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Teachers' Professional Development with Peer Coaching to Support Students with Intellectual Disabilities in STEM Learning

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ABSTRACT: In recent years, STEM learning has become a new education initiative worldwide. However, little research has considered the needs of students with Intellectual Disabilities (ID) in this initiative. Believing that individuals with disabilities should be evaluated and defined by their capacity, strengths, and broad range of interests and abilities, this research investigated this less-explored perspective in STEM learning, namely supporting teachers providing STEM learning for ID students. Four teachers in two special schools for children with intellectual disabilities worked collaboratively with each other in their schools to plan and implement STEM learning. Peer coaching was recommended to the teachers in order to improve their planning of STEM learning and their teaching practices for teachers' professional development (TPD). The qualitative research methodology was used, and detailed analysis of teachers' pre- and post-TPD interviews and reflections to identify good practices that helped ID students accomplish the tasks and disparities that influenced peer coaching was performed. While challenging, with support from peers and due considerations of the special learning needs of ID students, this research provides useful insights for teachers to support ID students in STEM learning, including the use of technology in the STEM learning design, the consideration of inquiry learning based on students' abilities in implementation, and the focus on teachers' disparity and school involvement with peer coaching.

Keywords: Teacher professional development, STEM learning, Peer coaching, Students with intellectual disabilities

1. Introduction

1.1. Education for students with special educational needs

The application of a general curriculum for all students, including students with special educational needs, before the turn of the last century, was proposed by the Individuals with Disabilities Education Act (IDEA) in the United States. Later in 1997, amendments were made to the IDEA requiring that "individualized education programs of students with disabilities include information about student engagement in and access to the general curriculum" (Wehmeyer et al., 2001, p. 327). This was to raise the standards for students with disabilities to ensure they attained levels of proficiency similar to those of their peers without disabilities. In Hong Kong, it was not until 2001 that there was a call for a general curriculum for all students, the rationale of "One Curriculum for All" by the Curriculum Development Council (CDC) being that "all children, whether or not requiring special educational services, have basically the same needs and should not be distinguished from each other." (CDC, n.d., para. 2) The Hong Kong government adopts a dual-track mode of providing special education. The Education Bureau, subject to the assessment and recommendations of specialists and the consent of parents, refers students with more severe or multiple disabilities to aided special schools for intensive support services. Other students with special educational needs (SEN) attend ordinary schools. Among the 60 special schools in Hong Kong, the majority are schools for children with intellectual disability (ID).

1.2. STEM learning for students with mild intellectual disabilities

In recent years, STEM (Science, Technology, Engineering, Mathematics) learning has been considered equally important for all learners. It is advocated by the Education Bureau of Hong Kong that STEM learning should critically equip young people with the skills and knowledge they will need to succeed (Education Bureau, n.d.).

Yet, research studies (Hwang & Taylor, 2016; Obi, 2014) reported that students with disabilities were under-represented in the STEM learning initiative.

Students with ID were defined as “significantly subaverage general intellectual functioning existing concurrently with deficits in adaptive behavior. And manifested during the developmental period that adversely affects a child's educational performance” by the IDEA Amendments (IDEA, 2018, Sec.300.8). They are always considered to face difficulties in using memory strategies and metacognitive strategies, with significant limitations in their cognitive functioning, problem-solving and generalization of previous knowledge (Stavroussi et al., 2010). As this may limit ID students’ engagement in STEM learning, it aroused our attention to provide professional development (PD) support to teachers of special schools with ID students so that these students would not be deprived of STEM learning opportunities.

It is strongly encouraged by the National Science Teacher Association (NSTA) (2017) to develop strategies for overcoming barriers to ensure that all students benefit from good science education and achieve science literacy. Contrary to the misconceptions that students with disabilities cannot be successful in STEM (Bruce-Davis et al., 2014), researchers have suggested that, “for the pupils with mild intellectual disability, it is typical the superiority of the concrete and objective thinking, and their logical thinking is closely connected to reality and to concrete situations” (Dostál et al., 2016, p. 3). STEM learning is valuable for enhancing the quality of students’ daily life, especially for those students with disabilities, by equipping them with content knowledge and skills to solve complex problems in the real world (Hwang & Taylor, 2016; Obi, 2014).

There is an emphasis on the importance of science inquiry and teachers’ support with the provision of essential steps to manage the cognitive load of students with ID (Lee & So, 2014). There have also been suggestions to adapt STEM learning for ID students, suggesting: (1) breaking down tasks into smaller steps, (2) dividing the tasks based on students’ ability, (3) expanding background knowledge, (4) providing relevant tools, and (5) taking safety precautions (So et al., 2019). Besides, although problem-solving skills are the basis of all learning and are thus essential for ensuring access to the general curriculum for students with disabilities, these students have few opportunities to receive problem-solving training (Agran et al., 2002). STEM learning provides ID students with opportunities to develop their problem-solving skills in real-world settings.

