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Challenging Traditional Teacher Professional Development by Implementing Technology-Supported Cooperative Learning

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Abstract. The goal of this study is to offer guidelines for the application of technology-supported cooperative learning professional development to enhance teachers' self-directed learning skills. A qualitative approach was used which was informed by the interpretive paradigm. Many technology-supported cooperative learning professional development prototypes were created as part of the iterative design-based research methodology used in this study. Seven primary school Mathematics teachers from South African government schools participated in the technology-supported cooperative learning professional development for six weeks as part of a purposive sample. All the participants were scheduled for data collection through semi-structured interviews and follow-up interviews. The qualitative analysis computer data analysis system was used to prepare, process, and analyse the data collected from the semi-structured interviews. According to the findings of this research, teachers needed professional development that is affordable, flexible, intensive, and ongoing. The findings of the study provided insights into the best practices for implementing technology-supported cooperative learning professional development and enhancing teachers' self-directed skills. The study has the potential to contribute to the field of professional development for teachers as it will provide evidence-based recommendations for the effective and sustainable implementation of technology-supported cooperative learning professional development.

Keywords: professional development; cooperative learning; self-directed learning; design-based research; mathematics education

1. Introduction

The primary objective of this investigation was to augment the ability of Mathematics teachers to engage in self-directed learning (SDL) via the utilisation of technology-supported cooperative learning (TSCL) as a professional development (PD) strategy. Furthermore, the study aimed to ascertain the teachers' perceptions and experiences regarding the suggested TSCL PD. It is widely acknowledged that teachers need to improve their content understanding as well as their teaching methods (Louws *et al.,* 2017b). Teacher PD is a vital component of providing high-quality teaching and learning in a country's educational system. Darling-Hammond *et al.* (2017) assert that teachers acquire the necessary knowledge and expertise to overcome their students' learning difficulties by participating in PD. However, the opinion of Louws *et al.* (2017a) is that although PD strategies are often used by teachers, they are unable to incorporate these innovative concepts and ideas into their daily activities. A growing body of research (Bates & Morgan, 2018; Jita & Mokhele, 2014; Yoon *et al.,* 2020), suggest that seminars, conferences, one-time only or sit-and-get PD have little impact on teachers' continuous PD. Adopting a similar position, Kennedy (2016) also argues that workshops, conferences, and seminars for teachers seem to fall short of equipping teachers with the skills they need for the twenty-first century.

However, previous research (Desimone, 2009; Guskey & Yoon, 2009) expresses the need for a new approach to teacher PD, one that considers the goal of PD, the needs of teachers, and the involvement of teachers in the development of skills and expertise so that they are able to meet the needs of the twenty-first century. Yoon *et al.* (2020) echo this sentiment as they argue that, in the twenty-first century, a good PD strategy enables teachers to use technology to find information, collaborate on learning, and focus on what they have learned. An (2018) asserts that using technology in PD opens up new opportunities for teachers to participate in their own learning as well as learning collaboratively with others, thanks to a variety of Internet resources and different application software provided by technology. Technology is an effective tool for supporting cooperative learning (CL), as well as for enhancing SDL (Bosch & Laubscher, 2019). The Partnership for 21st Century Skills also emphasises the value of using technology to aid learning in order to participate successfully in a competitive global economy.

This study introduces TSCL as a PD strategy, different from traditional PD, that enables teachers to collaborate in small groups in the comfort of their own space, regardless of their location, and at their own pace. This study proposes guidelines for implementing technology-supported cooperative learning professional development (TSCL PD), which is supported by the five basic elements of CL, to empower teachers to take charge of their own professional progress in terms of SDL development. This study was motivated by the following research question: How can TSCL PD enhance teachers' SDL skills? This study's novelty lies in its exploration of an innovative and promising approach to teacher PD that has not been extensively researched before. The study's findings have the potential to contribute to the development of more

effective and impactful teacher PD strategies, which could ultimately lead to improved educational outcomes for students.

