SUPPORTING MATHEMATICAL LITERACY IN POST-PRIMARY SCHOOLING: ISSUES TO CONSIDER WHEN USING A CO-TEACHING APPROACH

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This paper reports on the evaluation of co-teaching as a model for supporting mathematical learning from the student perspective. Research instruments included student surveys and focus group interview, along with semi-structured observations of lessons. The findings indicated consensus from students, both with and without SEN, that co-teaching was a favourable way of delivering mathematics lessons. Benefits included increased opportunities to get a teacher's attention; being more comfortable asking questions; greater range of learning experiences; and, the availability of assistance in a discreet way. These benefits afforded by the use of co-teaching provide learning contexts for developing mathematical literacy skills.

INTRODUCTION

This paper reports on the evaluation of co-teaching as an approach to support all students in the mathematics classroom, including those with special educational needs (SEN), and extrapolates implications for supporting the development of mathematical literacy skills. The study evaluated the co-teaching initiative of the special education teacher (SET) and the mathematics teacher from the perspectives of students and teachers involved; this paper reports on the student perspective only and centres around the following research question: What are the viewpoints, both positive and negative, of post-primary school students in relation to their co-taught mathematics lessons?

LITERATURE REVIEW

Mathematical literacy is defined as "formulating, employing and interpreting mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena" (Organisation for Economic Co-operation and Development [OECD], 2017). This requires students to grasp the mathematical concept and to be able to express their understanding clearly. Further, mathematical literacy is associated with social practice and culture (Jablonka, 2003) and, while this is often considered on the macro-level of society generally, it might also be considered at the micro-level of the classroom wherein culture exists and is influenced by teaching strategies and approaches used therein which, in turn, influence the social interactions of both teachers and students. Co-teaching offers a model of supporting student learning by increasing the level of interaction between teacher and student as well as between students themselves and therefore, offers a context for enhancing the development of mathematical literacy skills in an inclusive manner whereby teachers can anticipate and respond to individual differences in the context of everyone (Florian, 2008).

There are six models of co-teaching widely reported in the literature (Friend, Cook, Hurley-Chamberlain & Shamberger, 2010; Moorehead & Grillo, 2013), namely *one teach, one assist;*

station teaching; parallel teaching; alternative teaching; teaming; and *one teach, one observe* (see Figure 1). Research confirms *one teach, one assist* as the most dominant model in practice (Friend et al., 2010).

Figure 1: Diagrammatic Representation of Co-Teaching

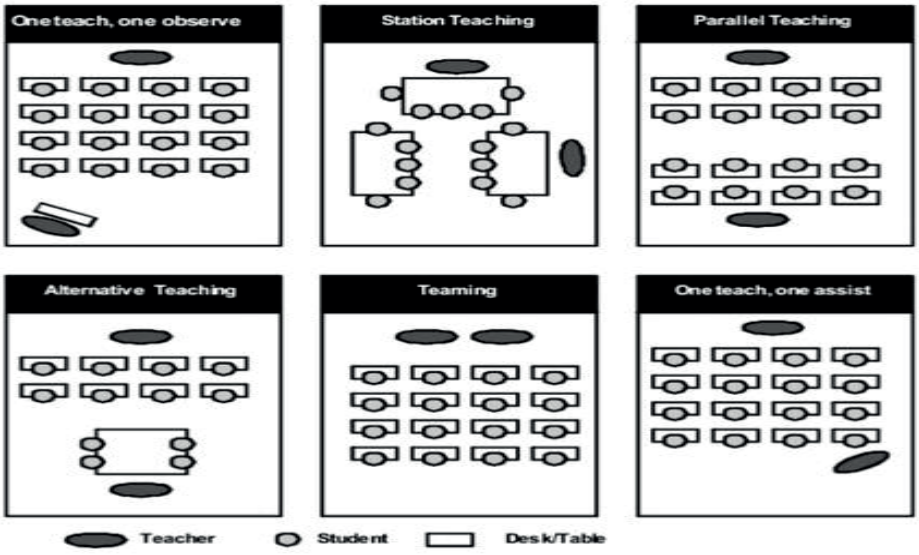

Image from Friend and Bursuck (2009), as cited in Friend et al., 2010, p.12.