1.3. Teacher professional development need for peer coaching on STEM learning

In the research of Margot and Kettler (2019), teachers felt that they lacked peer support, whereas they believed that if they were provided with united collaboration with peers, district support, prior experiences, and effective professional development, their efforts to implement STEM learning would be better received. Lee and So (2014) concluded in a previous study that teachers should take an active role in ensuring that the appropriate inquiry-based learning process is used to cater for students’ learning needs so as to develop their fundamental inquiry skills. Liew (2016) stated that, traditionally, the improvement of teaching practices has been left to individual teachers to work out on their own, and there has been a lack of support, feedback, or follow-up. Hence, the increasing challenges in teaching requires peer supports that offer more opportunities for teachers to engage in self-reflection, share their classroom experiences, and facilitate mutual growth in teaching.

The development of high-quality teachers positively affects students’ attitudes and motivation regarding STEM (McDonald, 2016). Peer coaching has been found to be an important tool for professional development. Peer coaching refers to the “sharing of information and experiences among two or more peer teachers to improve their teaching practice” (Hsieh et al., 2019, p. 2). The National Staff Development Council identified the concept of teacher peer coaching as part of the effective components for professional development programmes in 2001. Peer coaching was initially proposed in the in-service teacher professional development and then adapted for pre-service development since the 1980s (Lu, 2010). It was concluded that peer coaching offers unique advantages and much value for preservice teacher education. However, such teacher professional development programmes should empower the potential peer coaching for prospective teachers’ progress development, then organize, balance and be followed by constant evaluation. Peer coaching is widely used in teacher professional development (Wong & Nicotera, 2003; Zwart et al., 2007; Zwart et al., 2008), which attempted to enhance the quality of teaching and learning in the classroom. Thus, peer coaching has been used to equip teachers with early literary instruction, and has also been promoted in special education (Swafford, 1998).

Peer coaching may include out-of-class and in-class activities (Robbins, 1995; Showers & Joyce, 1996). Out-of-class activities include co-planning, study groups, problem solving, and curriculum development. In-class forms of coaching typically involve teachers in observing one another’s teaching. Pre-observation conferences set the stage for observations, and the teacher requesting assistance describes the desired focus of the observation. Postobservation conferences provide opportunities for the teacher and coach to discuss, analyse and reflect on classroom instruction.

1.4. The current study

In the implementation of "One curriculum for All," several hindrances have been identified that prevent students with ID from enjoying the same learning opportunities enshrined in the central curriculum. These hindrances are mainly related to teachers, and include: (1) teachers' skeptical perceptions and attitudes towards the change; (2) lack of guidance for schools to develop the necessary school-based curriculum and assessment system; (3) teachers' low expectations of students' learning needs and cognitive ability; and (4) lack of direction and training for teachers to change from skills-based instruction to developing students' cognitive ability and problem-solving skills (Humphreys, 2009; Li et al., 2009; Wong, 2015). Teachers' lack of knowledge and skills regarding how to include students with disabilities in their practices is a barrier to students' learning (Alston & Hampton, 2000). Therefore, peer coaching was employed in this teacher professional development to equip teachers well for STEM education for students with ID.

This research made reference to the design of STEM learning using contemporary technologies for mainstream students which have been found to be successful (Dogan & Robin, 2015). Professional development support was provided to teachers from special schools for children with intellectual disabilities to experience STEM learning in order to gain more knowledge and skills, and to practice the use of contemporary technologies. Afterwards, teachers were entrusted to apply the related skills and practices, with consideration of pedagogical concerns of students with ID and strategies to lower students' cognitive load for their better engagement in learning. Since STEM learning is a new initiative for special schools, peer coaching was recommended to the teachers involved in order to improve the planning and practices in the classroom. Figure 1 shows the conceptual framework of the research.