2. Literature review

The literature review explains what SDL entails, why it is important for teachers to develop into self-directed learners, CL and its basic elements, as well as various perspectives on teacher PD. A brief description of TSCL PD is also given.

2.1 Self-directed learning

SDL is considered an important life skill that promotes lifelong learning in a variety of studies (Guglielmino, 2013; Knowles, 1975). Knowles' (1975) adult learning theory, also known as SDL, is the foundation for the notion that individuals oversee their own lifelong learning. According to Knowles (1975, p.18), SDL is a process "… in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing learning strategies, and evaluating learning outcomes." Through SDL, students (teachers in this study) can take responsibility for their own learning, display independence in their learning, and may choose their own approaches and materials for learning to attain their chosen learning goals (Guglielmino, 2013; Verster et al., 2018).

2.2 The need for teachers to develop self-directed learning skills

Bagheri *et al.* (2013) as well as Du Toit-Brits (2019) argue that the increasing complexity and speed at which our environment is evolving has an effect on our daily lives and necessitates lifelong SDL. In support of this argument, Louws *et al.* (2017a) hold that teachers are the school's most valuable assets, as they stand at the crossroads of knowledge, skills, and values transmission. Moreover, they will only be able to fulfil such outcomes if they are properly prepared and able to maintain and enhance their self-direction. Bailey and Mentz (2015) draw attention to the fact that SDL may be a strong and meaningful tool for teachers to take responsibility for their own PD. Teachers who acquire SDL skills have the potential to become lifelong learners, which in turn results in an enhanced awareness of their personal strengths and limitations (Du Toit-Brits, 2019). SDL can thus be recognised as a means for teachers to further their PD by enabling them to select and implement the most effective learning approaches in order to improve and strengthen their teaching methodologies.

There are various teaching-learning approaches that have been connected to the advancement of SDL. CL, for example, is one of them (Loyens *et al.*, 2008; Mentz & Van Zyl, 2016). The following section discusses this approach in depth.

2.3 Cooperative learning

Various definitions of cooperative learning (CL) exist; however, it generally refers to an effective educational approach in which students of different levels of ability collaborate on a mutual activity in small groups to achieve a common objective (Bosch *et al.*, 2019; Johnson & Johnson, 2019). According to Slavin, in his

book "Cooperative Learning: Theory, Research, and Practice", cooperative learning involves "students working together in small, heterogeneous groups to achieve a common goal, with each student held accountable for his or her own learning as well as the group's success" (Slavin, 2014, p. 4). CL is a teaching strategy that enables group members to reach their full potential by letting them determine their own goals, design a strategy to attain them, and assess their own accomplishments (Bosch *et al.*, 2019). This teaching strategy, according to Johnson and Johnson (2019), is built on the idea that learning is more successful when students exchange ideas and collaborate in groups to complete a task. Each group member is held accountable for assisting others in learning, which fosters a sense of accomplishment (Felder & Brent, 2016). Furthermore, this technique promotes a sense of gratitude and respect among the members of the group (Goodyear, 2017; Johnson & Johnson, 2019).

2.4 The advantages and disadvantages of cooperative learning

An advantage of CL is that it fosters social interaction and communication among students (Slavin, 2019). This socialisation is believed to enhance students' (i.e., teachers' in this study) interpersonal skills, such as communication and leadership, which are valuable in their personal and professional lives. Additionally, CL promotes positive interdependence, whereby students feel accountable to their peers and are motivated to achieve the group's objectives (Johnson & Johnson, 2015). This motivation is thought to lead to higher academic achievement and a more positive attitude toward learning. Another advantage of CL is that it can promote critical thinking and problem-solving skills (Johnson *et al.*, 2020). This is achieved through the sharing of ideas and perspectives among group members, which can lead to a deeper understanding of the subject matter (Johnson & Johnson, 2019).

