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Early Mathematics Teaching Practices for Students with Autism Spectrum Disorders

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ABSTRACT Teaching mathematics to students with autism spectrum disorder at a preschool level can be challenging for many teachers. The present study aims to explore teachers' pedagogical practices in early mathematics at selected preschools. Multiple site-case approaches were utilised. Three preschool teachers served as participants; data were collected through semi-structured interviews and classroom observations. The findings showed diverse teaching approaches that were integrated into the process of teaching and learning in the early mathematics classroom; these included lesson modification based on children's needs and materials as well as student-centred learning, play-based learning, and mastery learning. The teachers assessed the learning outcomes from assignments, tests, and teaching reflection. Also, the teachers received feedback from parents in improving their teaching practices. The study revealed some significant insights into teachers' teaching practices with children along the autism spectrum in developing appropriate and relevant pedagogical approaches for teaching early mathematics in the preschool classroom.

INTRODUCTION

Autism spectrum disorder (ASD) is a growing and complex neurological development condition that affects an individual's ability to interact with others (Yakubova et al. 2019). Children with ASD commonly have difficulties in socialisation, communication, overall cognitive processing and other skills. These deficits can cause issues when they want to learn a specific subject matter. According to a report by the Centers for Disease Control and Prevention of the United States in 2019, approximately one in 59 American students was diagnosed with ASD, as compared to one in 150 American students in the year 2000 (Centers for Disease Control and Prevention 2020). Thus, the data show an increase in overall prevalence of ASD has increased at a rate of approximately 150 percent in roughly the last two decades (Centers for Disease Control and Prevention 2020). Children with ASD fall into the category of special needs learners (Rose and Shevlin 2020). They need specific education services to accommodate their particular needs in learning. Therefore, early intervention programmes are important for young children with ASD as a means of reducing the complexity of their neurodevelopmental disorders (Hyman et al. 2020; Rose and Shevlin 2020).

In particular, mathematics necessitates careful planning for special needs students. It is an indispensable subject yet challenging for some youngster with ASD – especially in comprehending abstract concepts (Juliet et al. 2015; Peklari 2019). In fact, Mayes and Calhoun (2006) mentioned that nearly 25 percent of students with ASD had problems in learning mathematics. Such children require more time to link one concept to another in early mathematical problems; this is especially true for those with low cognitive abilities (Peklari 2019). However, acquiring early mathematics necessary skills would provide a foundation for these students with respect to basic knowledge and functional life skills (Bouck et al. 2017). For instance, mathematical knowledge of independent-living skills such as purchasing, measuring, saving, and estimating are essential for daily life routines (Juliet et al. 2015).

Myriad aspects of the teaching process can support meaningful mathematics-related classroom learning for students with ASD. Ideally, numerous instructional approaches are integrated within the early mathematics classroom (Gunn and Delafield-Butt 2016). The diversity of needs and learning styles in students with ASD suggest that no single approach can be

effective for all (Anderson et al. 2018). Indeed, past research (Bae et al. 2015; Juliet et al. 2015; Goodwin 2018; Garcia-Garcia et al. 2019; Peklari 2019) has shown that the use of diverse approaches facilitated the learning of mathematics for students with ASD. For instance, Juliet et al. (2015) applied systematic instruction in mathematics at preschool students with ASD. Skills were taught within the ongoing routines of the classroom instruction via music, movement, art, and other activities (Juliet et al. 2015). Garcia-Garcia et al. (2019) proposed that integrating physical activities such as play and games during mathematics instruction creates an interactive learning environment. Peklari (2019) as well as Thompson et al. (2019) argued for small group direct instruction, an approach that has shown promising outcomes when teaching ASD students.

On the other hand, the inappropriate use of diverse approaches in teaching mathematics can profoundly impede ASD students in their learning of the concepts. For example, Bryant et al. (2015) found inconsistent results when three different approaches were used during a mathematics session: teacher-mediated, technology-mediated, and a combination of the two. The participants in Bryant et al.'s (2015) study showed no positive results when the approaches were used in the classroom instruction.

In Malaysia, students with ASD are allowed to learn under the Special Education Integrated Programme (SEIP) (Ministry of Education [MOE] 2014). The teaching and learning sessions in the classroom are based on the National Standard Preschool Curriculum (NSPC) for Learning Disabilities. The NSPC document outlined diverse approaches for teachers to utilise such as (1) student-centred learning, (2) play-based learning, (3) inquiry-based learning, (4) project-based learning, (5) mastery learning, (6) contextual learning, (7) a thematic approach, (8) an integrated approach, and (9) learning based on the diversity of intelligence. The teachers can use the suggested approaches along with various learning resources to assist ASD students in acquiring basic knowledge and concepts in subjects such as mathematics and science.