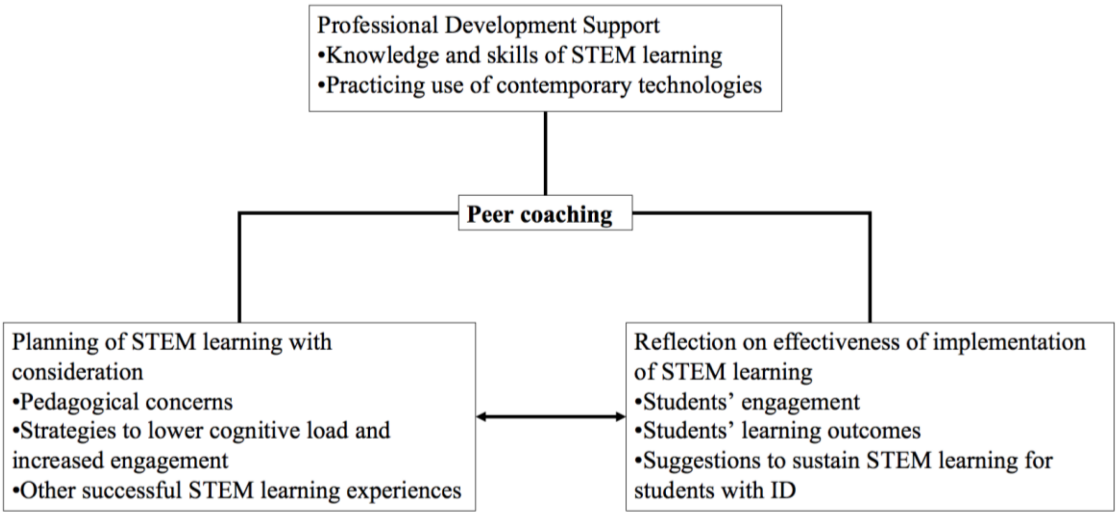

Figure 1. Conceptual framework of the research.

The following are the three research questions:

- What are teachers' prior perceptions of ID students' needs and peer support for professional development?
- How do teachers employ strategies in planning and implementing STEM learning to meet the needs of students with ID?
- How do teachers work by peer coaching in planning and implementing STEM learning for students with ID?

2. Methodology

2.1. Participants

The four teachers who participated in this teacher professional development support were from two special schools for children with intellectual disabilities with their classes of ID students. There were 10-12 students in each class, with students of different degrees of mild intellectual disabilities. Two teachers from the same school

(Teachers C1 and C2 from one school and Teachers K1 and K2 from another school) were considered as a peer group, and they all have at least 3 years of teaching experience in General Studies, a core subject at the primary level integrating science education, technology education, and personal, social, and health education, which is suggested in the primary school curriculum to provide students with appropriate STEM learning opportunities. The years of teaching experience and the subject background of the four teachers are summarized in Table 1.

Table 1. A summary of years of teaching experience and the subject background of the participating teachers

Schools	Years of teaching experience	Subject background
School C		
Teacher C1 (Male)	3 years of teaching GS	GS and IT
Teacher C2 (Female)	10 years of teaching GS	GS and Chinese language
School K		
Teacher K1(Male)	3 years of teaching GS	GS and IT
Teacher K2 (Female)	5 years of teaching GS	GS

2.2. TPD programme and procedure

The participating teachers took part in the following peer coaching support TPD events related to STEM learning:

(a) Teachers experienced and worked with some authentic STEM activities and contemporary technologies (e.g. coding device of Micro:bits, VR glasses, 3D printers, LEGO WeDo 2.0, App Inventor) designed by the research team in a 2-day workshop.
(b) The research team provided discussion on the pedagogical concerns from research studies on students with ID working on STEM or science learning.
(c) The research team introduced approaches to support students with ID in STEM learning by managing students' cognitive load.
(d) Taking into consideration the pedagogical concerns, teachers in peer groups worked on adapting and modifying one of the STEM activities they experienced during the workshop and planned for implementation in their own classes of students with ID.
(e) Teachers' reflection on the planning and teaching effectiveness with ID students at the end of the TPD support, followed by a debriefing session.

The peer coaching model of professional development (Liew, 2016; Soisangwarn & Wongwanich, 2014) that was used to improve student learning was recommended to the peer group by helping teachers to be involved in reflecting on their practice, while sharing successful practices and suggestions, and/or learning from and with their peers.

2.3. STEM learning design of the TPD programme

The topics selected by the school teachers from the two special schools (School C and School K) in this research were from the General Studies curriculum; one was about the design of an "Alarm system" under the topic "The Opium War" and the other one was about "Printing" technology under the topic "Four great inventions in ancient China."

In the Opium War alarm system topic, students first learned about the causes, processes and consequences of the Opium War. Afterwards, there was discussion of the use of different technologies including weapons, alarm systems, and communication systems during the war. The teacher made use of the old technology of alarms used during the Opium War to stimulate students to think about what they could design nowadays with contemporary technologies for an alarm system. This included a learning process which engaged the ID students in hands-on and minds-on opportunities, with the design of an alarm using the coding device of Micro:bit, which functioned when the infra-red sensor detected something approaching; the connected RGB LED bar and buzzer would be turned on. At the end of the lesson, students were encouraged to suggest how and where the designed alarm could be used on their school campus.

For the topic of printing technology, which was one of the four great inventions in ancient China, students were familiarized with the concept of printing by writing their names and using seals on worksheets. They also watched videos of ancient stories about the invention of printing in ancient days. The teacher then stimulated students to think about how the coding device (Micro:bit) they learned to use before could simulate the printing technology to print out a greeting such as "Happy New Year." The teacher provided each student with a Micro:bit and arranged them to work in groups, to use coding to individually create an alphabet, and later to group the letters into the greeting "Happy New Year" to experience the concept of ancient printing.