However, there are also some potential disadvantages of CL. For example, it may lead to social loafing, where some members of the group may not contribute as much effort or work as hard as others (Johnson & Johnson, 2015). Additionally, group work may not suit all students, particularly those who prefer to work independently or those who are uncomfortable with social interaction (Johnson *et al.*, 2020). Therefore, it is essential to consider both the advantages and disadvantages of cooperative learning when implementing it in educational settings.

2.5 Basic elements of cooperative learning

Following extensive research in the realm of group work and CL, Johnson and Johnson (2013) found that there are five basic elements that must be followed for effective CL. These elements are positive interdependence, individual accountability, beneficial face-to-face connection, adequate social skills, and group processing.

Positive interdependence necessitates that all students collaborate in such a way that no-one can achieve success without the support and assistance of the others (Johnson & Johnson, 2019). Individual accountability is the second important aspect of CL, and it is demonstrated when each group member is responsible for helping the group achieve its goal (Felder & Brent, 2016). Students encourage

and support each other's progress by sharing resources and providing guidance, assistance, and motivation through the promotive interaction of CL. The fourth crucial element of CL is social skills, which refer to the abilities we need for efficient group interaction and communication (Johnson & Johnson, 2014). Listening to one another, communicating effectively, sharing resources equitably, embracing and supporting one another, and participating in decision making are all examples of social skills (Johnson & Johnson, 2013). The fifth and final element of CL is group processing, which occurs when group members discuss how effectively they are meeting their objectives and maintaining positive working relationships. Bosch and Laubscher (2019) argue that, in order for a cooperative lesson to qualify as a successful CL lesson, all five characteristics of CL must be present. As such, CL was used in this study as a viable option for teacher PD in order to enhance teachers' learning experience during PD (Goodyear, 2017).

2.6 Teacher professional development

Extensive literature on teacher PD exists. Teacher PD can be defined as a person's growth in his or her work as a teacher (Darling-Hammond *et al.*, 2017). Teachers, like professionals in any discipline, must update their knowledge and abilities on a regular basis. Bates and Morgan (2018) define teacher PD as a process or activity aimed at enriching teachers' professional knowledge and abilities in order to increase student learning. In support of this viewpoint, Louws *et al.* (2017a) point out that teacher PD cannot be viewed as a one-time event that occurs on specific days during the school year, but rather as an ongoing process in which teachers must engage on a daily basis. Desimone (2009) agrees, stating that teachers must have access to substantial and continuous possibilities for learning at all stages of their careers if they are to be able to teach in ways that cater to the demands of the twenty-first century.

Traditional teacher PD has been the norm for many years; however, modern teacher PD has emerged as a more effective way to enhance teacher knowledge and skills. Traditional teacher PD often includes one-time workshops or seminars that provide general information on a specific topic (O'Dwyer *et al.*, 2018). This type of PD lacks sustainability and continuity, and teachers may struggle to apply what they learn in their classroom (Guskey, 2002). Moreover, traditional teacher PD often does not account for the individual needs of teachers or the specific context in which they teach (Guskey, 2002).

In contrast, modern teacher PD is more personalised and ongoing. It includes a variety of options such as online courses, webinars, virtual coaching, and peer learning communities that are tailored to the individual needs of teachers (Darling-Hammond *et al.*, 2017). This type of PD is more effective because it allows teachers to apply what they learn immediately in their classroom, and it fosters collaboration and reflective practice (O'Dwyer *et al.*, 2018). Another benefit of modern teacher professional development is the use of technology, which can enhance the learning experience and make it more engaging and interactive for teachers (Waters & Cameron, 2017). Technology can also provide teachers with access to a wealth of resources and connect them with teachers

from around the world, creating a more global and diverse learning community (Darling-Hammond *et al*., 2017).

According to Verster *et al.* (2018), to deliver effective teaching to students, it is critical that teachers have adequate opportunities to expand their knowledge and skills. One strategy is to shift from a traditional approach to teacher PD to one that emphasises lifelong continuous learning (Dresel *et al*., 2015), a strategy in which teachers actively participate in their learning. One of the alternatives to traditional teacher PD that challenges it is the use of TSCL. The goal of the TSCL PD in this study was to enhance the SDL skills of the teachers, including self-awareness, critical thinking, creativity, communication, problem-solving, and teamwork.