Even though the use of numerous instructional approaches is able to support meaningful learning (Siregar et al. 2020), it is also crucial to conduct the evaluation of its effectiveness. Self-evaluations of teaching practices are needed in providing evidence for instructional change (Boston et al. 2015; Amua-Sekyi 2016; Anderson et al. 2018). Boston et al. (2015) further argued the importance of classroom observation to examine the quality of mathematics teaching practices in terms of using correct mathematical language, linking representations to abstract concepts, or focusing on patterns and generalisations. Apart from teaching evaluation, assessment of students with ASD's learning outcomes is also essential for helping teachers monitor their learning progress (Peklari 2019). Assessments of student learning are imperative because, as numerous researchers have contended and as Anderson et al. (2018) underscore, 'Children with ASD often show inconsistencies across and within domains of development' (p. 111).

Despite these concerns, research studies on ASD students' learning needs in early mathematics programmes remain limited. Many scholars have focused rather on social and communicative skill acquisition (for example, Bouck et al. 2017). Therefore, to address this gap, a study focusing on the teachers' practices of teaching early mathematics is crucial to supporting a meaningful learning environment for students with ASD.

Objectives

In the Malaysian context, most research studies on students with ASD have examined such areas as the perceptions of teachers and parents, community awareness, music education, software development, behavioural emotional, and social interaction (Toran et al. 2016). Hence, the present study was conducted to provide evidenced-based data on teaching approaches, student learning assessment, and teaching evaluation during early mathematics instruction for ASD students.

METHODOLOGY

Research Design

The present study adopted a partially concurrent mixed-method research design (Hitchcock and Onwuegbuzie 2020), where both quantitative and qualitative data were collected based

on multiple-sites cases. A case study is essential in education to enhance the understanding of a particular context, community, and individuals that are studied (Hamilton and Corbett-Whittier 2013). In this investigation, researchers utilised this design as a means of revealing various teaching practices in early mathematics in an in-depth fashion and from both teacher interviews and classroom observations.

Participants and Setting

Participants were designated via a purposive sampling scheme to provide the answers to research questions (Onwuegbuzie and Collins 2017). Explicitly, the selected teachers were instructing special needs students at two preschools and an autism centre. These three teachers (Teacher 1, Teacher 2, and Teacher 3) have a minimum of three years of teaching experience at their current placement. The teachers also have at least one autism student in their classroom; all of them were teaching early mathematics during the study course. Table 1 presents the selected demographics information of the three teachers.

Data Collection

The primary data for this study were derived from a semi-structured interview lasting 30–45 minutes. The interview sessions were recorded using an audio recorder; the interviews were then transcribed. Classroom observations were also conducted wherein data were collected using the Teacher Observation Schedule Mathematics TEKS Connection Follow Up (K–6) (Woods 2012) to support the primary data. During the class observation, a researcher rated in the checklist any occurrences on each item every 5 minutes. The researchers triangulated the data gathered from the interview and classroom observation sessions for a better understanding of the teaching practices (Hamilton and Corbett-Whittier 2013).

Data Analyses

The interview transcripts were returned to the three teachers (who were involved in the member checking for data accuracy. The transcripts from the interviews were coded into smaller significant units using the constant comparison analysis (Smulowitz 2017). This coding process resulted in some similarities and differences in the data that were organised into comparable themes to attain the research objectives. Further, the observation checklist data were analysed descriptively (frequency and percentage) via the IBM SPSS Statistics package to support the main findings from the interview.

FINDINGS

The following part is presented according to research objectives based on themes, as emerged from the triangulation of data collected from the interviews and observations.

Teaching Approaches

The findings demonstrated that the teachers had been teaching early mathematics according to the content in the National Standard Preschool Curriculum (NSPC) for Learning Disabilities, which covers the basics of mathematics knowledge for all students with special needs. However, teachers had latitude to make some modifications to their teaching approaches based on the various levels of cognitive, behav-

Table 1: Demographics information of the three teachers

	Teaching experience current place	*Total teaching experience*	*Education background*
Teacher 1 (preschool A)	10	13	Bachelor of Special Education and Diploma in Early Childhood Education
Teacher 2 (preschool B)	4	12	Bachelor in Early Childhood Education
Teacher 3 (autism centre)	3	4	Bachelor in Early Childhood Education and Postgraduate Diploma in Special Education (Autism)

ioural, and the learning abilities and deficits of the students with ASD in the classroom. Teacher 2 stated:

For students with autism, everything will depend on their strengths and skills during classroom sessions…If the students are excellent, I can teach the content continuously…but if they show some disruptive behaviour, I have to slow the pace of my instruction!