2.4. Analytic framework

A qualitative research methodology with teachers' pre- and post-TPD interviews and reflections was employed to consider the perspectives and experiences of teachers during their planning and implementation with peer coaching support for ID students in STEM learning. Teachers were interviewed at the start of lesson preparation to know more about teachers' pedagogical concerns regarding students with ID in STEM learning, and after the implementation of the lessons to capture the effect of peer coaching. Moreover, teachers were asked to reflect on the effectiveness of the implementation of STEM learning with consideration of students' engagement and learning outcomes, and to make suggestions to sustain STEM learning for students with ID.

The interview questions were designed referring to projects involving collaboration between teachers and researchers to devise an intervention suitable for enhancing students' engagement and learning of science and mathematics (Bargerhuff, 2013; Ruthven et al., 2010), to address primary support and challenges to learning of students with disabilities, and to translate promising pedagogical principles into an operational apparatus for viable professional practice in STEM education. The following were the two revised interview questions (Bargerhuff, 2013) about students with ID: "What are the primary supports to STEM learning for students with ID?" and "What are the primary challenges to STEM learning for students with ID?". Three interview questions were also revised about peer coaching (Ruthven et al., 2010): "What are the key factors that shape patterns of peer coaching?", "What can be learned from this teacher professional programme with peer coaching to inform more effective further design and professional development?" and "How do teachers use peer coaching to understand and address key challenges of students with ID in STEM education?"

Moreover, the peer coaching model of Zwart et al. (2009), including the teacher level of *Trajectory*, *Interaction*, *Dyad*, *Individual* and the school level of *School* (Figure 2), was also included in the design of six interview questions to guide teachers in identifying the experiences and challenges in peer coaching at both the individual and school levels. In the post-interview, Zwart's model was used to encourage the teachers to share how peer coaching affects teachers' STEM practices and their professional development. As a result, there were 21 questions in the pre-interview and 24 questions in the post-interview in the following aspect: (1) the learning difficulties of ID students, (2) the strategics of supporting practice, (3) teachers' perceptions of STEM learning for ID students and peer coaching for professional development.

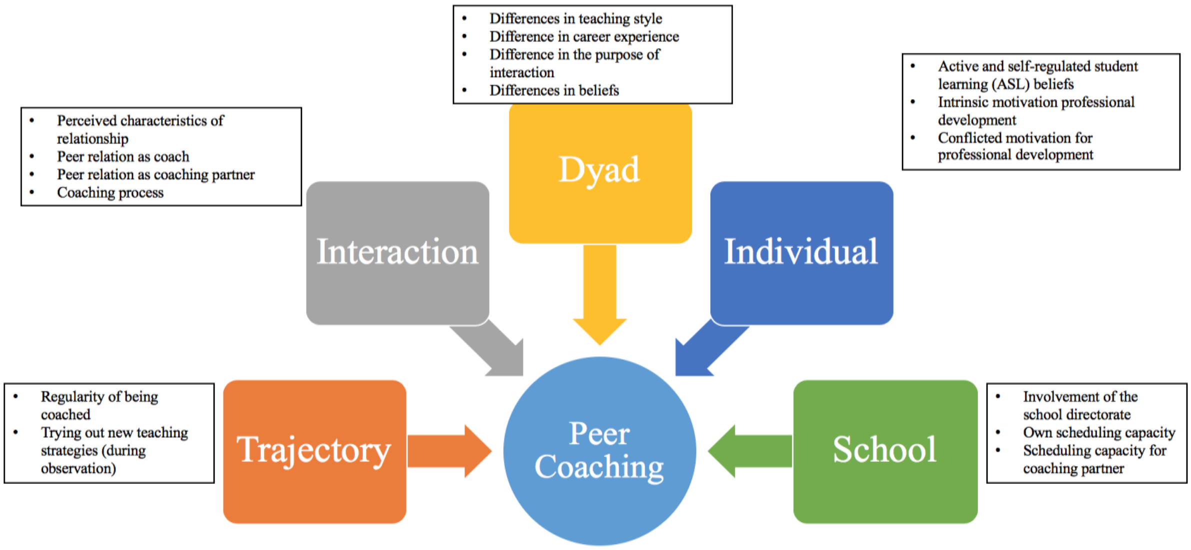

Figure 2. Peer coaching model (Zwart et al., 2009)

3. Findings

The interviews and reflections were independently coded as themes in NVivo 11 by two researchers. The research team conducted the coding repeatedly, then compared and revised the coding until all the codes were consistent (Strauss & Corbin, 1990). Concepts were identified and categorized as codes for further analysis. To answer the first research questions, the concepts related to teachers' prior perceptions of ID students' needs and peer support for professional development during the pre-interview analysis were identified. To answer the other two research questions, teachers' use of strategies in planning and implementing STEM learning to meet the needs of students with ID and how peer coaching supported this were captured during the post-interview analysis.

3.1. Teachers' initial perceptions of STEM learning for ID students and peer support for professional development

Participating teachers were invited to the pre-TPD interviews to capture their initial perceptions of students' needs for STEM learning and peer coaching for teacher professional development. The data were analysed based on teachers' views on two main aspects of STEM learning: (1) learning difficulties of ID students and strategies of practice supporting students' learning; and (2) support of peer coaching for teacher professional development.

