. Close, D. Corcoran, and T. Dooley (Eds.), *EProceedings of the Second National Conference on Mathematics Education MEI2* (pp.216 -228). Dublin: MEI.

Cohen, E.G. (1994) Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, *64*(1), 1-35.

Cohen, E.G. and Lotan, R.A. (Eds). (1997). *Working for equity in heterogeneous classrooms.* New York: Teachers College Press.

Cohen, E.G., Lotan, R.A., and Holthuis, N.C. (1997). Organising the classroom for learning. In Cohen, E.G. and Lotan, R.A. (Eds.), *Working for equity in heterogeneous classrooms* (pp. 31-43). New York: Teachers College Press.

Cohen, L., Manion, L and Morrison, K. (2006). *A guide to teaching practice.* London: RoutledgeFalmer.

Conway, P. and Sloane, F.C. (2005). *International trends in post-primary mathematics education.* Dublin: NCCA.

Cooper, J., & Mueck, R. (1990). Student involvement in learning: Cooperative learning and college instruction. *Journal on Excellence in College Teaching, 1*(1), 68-76.

Faulkner, F. (2009). The changing profile of third-level service mathematics students (1997-2008). In D. Corcoran, T. Dooley, S. Close, and R. Ward (Eds.), *EProceedings of the Third National Conference on Mathematics Education MEI3* (pp.355 - 366). Dublin: MEI.

Gill, O and O'Donoghue, J (2007). Service Mathematics in Irish universities: Some findings from a recent study. *Adults Learning Mathematics – An International Journal, 2*(2), 6-19.

Gill, O. and O'Donoghue, J. (2005). What counts as service mathematics teaching in Irish universities? In S. Close, T. Dooley, and D. Corcoran (Eds.), *EProceedings of the First National Conference on Mathematics Education MEI1* (pp.279 -290). Dublin: MEI.

Hiebert, J. S. and Grouws, D.A. (2007). The effects of classroom mathematics teaching on students' learning. In F.K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371-404). Charlotte, NC: National Council of Teachers of Mathematics.

Hoban, R., Finlayson, O. and Nolan, B. (2011). Mathematical transfer: Studies of students' abilities in transferring mathematical knowledge to chemistry. In T. Dooley, D. Corcoran, and M. Ryan (Eds.), *EProceedings of the Fourth National Conference on Mathematics Education MEI4* (pp.215 -226). Dublin: MEI.

Lotan, R.A. (1997). Complex instruction: An overview. In Cohen, E.G. and Lotan, R.A. (Eds.), *Working for equity in heterogeneous classrooms* (pp. 15-27). New York: Teachers College Press.

Lotan, R.A., Cohen, E.G. and Morphew, C.C. (1997). Principals, colleagues and staff developers: The case for organizational support. In Cohen, E.G. and Lotan, R.A. (Eds.), *Working for equity in heterogeneous classrooms* (pp. 223-239). New York: Teachers College Press.

Lyons, M., Lynch, K., Close, S., Sheerin, E., and Boland, P. (2003). *Inside classrooms: The teaching and learning of mathematics in social context*. Dublin: Institute of Public Administration.

Mason, J., Burton, L. and Stacey, K. (1982). *Thinking Mathematically*. London: Pearson.

Ní Fhloinn, E. (2009). Diagnostic testing in DCU: A five-year review. In D. Corcoran, T. Dooley, S. Close, and R. Ward (Eds.), *EProceedings of the Third National Conference on Mathematics Education MEI3* (pp.367-378). Dublin: MEI.

Nolan, B.C. (2008). Using case studies in a mathematics tutor training programme. In Green, D. (Ed.), *Proceedings of the CETL-MSOR Conference 2007*. Loughborough: Maths, Stats and OR Network Publications.

O'Keeffe, L. and O'Donoghue, J. (2009). Assessing the effect of mathematics textbook content structure on student comprehension and motivation. In D. Corcoran, T. Dooley, S. Close, and R. Ward (Eds.), *Proceedings of the Third National Conference on Mathematics Education MEI3* (pp.283-294). Dublin: MEI.

Springer, L., Stanne, M.E. and Donovan, S.S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering,and technology: A meta-analysis. *Review of Educational Research*, *69*(1), 21-51.

State Examinations Commission, (2005). *Leaving Certificate Chief Examiner's Report – Mathematics*. Athlone: State Examinations Commission. Retrieved on 20th May 2013 at http://www.examinations.ie/archive/examiners_reports/cer_2005/LCMathematics.pdf

Watson, A. and Mason, J. (1998). *Questions and prompts for mathematical thinking.* Association of Teachers of Mathematics.

Watson, A. and Mason, J. (2005). *Mathematics as a constructive activity: Learners generating examples.* London: Routledge.