Once in a while, teachers taught students individually according to their learning needs and behaviours. According to Teacher 1, many students with ASD were unable to focus and give full attention when they were learning in a group setting.

Usually, I have to teach them one-to-one. However, when I was on a one-to-one session, the other students are left out and get distracted. They could not focus when they are in a group.

Teachers 2 and 3 regularly adapted the direct-instruction approach to help students with ASD in constructing mathematics knowledge. However, according to Teacher 2, this approach assisted ASD students to understand knowledge in terms of procedural actions. The teacher would repeat the same mathematics concept several times so that these students were able to acquire the knowledge. Quantitative data from class observations in Table 2 supported the interview data wherein the percentage of direct-instruction used for Teachers 2 and 3 is high (ranging from 83.3% to 100%); this shows that early mathematics teaching was focusing on mastery learning. Similarly, Teacher 1 (83.3%) put more emphasis on the seatwork approach, in which students were sitting at the desk, whereby the teaching session was focused on doing mathematics worksheets and utilizing textbooks.

During the interviews, teachers mentioned the use of various teaching aids and instructional materials in the forms of electronic and non-electronic resources to support teaching and learning. The teaching aids and instructional materials used were smart board (autism centre), interactive media (autism centre), concrete/ manipulable materials, CD player, television (TV), videos, laptops, and worksheets. For example, Teacher 2 also used songs played on the TV after break during school sessions to prevent the students from losing their focus and displaying disruptive behaviours. Teacher 2 claimed that watching a singing programme was a reward for the students after the first part of the learning session. Additionally, Teacher 2 praised the students after they completed the lesson, as a kind of reward. Teacher 2 noted:

Everyone loves watching television. Typically, students would have TV or games after a school break session; however, before the break session is a big NO about switching on the TV. I did it before and noticed the students with autism could not stay focused. So, for me, I want them to learn first. Then, I can reward them by watching television.

Teachers also utilised hands-on learning to attract the students' attention to participate in the learning process in the classroom actively. Teacher 3 provided many hands-on activities to enhance early mathematics learning. She commented:

I usually give them a lot of hands-on activities such as block and puzzle. Students with autism cannot sit still and learn. However, I cannot let them play for 100 percent during a class session because I want to discipline them.

Apart from hands-on activities, Teacher 3 also adopted role play about a real-life situation for the ASD students as a means of assisting them to comprehend a specific mathematics concept. According to Teacher 3:

When I want to teach the students about money, I will set up a shopping situation in the classroom. I print some paper sample money and provide some food to sell. I want the students to role-play the situation. This strategy is called learning through playing.

Table 2: Frequency and percentage of classroom setting

		Teacher 1 n (%)	*Teacher 2 n (%)*	*Teacher 3n (%)*
1.	Direct instruction (lecture)	2 (33.3)	5 (83.3)	6 (100.0)
2.	Seatwork (for example, worksheets, textbooks)	5 (83.3)	3 (50.0)	2 (33.3)
3.	Learner-centred (for example, cooperative learning, project-based, inquiry)	3 (50.0)	3 (50.0)	1 (16.7)

Teacher 3 believed the mathematics concepts become meaningful to students with ASD when they know how to use the concepts from a contextual learning perspective. Therefore, utilising everyday life applications during classroom instructions in early mathematics can help students visualise the concepts better. Teacher 3 said:

It is indeed the one that I always do. For example, in the determination of the day of the week, the students familiar with the name of days... like today, I will ask them what day today is? The same goes for months. So, that are examples of applications in real life.

From several classroom observations done to support the primary data from the interviews, it was found that the teachers integrated numerous teaching approaches (Table 3) in the early mathematics lessons. For instance, Teacher 1 used real money and a worksheet to teach a topic on currency (66.7%), and Teacher 2 utilised the number scrabble to explain a topic on the concept of numbers (83.3%). For Teacher 3, the use of smart boards and songs on YouTube to illustrate the concept of time in a day was exciting for the students (100%). It also showed that the children were engaged and active during the learning process. These teachers believed that the teaching approaches used were appropriate for the students in acquiring early mathematics knowledge and skills.