3.1.1. Learning difficulties of ID students and strategies of practice supporting ID students' learning

For the *learning difficulties of ID students*, Teacher K1 responded that his students usually had dyslexia, while Teachers K2 and C1 reported that it was not easy for their students to understand concepts. Teacher C2 observed that her students with ID were weak at problem solving and creativity. All teachers emphasized that although ID students liked to explore and inquire, they were only able to work on tasks of appropriate levels of difficulty, and there should be strategies to meet ID students' needs. For example, Teachers C1 and C2 considered that learning related to real problems would help ID students engage in learning, Teacher K1 suggested the usefulness of providing different learning activities, whereas Teacher K2 proposed the importance of students' sense of success in completing the tasks.

I found students having difficulties with basic teaching methods, such as writing and reading. But I had more chances to use electronic devices, which might help ID students understand concepts of different levels …… Students were more interested in the use of different tasks, and they liked to explore and inquire even if the concepts were difficult. (Teacher K1, Pre-TPD)

Our ID students lacked basic concepts…… However, if we provided opportunities for ID students to try to make some easy models, they would be impressed by that…… and it should be related to their life. (Teacher C1, Pre-TPD)

I thought ID students were weak at problem-solving and creativity……We could break down the tasks and let them know everything in order. And school should provide more opportunities for them in inquiry because of their lack of life experience. (Teacher C2, Pre-TPD)

Regarding *practices supporting ID students' learning*, although the participating teachers indicated that students would be curious and interested in the STEM learning, Teacher K1 stated that ID students would be restricted by their lack of abilities in performing different kinds of tasks. Teachers agreed that some teaching strategies would help ID students in STEM learning. For example, three teachers proposed the design of tasks with interesting and hands-on activities and experiments to meet the needs of ID students. Teacher C2 proposed that breaking down the tasks into small steps would facilitate students' success in completing the tasks. Although the teachers thought that they faced many difficulties and had little experience with STEM learning, there would be room for them to reflect on planning and teaching to sustain their professional development in STEM learning.

3.1.2. Initial perceptions of peer support for teacher professional development

When teachers were asked about their views on peer coaching, all of them thought that the *trajectory* of peer coaching was collaborative lesson planning and co-teaching. For example, Teacher K2 considered that teachers could help each other, with senior teachers leading the peer group and junior teachers providing new ideas. They stated various factors which affected teachers' *interaction* in peer coaching, for example, relationships of teachers (Teachers K1, C2), differentiation in subject background (Teacher K1), seniority (Teacher K2), time availability (Teacher C1) and interests in STEM (Teacher C2). The categories of *Dyad* and *Individual* were about the influence of personal characteristics, the emphasis on the importance of knowledge and understanding in the local curriculum and theme (Teachers K1, C1, C2), teaching style (Teacher K2) and the different subject backgrounds (Teachers K1, K2, C1).

For peer coaching with collaborative lesson planning and co-teaching, I thought senior teachers were leading the peer group while junior teachers were providing new ideas, but it might be restricted by the time available. And, the different teaching styles and disciplinary backgrounds might also affect teachers' participation in peer coaching. (Teacher K2, Pre-TPD)

It depends on teachers' interests in the specific topic, which would influence the effectiveness of the teacher interaction. Moreover, the different understandings of the subject and curriculum would be one of the reasons for peer disparity. It might affect teachers' discussion and suggestions. Nevertheless, teachers with different subject backgrounds could offer views from different angles, which might be overlooked previously during planning and teaching. (Teacher C1, Pre-TPD)

All teachers believed that peer coaching took time to develop among teachers with a common goal for professional development (Teachers K1, K2) and assurance by the school policy (Teachers C1, C2). Moreover, they believed that peer coaching support would influence teachers in the planning and implementation of STEM learning. Teacher C1 argued that it might not have much effect on the curriculum design, while Teachers K1 and K2 expected that they could share different duties to cater for students' learning needs in the STEM planning and teaching process. Three of the participants supposed that peer coaching support would help to resolve insufficient complementarity among teachers (Teachers K1, C1, C2), but Teacher K2 stated that peer coaching could help him have more awareness of students' learning diversity of different abilities from his peers. Teacher K1 said that if he were not familiar with Micro:bit, he could learn it with peer coaching support and then understand more teaching approaches. Teacher K2 thought that she just had basic knowledge of Micro:bit, but she could receive many suggestions from peer coaching, which made the STEM practice easier. Teacher K1 proposed that teachers could re-examine the feasibility of ideas, and adjust the depth, method, and content of STEM learning from peer coaching support, while Teachers C1 and C2 raised the support of discussion with other teachers for resolving insufficient complementarity. The two obstacles highlighted by teachers which restrained the current peer coaching support were teachers' different understandings of STEM (Teacher K1) and the limited time and opportunities for communication during the school day (Teacher K2, C1, C2).