It is accepted that the research base surrounding co-teaching in mathematics is extremely limited (Magiera & Zigmond, 2005), with a review of special education and mathematics literature concluding that only one fifth of empirical studies concerned students at second level, while none focused on co-teaching (Van Garderen, Scheuermann, Jackson & Hampton, 2008). Despite this dearth of primary research, some insight into how co-teaching can theoretically be utilised successfully in mathematics classrooms is available. For instance, Moorehead and Grillo (2013) outlined how stations can be arranged for re-teaching, independent practise and problem-solving activities, thus giving opportunities for development of mathematical literacy competencies such as reasoning, argumentation and mathematical communication (Rizki & Priatna, 2018). This use of stations may also facilitate both teachers having a strong voice in the classroom, all the while promoting superior literacy development for students.

Successful strategies for the teaching of mathematics to students with SEN include explicit instruction (Doabler & Fien, 2013) and scaffolding (Bakker, Smit, & Wegerif, 2015). In addition, comprehension can be increased if students are comfortable with mathematical vocabulary, which can be taught by stimulating prior knowledge, repetition and differentiated instruction (Riccomini, Smith, Hughes, & Fries, 2015). Co-teaching may be an effective way of incorporating these strategies into lessons to support the mathematical literacy of all students. The presence of two teachers also maximises the opportunity to assess for learning to ascertain where a student is at in their mathematical understanding informing the scaffolding and extension of that learning. As such, the combination of subject teacher and special education teachers' expertise may develop their vision of practice, knowledge of

students and content, as well as their repertoire of tools and practices, thus effectively supporting students during mathematical literacy during lessons (Ghousseini & Herbst, 2016). Of course, teachers need to question whether the second adult present is actually adding value to the lesson. This is particularly relevant at post-primary level, when subject matter is advanced, and special education teachers may not be mathematics specialists. Research suggests that special education teachers may need to become content specialists to ensure their preparedness to work in mathematics classrooms at this level (Murawski & Bernhardt, 2015). As the importance of parity between co-teachers is a recurring theme throughout the literature (Cook & Friend, 1995; Friend, 2008), this is an important factor to be borne in mind when allocating pairs to co-teach mathematics at post-primary level.

METHODOLOGY

The main participants in this study were a class group of 26 students of mathematics, aged 12 or 13 years, in the first year of a mainstream, urban, post-primary school, along with their two co-teachers, both mathematics specialists and one of whom was in the role of SET. Two students had special educational needs. This study comprised three phases, during which data were collected from students, teachers and an independent observer, over the duration of one academic year. This paper focuses on data collected from the student cohort; evaluative data collected from the teacher perspective is reported elsewhere (Carty & Farrell, 2018).

An illuminative evaluation approach (Parlett & Hamilton, 1972) was used to frame the first phase. Using a questionnaire, data were obtained regarding the students' perspectives on the existing co-teaching practice, where co-teaching had been in place for one term using primarily a '*one-lead, one-assist'* model. This illuminated students' perceptions of the positive aspects, as well as the elements of the class they found challenging. During an intervention period of seven weeks (32 class periods), five of the six models of co-teaching were used in the class (*one-teach, one-observe* was not used). Each model was used multiple times so students became familiar with the associated classroom routines. In ten of the lessons, two or three of the models were utilised. The post-intervention framework was evaluative in nature. Students were surveyed again with a focus on eliciting the impact of each co-teaching model from their perspective. In addition, four students took part in a focus group interview.

A grounded theory and content analysis were undertaken. The focus group interview was transcribed and coded. Similarly, responses to student questionnaires were coded ensuring missing data was considered. For each question, variables were defined and labelled. The use of SPSS facilitated interrogation of this data to include frequencies, measures of central tendency and investigation of statistical significance. The data collection instruments were employed to generate a range of data across all student participants, with the focus group interview giving a voice to the less literate students in the class.