2.7 Technology-supported cooperative learning professional development

TSCL PD opens up new opportunities for establishing individual flexibility in terms of independent study time, location, and pace (Wanner & Palmer, 2015). E-mail, instant messaging (text or audio/video-based conversations), interactive websites, and social networking have made long distance communication possible (Assareh & Bidokht, 2011). Teachers can work on the same activity at the same time because of the large amounts of information available and the use of technology to support CL, as well as sharing equal responsibilities and resources (Johnson & Johnson, 2014). In this study, various technological tools, including GeoGebra, Google Docs, and Google Classroom, were used with the support of CL to improve teachers' SDL skills. It can be inferred that TSCL has the potential to be an effective PD strategy in that teachers can be in control of their learning, make appropriate decisions independently, become lifelong learners and experts in their fields.

3. Methodology

The empirical component of the research used a purposive sample of seven teachers from various primary schools who attended weekly PD at an affluent private school in the Bojanala district in South Africa. This study used a qualitative design-based research approach (DBR) and three prototypes of the TSCL PD were developed and improved on, using participant interviews and informal discussions. DBR is an approach to educational research that focuses on the iterative design and testing of educational interventions in authentic settings (McKenney & Reeves, 2014). It is also referred to as design research, design experiments, or educational design research.

The study was framed under the interpretive paradigm. The first stage was to conduct a literature review, which was followed by an examination of the teachers' needs to ascertain their PD requirements and potential ways to improve their SDL. After a needs analysis and literature review, a suitable TSCL PD intervention was created, modified and improved – this new suggested PD challenged the traditional method of conducting PD and especially, set out to also address teachers' needs regarding PD. The TSCL PD was designed as a strategy for teachers to take charge of their own PD, thus making them more

self-directed. All of the participants were scheduled for a semi-structured interview and a follow-up interview in order to collect data. The interviews were audio-recorded and transcribed before being coded with ATLAS.ti™. The data were analysed in line with Creswell's (2009) six steps of analysing qualitative data. These steps are the following:

- Collecting data - Gathering qualitative data through interviews, and other means;
- Organising data - Sorting and organising the data into manageable categories and themes;
- Reading and reviewing data - Reviewing the data in detail to identify patterns, themes, and important features;
- Developing codes and categories - Creating codes and categories that capture the key themes and concepts present in the data;
- Identifying themes - Identifying the overarching themes that emerge from the coded data; and
- Interpreting and reporting results - Interpreting the findings, drawing conclusions, and reporting the results of the analysis.

Creswell (2009) correctly notes that by following these steps, researchers can examine qualitative data in a methodical manner and better comprehend the research issue or phenomenon under study.

4. The Intervention

As part of the design-based approach, for the refinement of solutions in practice, three (3) cycles of implementation using collected data (matching the study objectives) were carried out. The TSCL PD strategy was developed and re-tested based on a thorough examination of the data collected. Multimedia components such as live video broadcasting, immediate text-based communication, video conferencing, interactive web pages, and synchronous chat sessions were included in the TSCL PD. The intervention's cooperative tasks were designed to meet the conditions for effective cooperative learning identified by Johnson and Johnson (2013): positive interdependence, individual accountability, promotive interaction, interpersonal and small group skills, and group processing.