peer coaching required continuous professional support. Teachers could share different duties to cater for students' learning needs and re-examine the feasibility of ideas, then adjust the teaching depth, methods, and content of lessons through peer group support…But, it was not easy for teachers to communicate with each other due to their different understanding. (Teacher K1, Pre-TPD)

I considered that peer coaching was important for improving teaching. Teachers could gain various suggestions from different angles through peer coaching support. Therefore, it would resolve insufficient complementarity among teacher…… At the planning stage, there was a need to figure out what ID students were interested in through peer discussion. Yet, at the teaching stage, co-teaching could be used with one teacher as the lecturer and the others assisted the ID students to follow the tasks. (Teacher C2, Pre-TPD)

3.2. Changes in teachers' perceptions of STEM learning for students with ID and peer coaching for professional development

The changes in teachers' perceptions were identified from the comparison and contrast of teachers' interview responses during the pre- and post-TPD interviews, as well as from teachers' reflections. The following paragraphs summarize the new ideas from teachers, namely technological needs of ID students in STEM learning, practices supporting ID students' inquiry in STEM learning, as well as support of peer coaching for teacher professional development.

3.2.1. Technological needs of ID students in STEM learning

It was found in the post-TPD interviews that the teachers were aware of students' learning needs regarding the use of technology, such as the use of electronic devices (Teachers K1 & C1) and coding (Teacher C1). However, ID students were constrained by their low abilities in some difficult coding tasks (Teacher C1), their difficulty in learning collaboratively (Teacher K1) and the technical problems encountered (Teacher K2). Teacher C2 suggested that improving students' interest in the topic by providing more time and inquiry opportunities would increase students' engagement in coding.

For students with ID, how to use some electronic devices for extended learning is one of the new STEM learning needs. I helped students with ID to recall their existing knowledge and to adopt a new teaching model. But the level of students' engagement still differed, and there were problems in the coding activity with collaborative learning due to the differences in students' ability. (Teacher K1, Post-TPD)

I thought students with ID need more chances to do coding and we also tried to simplify the codes in the lesson design. However, it was still not easy for students to follow. Since learning how to use technological devices is important nowadays, I considered that the teaching design should be able to help students with ID to connect their previous knowledge and to address students' learning ability to engage them in more participation. (Teacher C1, Post-TPD & Reflection)

Technological needs were also identified from the coding tasks. Teachers K1 and K2 found it demanding to link STEM learning to daily life with the use of technology. Teachers C1 and C2 worried that too much content was involved in the coding tasks of STEM learning, which overlooked the variation in students' abilities. Yet, teachers also provided suggestions for different abilities in the coding tasks. Teachers K1 and K2 emphasized students' role in meeting the technological needs, with Teacher K1 focusing on cooperative learning with higher ability students guiding the lower ability students, and Teacher K2 focusing on tasks in accordance with different students. Teacher C1 suggested that it was necessary to simplify the Micro:bit coding activity, even though it was mastered with ease by students with higher ability, as students with lower ability had difficulty engaging in the tasks. Teacher C2 suggested more arrangement for students of lower ability to participate more in simplified tasks, or grouping students with different abilities for them to work collaboratively to accomplish tasks of various levels of difficulty.

There was too much content for ID students in one lesson, whereas the coding task with variables might be unfamiliar for the class of students with varied abilities. We also encountered technical problems with the Micro:bit activity. I suggested that teachers should simplify the coding activity or group students with different abilities to work together to complete tasks of different levels, so that both the higher ability and even lower ability students would be engaged in STEM tasks. (Teacher C1, Post-TPD)

3.2.2. Practices supporting ID students' inquiry in STEM learning

The analysis also identified new ideas on practices which support ID students' inquiry in STEM learning in four aspects, including (1) *teaching strategies*, (2) *classroom management*, (3) *students' engagement*, (4) and *students' interest.*

After the planning and implementation of STEM learning for their ID students, participating teachers concluded some effective *teaching strategies* to meet the learning needs of students with ID. The teaching strategies suggested were: heterogeneous grouping with tasks divided in accordance with students' ability (Teacher K1), previous knowledge building for expanding background knowledge (Teachers K1, K2), activities and examples related to daily life to set scenarios for inquiry (Teachers K2, C2), a small-step approach which breaks down the activities step by step for inquiry (Teachers C1, C2), hands-on experience for inquiry (Teachers C1, C2) and adjustment of teaching according to students' feedback (Teacher C1).

Our students had never used Micro:bit before, so we provided some training, knowledge about Micro:bit and coding for students with the help of the IT teachers……The STEM activities connected more to life experiences were able to help students build up a mind with the use of STEM for inquiry to solve a problem. (Teacher K2, Post-TPD)

Teachers also articulated the importance of *classroom management*. Teachers K1, K2, and C2 held similar thoughts that more guidance and management in the STEM learning lessons were needed for students for the reason that they lacked the experience of group inquiry (Teacher K2). Yet, Teacher C1 assumed that if students were sufficiently and actively involved and participated in the lesson, it did not need extra work with classroom management.