RESULTS AND DISCUSSION

After one term of co-teaching, the pre-intervention time period, students were invited to fill in a questionnaire about their experiences in their mathematics class. There was a response rate

of 100% (N=26). Students were asked to rate various facets of their experience on a Likert scale, as well as being presented with three open-ended questions, allowing them to elaborate on the aspects of their lessons they enjoyed or those they found challenging.

Students' overall perceptions of existing co-teaching practice (pre-intervention)

It is notable that 24 students either agreed or strongly agreed with the statement that they liked their co-taught class. In addition, 25 students agreed or strongly agreed they could quickly get a teacher's attention when they needed to, while 21 indicated being comfortable asking questions. On the other hand, 8 students agreed they felt distracted at times, with another 8 students undecided on this question. Analysis of the three open ended questions showed the main benefit of co-teaching from the students' perspectives was the availability of help at all times (n=18). The option of asking for help discreetly (n=7) and the availability of a second teacher if there was a difficulty understanding the first one (n=7) were also noted by students. When asked for the main drawbacks, the most popular responses included difficulty with different styles of teaching (n=12), never having a free period in the subject (n=12) and no drawbacks (n=6). Students were also asked to identify if there was anything that would help in their learning of mathematics. More use of *station teaching* (n=8) and the incorporation of more fun activities (n=8) were the most popular responses, along with less homework (n=4) and more use of technology (n=4). Overall, students were very positive about the class, with the majority (n=21) indicating they would choose to be in a co-taught class again. Following analysis of the data from the pre-intervention stage, and in consultation with the class teacher, areas for improvement and refinement during the intervention phase were identified. These centred around development of students' mathematical literacy by utilising a much wider range of co-teaching models in class, as well as increasing the differentiation for all students through the use of technology and active learning methodologies.

Students' perceptions of the usefulness of each co-teaching model (post-intervention)

In analysing the extent to which students were becoming more mathematically literate, the students were happy to raise their hand and ask for assistance from both teachers equally, even during lessons where '*one teach, one assist'* was the model in use. Focus group interviewing reiterated that three out of four students said it did not matter to them which teacher led the class and which assisted the students, illustrating the parity of the teachers in the eyes of the students. The main advantage of co-teaching, and in particular '*one teach, one assist'*, from the students' perspectives was still the availability of help without having to disturb the class, reported in half (n=13) of students' questionnaires.

Station teaching was implemented in the classroom for four full and six partial lessons during the intervention phase. Stations were used for re-teaching, independent practise and problem-solving activities (Moorehead & Grillo, 2013). Analysis of student questionnaires revealed 23 positive statements relating to this model including freedom to choose which station to work at, effective for revision of topics and a feeling of independence during these classes. For instance, one student indicated that *"you could focus on things you were unsure of, and not do things you already knew"*, echoing literature reporting the advantages associated with students taking responsibility for their decisions (Murdock, Finneran & Theve, 2015), and the

importance of post-primary students not being subjected to a repeat of sixth class mathematics (O'Meara, Prendergast, Cantley, Harbison & O'Hara, 2019). Only nine negative statements were made by students about station teaching, of which the most common related to not getting to all stations and getting distracted at a station.

Fourteen students made positive statements about *Teaming*, while eight made negative assertions. Points in favour of the model developing mathematical literacy in students included it being an effective way of facilitating students to use appropriate tools strategically and look for, and express patterns in repeated reasoning (Hillman, 2014). Some students reported that concepts were easier to understand and made more interesting if both teachers explained them. Two students outlined that being shown multiple methods of solving a problem was confusing. Both teachers busy at the board, with none available for individual assistance, was also perceived by a minority of students as another drawback to this model. The major advantage of *teaming* is the importance of being able to approach a problem in a variety of ways for examination purposes (Jang, 2006). However, none of the students in this study identified this as a helpful aspect of the *teaming* model of co-teaching. Perhaps their young age, combined with inexperience of formal examinations meant the students in this study could, as yet, not appreciate the benefits of multiple approaches to problem solving.