Assessment of Learning

The teachers were aware of and understood the importance of assessing students: by so doing, they could identify students with ASD who, developmentally, had gaps in their early mathematics understanding. It was also found that the teachers utilised class assignments as a method to measure the progress of their students in mathematics. For example, Teacher 1 used items from the exercise book to measure the learning progress of the students. Along the same lines, Teacher 2 focused on an assessment instrument that covers all core subjects (as contained in the National Curriculum Standard).

I did not do any tests, but I used the assessment instrument. That instrument covers all the subjects: Malay, English, Mathematics, and Science. The assessment followed the National Curriculum Standard.

In contrast, Teacher 3 performed a weekly assessment of mathematics to examine students' achievement in a way slightly different from those of other teachers. According to Teacher 3, the mathematics test was done weekly; students were prohibited from copying from friends and asking the teacher. Teacher 3 stated:

Usually, on Thursday, every week, I do an assessment test. Monday to Wednesday is a practice day for the students. So, after teaching the content, the students do some mathematics exercises. All the tables will be separated, the students cannot copy from a friend, and the teacher will not help.

Based on the classroom observations, the percentages of teachers did learning assessment ranged from 16.7 percent to 50.0 percent (Table 4). Specifically, the teachers utilised formal assessment of mathematics practices (for example, worksheets or exercise books following the mathematics lessons). It could be hardly seen that the teachers used other informal approaches in assessing the students' outcomes after each learning session. The teachers chose to conduct tests of paper and pencil in evaluating students' learning outcomes. Apart from assessing learning outcomes in mathematics, all teachers have continuously corrected students' perfor-

Table 3: Frequency and percentage of teaching aid used

	Teacher 1 n (%)	*Teacher 2 n (%)*	*Teacher 3n (%)*
1. Uses concrete models	4 (66.7)	5 (83.3)	0 (0.0)
2. Uses pictorial representations	1 (16.7)	6 (100.0)	3 (50.0)
3. Uses verbal (oral or written) representations	4 (66.7)	3 (50.0)	3 (50.0)
4. Uses tabular or graphical representations	1 (16.7)	0 (0.0)	3 (50.0)
5. Uses symbolic or numeric representations	1 (16.7)	3 (50.0)	3 (50.0)
6. Uses technology to present material	0 (0.0)	0 (0.0)	6 (100.0)
7. Assists students with technology	0 (0.0)	0 (0.0)	4 (66.6)
8. Uses technology as a communication tool	0 (0.0)	0 (0.0)	4 (66.6)

Table 4: Frequency and percentage of teacher behaviour

	Teacher 1 n (%)	*Teacher 2 n (%)*	*Teacher 3n (%)*
1. Praise student behaviour	2 (33.3)	1 (16.7)	5 (83.3)
2. Praise student performance	3 (50.0)	4 (66.7)	5 (83.3)
3. Correct student behaviour	6 (100.0)	4 (66.7)	4 (66.7)
4. Correct student performance	3 (50.0)	5 (83.3)	3 (50.0)
5. Assessment	1 (16.7)	3 (50.0)	2 (33.3)

mance and behaviour (ranging from 50% to 100%) to support the development of social and communication skills.

Evaluation of Teaching Practices

Based on the findings, the teachers engaged in self-reflection to examine the effectiveness of their instructional practices. For Teacher 2, reflection on the teaching (that is, feedback) was done through students' reactions during the learning process in the classroom:

For me, when I am teaching, I will look at their reactions. If I explain a particular mathematics concept, the students react, because sometimes, when we were teaching, the teacher asks a question, the teacher also will answer. If there is no response from the students that means maybe they do not understand nor are they interested. So, I am going to change the approach… Typically, during our teaching and learning session, during that time, if they do not like it, they will not respond ... if the students can make a response, I believed the students could get the content.

Meanwhile, Teacher 3 claimed that ASD students' ability to master a topic could reveal the impact of her teaching practices:

Evaluating my teaching practices will be based on students' understanding of a particular topic through classroom exercises. If there are 16 students but one student did not get it, I think my teaching is acceptable. Only one student needs a particular way to teach. But when I teach, if all students or more than half the class do not understand the topic that I taught, I have to use a different method to present the mathematics concept.

In addition, the teachers sought feedback from parents on their teaching practices. Teacher 1 sometimes received input from parents through daily communications with them. Similarly, Teacher 2 stated that a meeting with the parents is conducted at least twice a year (arranged by the school administration).

I meet with parents twice a year. During the first meeting, I ask parents to reflect on their child's performance from the beginning of the year. Usually, I receive both positive and negative feedback. In this manner, I use feedback to improve my teaching practices.