Students' better engagement in learning was observed by the teachers too. Teachers K1 and K2 stated that ID students' engagement in learning was more active than before and better than they expected, but they were provided with relatively fewer opportunities to explain thoughts as they were regarded as having difficulty understanding questions from teachers. Teacher C1 reported that his class of ID students were active in working with other students in group inquiry, and they were also eager to explain their thoughts to their peers. Particularly, teachers found the factors affecting *students' interest* in STEM learning. Teacher K1 considered that students with ID were more interested in the electronic teaching kits as they had had few opportunities to use such instruments before. Three teachers (Teachers K2, C1 and C2) agreed that the STEM learning experience with the hands-on activities and electronic devices increased students' interest. Teacher K2 focused on students' sense of success when both Teachers K1 and K2 concentrated on students' gain in STEM knowledge in the tasks.

Students performed better than I expected; they could concentrate on most of the learning activities…… And they also had interest in the electronic teaching kits. After these lessons, students might try to learn more about the electronic devices by themselves, which enriched their interest in STEM. (Teacher K1, Post-TPD & Reflections)

We gave chances to students to reflect on the process of learning; they shared their experiences of STEM learning and this helped to increase their STEM knowledge, interest and confidence. (Teacher C2, Post-TPD)

3.2.3. Support of peer coaching for teacher professional development

For the support of peer coaching for teacher professional development in STEM learning, the changes in teachers' views were also analysed with reference to *Trajectory*, *Interaction*, *Dyad*, *Individual*, *School*, and *STEM learning development*. Teachers C1 and C2 added to the *trajectory* that peer coaching allowed more discussions and lesson planning among peer groups. The two factors concluded by teachers with the peer coaching support influencing teachers' *interaction* were time allowed (Teacher K2) and teachers' different subject background (Teachers C1 and C2). For *Dyad,* all teachers were aware of the differences with individual teachers' knowledge, experience, and style of teaching. Teacher K1 responded that different subject background was an obstacle to peer coaching support because teachers were usually familiar with their own subject background. Most of the teachers (Teachers K2, C1, and C2) believed that teachers' teaching experiences affected their involvement supported by peer coaching, as senior teachers usually had more experience of handling problems. Teachers K1 and K2 added teaching style as the difference of *Dyad*. For the *individual,* Teacher K1 considered that the effectiveness of teachers' interaction was related to individual teacher's engagement in the planning and implementation of lessons.

Teachers had too much workload already, and there was less room and time for us to communicate with each other…… But it was also about my teaching experience for the reason that I did not have such knowledge and ability to have peer coaching with my colleagues if I was not familiar with that topic. (Teacher K2, Post-TPD)

We had more interaction to supplement and complement each other by peer coaching support, but if teachers had the relevant subject knowledge, it would facilitate better interaction. Peer coaching also had disparity in teaching style and teaching experience…… For the individual, time and effectiveness of peer coaching were the important factors. If one did not engage oneself in STEM teaching, it affected the result of peer coaching a lot. (Teacher C1, Post-TPD)

Teachers started to pay more attention to the ways to improve peer coaching at the *school* level to strengthen their professional development. Teacher K1 focused on the pairing-up of teachers for research or new initiatives, but Teacher K2 considered that the heavy workload was an obstacle. Teacher C1 found the integration of teachers' different subject knowledge in the design useful, and Teacher C2 noted the improvement of teachers' relationships as a team.

The changes in *STEM learning development* were found to be supported by peer coaching. Teacher K1 summarized that the peer-supported STEM learning design had clear content for inquiry and layout for students with ID, and was more inquiry-focused in nature. Teacher C1 said he had more chances to discuss with colleagues, so the consideration of STEM learning was broader with suggestions from the peer group. Similarly, Teacher C2 stated that peer coaching helped teachers discuss more how to solve the problems in the lesson design.

Providing teachers with more opportunities for pairing-up in order to have some research or new practices is important at the school level……For the design of the STEM learning, we should teach the content more clearly. (Teacher K1, Post-TPD)

Schools could provide team-building opportunities to improve teachers' relationships for peer coaching……We appreciated the peer coaching support in STEM education because we could be aware of the deficiencies in the teaching design and students' difficulties and work together to solve them. Teachers needed to have a lot of planning and preparation in STEM lesson design, and I was afraid that it was challenging for us to work on it by ourselves. (Teacher C2, Post-TPD)

4. Discussion

Teachers appraised peer coaching with professional development support for planning and teaching, which helped them identify the technological needs of students with ID in STEM learning. After the experience of planning and implementation, the participating teachers reflected on the practices for students with ID, and focused on students' inquiry in accordance with the students' abilities for better engagement in and sustainability of STEM learning. With the peer coaching support, teachers also listed different teachers' disparities that may influence their participation in peer coaching, and school involvement in peer coaching to support students with ID in STEM learning.