Alternative Teaching represented the biggest talking point. Responses to the student questionnaire reveal 14 positive statements and 13 negative relating to this model. On closer inspection, it was noted that the responses were linked to whether a student was in the smaller or larger group. Students in the smaller group report it being an excellent way of gaining help following an absence, targeting the people who need the support and availability of assistance without disrupting the rest of the class. Students who found the model unhelpful report never being in the small group, difficulty getting a teacher's attention in the larger group and feeling distracted due to curiosity about what the smaller group were doing. Despite the teachers' concerns surrounding stigmatisation of the students by including them in the smaller group, both students with SEN chose it as their favourite model of co-teaching. The intense and individual instruction available in the small group appealed to the students. It is important to note that the teachers rotated the roles of working with small and large groups, both adding to their parity in the classroom and lessening the stigma associated with receiving additional support.

All participants in the study agreed that *Parallel Teaching* only worked if the two groups did not share the same physical space. During the intervention period, this model was trialled on five occasions, two of which were in the same physical space. For three of the classes, one teacher moved to another location, bringing half of the students. The main benefits of this model for students were that the smaller class size meant it was easier to concentrate and get a teacher's attention. The main drawback identified by students in relation to this model was the noise levels when both groups shared the same physical space, a finding reflected in the limited literature on this model (Cook & Friend, 1995).

Having examined the literature on co-teaching, it is evident there is a requirement for research to focus on specific models (Gurgur & Uzzuner, 2011), which this study has endeavoured to do. From analysis of the students' questionnaires following the intervention in total 125

positive statements were made regarding co-teaching, compared with 46 negative statements, of which, some would be viewed as positives, mirroring findings in the literature (Dieker, 2001; Wilson & Michaels, 2006). For instance, constant monitoring, pressure to stay on task and never getting free periods, though perceived negatively by students, could be positive in terms of developing mathematical literacy.

Several students praised the increased use of digital resources in the classroom. This use of technology, a key competency for mathematical literacy (Rizki & Priatna, 2018) resulted due to collaboration between teachers and was a direct consequence of co-teaching.

CONCLUSIONS

This study, although small-scale, indicates that co-teaching enhances student engagement and participation. It increases opportunities for student-teacher interactions and broadens the range of teaching strategies that can be implemented in a lesson. Many of the benefits of having two teachers as perceived by students provide them with increased exposure to experiences and skill development that enhance their mathematical literacy. For instance, opportunities to self-select the difficulty level of the mathematical task that they work on during station teaching reveal the willingness of students to push and challenge themselves, rather than choosing tasks that they could manage with ease, all the while progressing their mathematical skills. The use of stations also provided students with feelings of independence, which made their classes more enjoyable. As few people generally are willing to view the world through a mathematical lens, and many experience maths anxiety which reduces their willingness to engage in mathematics, let alone enjoy it (Turner, 2016), these findings indicate students show a positive disposition towards mathematics following the support and scaffolding co-teaching affords them.

Both students with SEN had high participation levels during lessons. One of these, who referred to the high levels of monitoring during mathematics as a drawback, conceded it was better for her overall. The other student, encouraged by the competitive aspect, thoroughly enjoyed working at her own level on digital challenges. As both students did not exhibit high levels of self-efficacy pre-intervention, these represented very positive outcomes in terms of developing their mathematical literacy. Considering the social aspect of mathematical literacy (Jablonka, 2003), the fact that students with SEN feel comfortable in the mainstream class is important in providing a context for the enhancement of their mathematical literacy skills in an inclusive setting.

Co-teaching is not firmly established in post-primary schools leading to a dearth of literature, particularly in the Irish context and especially in mathematics classrooms. Utilisation of all models provides teachers with tools to reach all learners and enhances the student experience, which leads to improved outcomes in terms of developing key mathematical competencies and literacy skills. There are implications also for teacher educators who are in the position of modelling the very teaching strategies they wish to develop in their student teachers (Hallett, 2010). Using the practice of co-teaching in their own instruction allows student teachers to experience the approach themselves (Farrell & Logan, 2018; Logan & Farrell, 2018) which

may influence their pedagogical decisions and practices when qualified in line with policy expectations (e.g. Department of Education and Skills [DES], 2017).

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