Participants were informed at the start of each session that they would be using the CL jigsaw method and were told what the requirements of the task were. This involved making a contribution to the collective effort of the team, actively listening to the perspectives of team members, and providing assistance to other members of the team. Participants were allocated to a home group where the facilitator assigned a particular role to each member – a group leader, a scribe, and a presenter. Different members from the home groups, who shared the same role (e.g. leaders – 1, scribes - 2, presenters - 3), met in new groups, known as expert groups, where they were expected to work cooperatively on a task. Thereafter, they would return to their home groups to share the information which they had gained. Figure 1 below shows how teachers were organised during the TSCL PD intervention where each was assigned a particular role:

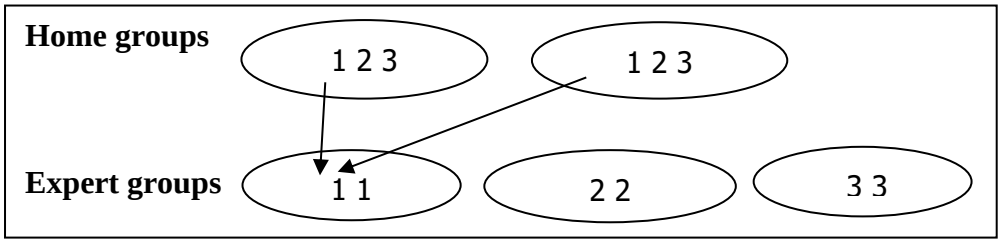

Figure 1. Grouping of teachers
Source: Author's own compilation

At the start of each section of work, the facilitator ensured that individual accountability was emphasized by giving participants a rubric to use as a guide. The facilitator circulated among the groups to ensure that team members assisted one another in making conceptual connections. Google Meet was used by each group as a virtual chat room to encourage collaboration and to simulate grouping within the jigsaw method i.e. base group and expert group. Through members' assisting one another**,** promotive interaction was stimulated. By fostering mutual respect among group members, resolving conflicts, cultivating decision-making abilities, and building trust, the interpersonal and small group skills of the participants were enhanced. Promotive interaction was stimulated when members assisted one another, exchanged required resources, and provided feedback to each other. Following the completion of each task, members discussed their experience, how effectively they collaborated, what was effective and what was ineffective; and this promoted group processing.

5. Findings

The data collected from the participants through the initial and subsequent interviews were examined and divided into four primary themes: the support of technology in teacher PD, elements of CL, characteristics of SDL, and teacher PD. All direct quotations are presented verbatim and without editing.

5.1 The support of technology in teachers' professional development

The utilisation of technology in teacher PD was applauded by the participants as a superior approach to the conventional PD strategies they had previously experienced. Because of the relevance of the session and the general excitement about employing newly introduced technology skills and resources, participants felt confident in their abilities to put what they had learned into practice right after the TSCL PD. The following are some of the experiences reported by the participants:

> *It was very nice to use technology during the professional development, hey. You see, with previous professional development workshops I attended, we had to sit, listen and take notes, but now, due to the fact that there is a computer in front you, there is this feeling that you have to engage with it, press it, research or do something on the computer (D10:5).*

Other participants shared their views on how technology has enabled long-distance communication:

> *Well, with the power of technology, I was able to participate in the professional development sessions, which were very far away from where I stay, even if I was in a different location. I had the same experience as with everyone who was in the same room with the facilitator and this for me proves that, learning can occur simultaneously, regardless of location (D12:4).*

> *My favourite activity in the professional development was using real-time collaboration with Google Docs … I was so impressed about how we can work together in the same document in real time and in different locations (D20:1).*

The use of technology in PD, according to some participants, has the potential to provide them with an opportunity to become actively involved in discovering and visualising concepts, allowing them to build a deeper understanding of the topic.

> *Tools like Google Classroom for instance, aids the transition of instruction from being teacher-centred to being student-centred enhancing learning through critical thinking (D17:11).*

> *I really enjoyed using GeoGebra a lot in the professional development session. You see, similar applications like GeoGebra can help students with visualisation, amplifying their comprehension and the probability of transferring their academic knowledge to a setting outside of school (D18:3).*

It is clear that technology gave teachers more autonomy over the learning process and increased their capacity to work in their own area. This allowed participants to think critically and collaborate with others.