4.1. Use of technology for ID students in STEM learning

Teachers' prior perceptions of the learning needs of ID students was almost similar with other subject learning. After the professional development support for STEM planning and implementation, teachers tended to think more about the unique needs of ID students in STEM learning, and reported their technological needs, including the use of electronic devices and coding. In research on increasing opportunities in STEM for more capable students with ID, technology was found to help ID students learn STEM skills and address the industrial demands (Lawler et al., 2018). Teachers in this research agreed that the technology needs in STEM learning offered meaningful possibilities to motivate ID students to use technology, thus fostering students' interest in STEM and related skills. So et al. (2019) also stated that it is important to provide opportunities for ID students to learn about contemporary technologies in science inquiry and engineering tasks during STEM learning.

4.2. Consideration of inquiry learning based on students' abilities

Since the teachers in special schools did not have much experience with STEM learning, they only held succinct ideas that students with ID should be interested and would be active in STEM learning. This research provided teachers with opportunities from design to implementation with peer coaching support, for them to develop enhanced understanding, and better practices to improve students' inquiry learning in STEM learning and to sustain STEM learning in the future.

Teachers proposed the use of adapted strategies/steps to manage the cognitive load of ID students with inquiry learning, such as setting scenarios to introduce the inquiry problems, having clear learning content, breaking down the activities into small tasks and emphasizing the student role (Lee & So, 2014). STEM activities should be designed to be intently related to science inquiry (Maqbool & Hariharan, 2017) and Dostál et al. (2016) also concluded the findings of their research on applying inquiry-based instruction/problem-based learning with students with mild intellectual disability, particularly in science education. Their findings showed that students better acquired scientific terms and had a more positive attitude towards science and technology, as well as having higher motivation and social trust.

However, participating teachers also paid attention to students' abilities in the inquiry process to manage their cognitive load. Asghar et al. (2017) pointed out that complex scientific problems may place high demands on working memory. This might result in a high cognitive load and even overloading. Thus, the cognitive load was a major determinant of learning in problem-solving situations. The teachers understood that STEM learning should be designed according to students' ability, setting different levels of tasks in inquiry learning, arranging heterogeneous grouping and so on, in order to encourage more ID students to engage in STEM learning.

4.3. Focus on teachers' disparity and school involvement with peer coaching

With the support of peer coaching for teacher professional development, teachers realized the importance of managing and balancing teachers' disparity and school involvement when they worked in planning and providing STEM learning for their ID students.

To handle teachers' disparity for better practices with peer coaching, there is a need to build a safe environment that is open to disagreement by teachers. Moreover, Glazer and Hannafin (2006) stated that "emotions and attitudes play an important role in an individual's decision to interact with a peer" (p. 186). The need to take care of different teachers' emotions and attitudes in the teacher professional development support of peer coaching and catering for one's emotion and attitude for a safe and open environment are essential. Thus, teachers are always restricted by time and knowledge of the STEM disciplines (Margot & Kettler, 2019), whereas the participating teachers in this research were able to understand and manage their disparity through learning from each other by discussion, reflection and peer assistance. They were able to think more, thus overcoming the insufficient complementarity and inflexibility in their practices, which has been cited as a barrier to STEM (El-Deghaidy et al., 2017; Lesseig et al., 2016). From the peer coaching model (Zwart et al., 2009) mentioned before that the disparity of teachers may be mainly due to their teaching style, career experience, purpose of teachers' interaction and beliefs. However, it was found in this research that differences in teaching style simulated teachers' learning. Hence, teachers' disparity is a two-edged sword, and how to balance teachers' disparity in the process of peer coaching needs to be explored in future research.

Lastly, teachers mentioned school involvement in teachers' peer coaching because they all regarded that peer coaching was still developing in the school and it was new to teachers. Teachers raised more specific methods at the *school* level for improvement, such as pairing-up, team building, and so on. As suggested by Zwart et al. (2009), schools need to find intrinsically motivated teachers to experience peer coaching, while teachers perceived that school support, guidance, and flexibility were necessary for providing STEM learning opportunities for ID students (Margot & Kettler, 2019). Although peer coaching for teacher professional development was new to the teachers in this research, the practices broadened the teachers' insights regarding both peer coaching and STEM learning.

5. Conclusions

Three key implications were observed by the participating teachers in this professional development about STEM learning with peer coaching. Teachers would employ the following strategies in planning and implementing STEM learning to meet the needs of students with ID, including the needs to use technology for ID students and considering ID students' abilities in the process of inquiry practices. Teachers also gained more insights on working by peer coaching by managing teachers' disparity and school involvement with peer coaching support for teacher professional development. Teachers' STEM professional development with peer coaching can be considered as an approach to encourage more teachers in special schools to become involved in STEM learning and to open the pathway to accommodate students with ID and engage them in today's STEM initiatives.

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