Moreover, Teacher 3 described that she gave a weekly report every week to the parents and made sure communication happened between the teacher and parents. Teacher 3 offered:

On Friday, I will return the assigned work (mathematics test) to parents and ask them to help the students at home. I firmly ask parents always to communicate and give feedback.

The teaching-practices evaluation would help teachers to cross-examine the suitability of their instructional practices in enhancing students' early mathematics learning. At the same time, the classroom observation data from Table 5 show teachers had redirected student's thinking ranging from 16.67 percent to 100.00 percent. In addition, the percentage of teachers showing interest in students' work was high (from 33.33% to 83.33). Teachers did encourage

Table 5: Frequency and percentage of teacher response

	Teacher 1 n (%)	*Teacher 2 n (%)*	*Teacher 3n (%)*
1. Redirect student's thinking	1 (16.7)	6 (100.0)	4 (66.7)
2. Show interest in student's work	5 (83.3)	5 (83.3)	2 (33.3)
3. Encourage student's to question	2 (33.3)	0 (0.0)	1 (16.7)
4. Encourage extended student's responses	0 (0.0)	2 (33.3)	3 (50.0)

students to question; this extended students' responses.

DISCUSSION

The findings of this study show that the selected teachers used various teaching approaches and made appropriate modifications of the lessons in supporting the ASD students; this is in line with Anderson et al. (2018). While these teachers put much emphasis on using direct instruction, they also adopted self-regulation, goal structure, concrete-representational-abstract, and Integrated Behavioral Experiential Teaching (IBET) appropriately during mathematics instructions, as suggested by Peklari (2019) and Thompson (2019). Additionally, teachers used individual teaching approaches that were practical and effective in instructing students with ASD (Anderson et al. 2018; Siregar et al. 2020). The data showed that teachers used play-based strategies and repetition techniques to help the ASD students master early mathematics skills. In fact, many past studies support these teaching approaches as effective for ASD students (Goodwin 2018; Garcia-Garcia et al. 2019). Specifically, Garcia-Garcia et al. (2019) suggested that play activity has allowed students with ASD to show their feelings, emotions, and ideas. On the other hand, the repetition teaching technique could assist in their long-term memorisation of abstract mathematics concepts significantly (Goodwin 2018). Throughout the classroom observation, we noticed that the teacher participants frequently asked the students to do mathematics worksheets practice in order to master the basic concepts. Both quantitative and qualitative data revealed that these teachers frequently used teaching aids and instructional materials such as smart board, blocks, puzzles, and songs to nurture and scaffold students' mathematical development. Teaching aids by Anderson et al. (2018), Bae et al. (2015) and Bouck et al. (2017) have been substantially shown to help ASD students learn mathematics.

Teachers in the present study efficaciously and continuously measured students' learning of early mathematics and teaching practices through formative and summative assessments. The data collected through interviews and classroom observations supported their practices in assessing students with ASD learning outcomes through assignments, quizzes, standard instruments, and parents' feedback. Amua-Sekyi (2016), Anderson et al. (2018), and Peklari (2019) argued for the use of various assessment strategies and indicators to assist teachers in examining the students' acquisition and development of early mathematics skills. Meanwhile, the evaluation of teaching practices and assessment of learning is a part of the improvement process in educational practices (Boston et al. 2015). Teachers are able to identify whether teaching activities involving students can produce the intended learning or vice versa from evaluations. Furthermore, the students' learning assessment and the evaluation of teaching practices can provide teachers with data on reviewing, designing, and creating meaningful and engaging instructional activities for individuals with ASD (Boston et al. 2015). It is interesting to note: the researchers found that the teacher participants did not solely focus on the early mathematics content. They also devoted attention to social skills and communication aspects, as mentioned by Bouck et al. (2017). The data from the classroom observations showed all teachers had emphasised promoting positive behaviour among their students with ASD while they learned early mathematics.

CONCLUSION

Effective teaching practices play an essential role in developing early mathematics knowledge for students with ASD. Teachers need to continually update and upgrade their teaching practices following the current educational development in acquiring meaningful pedagogical methods. Referring to the various difficulties facing students with ASD, the variety of approaches, strategies, and teaching techniques should be used and applied by teachers to suit their students with ASD needs.

RECOMMENDATIONS

It is hoped that the current study contributes and assists special education teachers in providing ideas on teaching practices to be used to educate students with ASD and thereby improve their mathematical growth. It is recom-

mended that further studies to be conducted to identify productive and meaningful instructional strategies that also support ASD students in acquiring early mathematics.

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