5.2 Elements of cooperative learning

Participants learned to cooperate with one another and exchanged needed resources, resulting in positive interaction. Some participants stated that they were aware that they could ask for assistance at any time:

> *In our group, we would encourage each other to work as a team towards a common goal and this allowed us, individually, to be more responsible in our respective task and also depend on each other for help (D11:7).*

> *With the help of instruction document we had and the help of my group members, we finally won the battle (D9:7).*

The ability of the participants to converse with one another successfully and pay close attention to what they were saying was another indication of the presence of social skills:

> *The chatting tools and videos calls we used during the sessions allowed us to be able to listen to each other and gave one another a chance to share and demonstrate our ideas to the best of our ability (D13:4).*

In the following statement, another participant refers to the significance of group

processing as a means of reflection after each TSCL PD session:

> *When planning a professional development, we should provide a clear learning target and a reflection time like the ones we had in our sessions. In this way, teachers never leave us feeling confused or doubtful about what we've been teaching them and whether they've grasped it (D14:8).*

Johnson and Johnson (2013) propose that effective interdependence requires that participants rely on one another to complete tasks. During the intervention tasks, each group member was responsible for a particular segment of the subject matter, and it was mandatory for each member to teach their respective sections to other members of the group to ensure uniform comprehension of the topic. A single participant indicated that:

> *Collaborating with fellow colleagues to share acquired knowledge offered me the chance to persistently improve and contemplate on my actions while performing tasks (D19:1).*

The following are the participants' perspectives on specific roles in the TSCL PD:

> *Having a role in the professional development allowed me to stay on task and pay closer attention to the task at hand, while also trying to make sure that all my group members are also focused (D18:8).*
>
> *As a team leader, I found it challenging to ensure that everyone's voice was heard and treated equitably (D18:9).*

The findings of this study demonstrated that participants became interested in their learning when CL was used in conjunction with the five elements described by Johnson and Johnson (2013). The findings from participants' responses also showed that certain aspects of CL, such as positive interaction, social skills, group processing, and positive interdependence, were present. These elements of CL appear to have aided teachers' learning, based on their comments. The application of CL in teacher PD significantly improved teachers' perceptions of the TSCL PD.

5.3 Characteristics of self-directed learning

The data revealed some characteristics of SDL, such as self-awareness, linking knowledge to real-world situations, taking control of the learning process, and a desire to learn. As shown in the quote below, one of the participants claimed that the TSCL PD helped her to become more self-aware:

> *Learning with other colleagues helped me to acknowledge, understand, and work diligently to overcome the challenges and obstacles standing in the way during the task that we were given (D17:3).*

In addition, the same individual stated that:

> *The technology-supported cooperative learning professional development provided me with the opportunities for creating learning environments that extend the possibilities of advancing my skills as a teacher, … to a point now where I can make Mathematics classes more interesting and more fun (D17:4).*

According to Guglielmino (2008), another feature of SDL is the capability to connect information and utilise it in unfamiliar contexts. The participants provided some examples of how they employed the knowledge acquired during the TSCL PD in their respective classrooms:

> *The professional development afforded me the opportunity to use different computer applications so that I can use multiple representations to help students understand Maths concepts (D25:5).*

> *Now, with the few skills that I have learnt, I can now create lessons that can accommodate a variety of learners (D23:4).*

During the TSCL PD sessions, a few of the participants expressed their excitement in the learning process, as well as valuing the input and remarks provided by their fellow participants:

> *Well, seeing other group members being fully hands-on and enjoying their work, made me realise that I also have to take part and be involved as well. So, ya, seeing everyone working, motivated me to take responsibility for my own learning (D14:5).*

> *I guess … learning with other colleagues helped me to acknowledge, understand, and work diligently to overcome the challenges and obstacles standing in the way during the task that we were given (D17:3).*

These remarks seem to suggest that teachers share some characteristics of self-directed learners. Examples of 21st-century and also self-directed learning skills included creating goals, processing information, making decisions, identifying relevant information, and analysing circumstances. Based on participants' comments, decision-making, acquiring pertinent information, and assuming accountability for personal learning are the frequently cited SDL skills. One participant stated emphatically that the TSCL PD assisted her in becoming more responsible and accountable for her learning decisions and behaviours:

> *My usual approach involves recollecting a familiar encounter, then contrasting it with a new experience and determining its relevance before arriving at a decision (D22:8).*

Another individual voiced his thoughts as follows:

> *The technology-supported cooperative learning professional development supports me in using appropriate learning styles to solve challenges I face in teaching by helping me see how I can plan and prepare for better lessons and even changing my teaching practices (D25:4).*

According to the above comments, the TSCL PD helped teachers enhance their teaching skills while also assisting them in becoming more self-directed.

5.4 Teacher Professional Development

The majority of the participants were quite specific about the type of PD in which they desired to participate. Having options during PD, according to one participant, is important:

> *As teachers, I believe this would aid us in choosing professional development opportunities that specifically address areas we seek to enhance (D2:13).*

Likewise, another participant remarked:

> *Professional development should not be a once-off thing, because there are many teachers out there who struggle with a lot of different things, so it will be nice if different concepts are treated on different days (D13:3).*

Some participants expressed the need for professional development that is adaptable to their timetable. For example, participant 5 said:

> *I suggest a flexible professional development format similar to the one we experienced, where individuals can easily communicate with others despite geographical distance (D12:10).*

One participant emphasised:

> *I would recommend an on-going professional development that creates a culture of learning throughout each session and additionally supports teachers' efforts to engage their own learning (D11:9).*

The same participant also stated:

> *Encouragement should be provided to teachers to opt for professional development opportunities that offer challenges and help them achieve a sense of accomplishment through hard work (D11:9).*

The most effective PD strategies, according to participants, are those that are interactive and ongoing. This was consistent with the literature, which advocates for practical teacher development models that occur in numerous cycles to help teachers gain in-depth knowledge, skills, and practices.

6. Discussion

According to the study's findings, participants were pleased with their participation in the TSCL PD. This was ascribed to the fact that the TSCL PD addressed each participant's needs. Darling-Hammond *et al.* (2017) express a similar view that successful teacher PD should take into consideration teachers' needs, experiences, and teaching standards. Participants were provided with a platform during the TSCL PD to share their concerns, ideas, and resources through various technological applications and work both individually and collaboratively with their colleagues, resulting in the development of long-term, dedicated, and caring relationships (Johnson & Johnson, 2019). The TSCL PD helped all the participants in this study with solving new problems in the classroom, collecting new information, improving content awareness, and gaining control over their own learning, which is a vital component of SDL (Sekano *et al*., 2020).

Another feature of SDL that was evident from the TSCL PD is that teachers worked individually on their devices, using appropriate human and material resources to find relevant information in order to accomplish the task that had been assigned. These findings appear to be in accordance with the literature,

which indicates that inquiring about and searching for information can be a means of self-regulation and guiding one's own learning (Guglielmino, 2013). When using technology, the facilitator frequently encouraged teachers to take risks and make mistakes, then provided them with enough time to explore how they could remedy their mistakes, which helped the teachers take ownership of their own learning (Felder & Brent, 2016). The use of several roles in the TSCL PD, according to the participants, also encouraged them to take responsibility for their own learning. Compared to the traditional PD they had previously completed, all teachers commended technology as their favourite means of conducting PD.

As a result of the significance of the session and the overall excitement regarding the adoption of recently introduced technical abilities and tools, such as video conferencing skills, each participant experienced a sense of confidence in their capacity to implement the newly acquired knowledge right after the TSCL PD.

7. Guidelines on the implementation of technology-supported cooperative learning professional development to enhance teachers' self-directed learning

One of the features of DBR is that research needs to produce design outcomes (McKenney & Reeves, 2014). Based on the literature and the above findings from this research, guidelines for implementing TSCL PD have been developed to enhance teachers' SDL. From the corpus of data, the following themes relating to design guidelines arose: the needs analysis, clear objective and focus, structured tasks, content focus, active learning, elements of CL, ongoing training over a long period of time, evaluation and feedback and teachers' values and principles. Guidelines relating to each of these themes are discussed in detail in Table 1 below:

Table 1. Guidelines on the implementation of technology-supported cooperative learning professional development to enhance teachers' self-directed learning

Guidelines on the implementation of technology-supported cooperative learning professional development to enhance teachers' self-directed learning		
Theme	**Guideline**	**Motivation**
The needs analysis	The introduction of TSCL PD should begin with a needs analysis to understand what kind of PD teachers require and how their SDL might be enhanced.	In order to build an effective PD strategy, the needs analysis strives to gather as much information as possible (Zohoorian, 2015). A needs analysis is an effective method for evaluating an individual's learning requirements (i.e., teachers) to identify the gaps that may hinder TSCL PD from achieving its objectives.
Clear objective and focus	A relevant and effective intervention should be developed and implemented after a	Having a clear objective and focus in PD helps teachers align and have a common objective rather than competing with one another

	needs analysis and literature review (in this research this was in the form of PD).	(Guskey & Yoon, 2009). It is crucial to emphasise that many variables, including the goals it tries to achieve in terms of institutional and teacher professional needs, must be made clear when adopting TSCL PD.
Structured tasks	The TSCL PD must be well-structured and have measurable objectives that meet the learning needs of each individual teacher (auditory, hands-on and visual).	Structured tasks are defined as tasks that are clearly specified and stated, with larger activities being divided into smaller, more manageable tasks. Each teacher must be provided with cohesive, purposeful learning experiences that begin with specific learning objectives and continue with instructional activities that logically lead to the expected outcomes (Guskey & Yoon, 2009). In support of this view, Reitsma and Mentz (2009) also add that a successful PD strategy for teachers concentrates on four related factors (context, content, process, and structure) that provide guidance for the execution of the PD approach.
Content focus	The TSCL PD should concentrate on the content related to a specific curriculum as well as teaching practices that enhance teacher learning in the context of the teachers' classrooms.	Teaching strategies related to content of the curriculum that enhance teacher learning in the teacher's classroom contexts are referred to as content focus (Desimone, 2009). Desimone (2009) states that "… the content focus of teacher learning may be the most influential issue …" in designing effective PD. To facilitate teacher learning within their classroom settings, PD strategy for teachers should emphasise teaching strategies that correspond with specific curriculum content (Darling-Hammond *et al.*, 2017).
Active learning	The TSCL PD should be designed in such a manner that teachers are given an opportunity to be involved with the content and process of PD so that they have greater control over their learning.	Active learning promotes greater knowledge retention of the material, as teachers are engaging with the content rather than merely listening to it. Darling-Hammond *et al.* (2017) support this by stating that an effective teacher PD strategy is the

		one which affords teachers an opportunity to engage with the course material through discussions and problem solving.
Elements of cooperative learning	The five components of CL must be incorporated into the execution of PD in order to motivate teachers to engage in their own learning more actively, as well as for successful and effective cooperation (Bosch & Laubscher, 2019).	The success of the interaction among group members is increased by including CL features (Johnson & Johnson, 2019). It also enhances group members' SDL skills (Mentz & Van Zyl, 2016). Positive interdependence (which will help teachers to recognise they need each other to fulfil the work), promotional interaction (which will allow teachers to assist one another), individual accountability (being responsible for own individual work), and interpersonal skills (providing teachers with decision-making, trust-building and communication skills) are just a few of these key characteristics.
Ongoing training over a long period of time	The TSCL PD should be a continual process which includes follow-up and reliable assistance so that teachers can acquire the necessary knowledge and skills they need to adopt new strategies.	Ongoing training over a long period of time is an important aspect of teacher education because it ensures that teachers maintain a high level of expertise and keep up to date with new research on how children are learning new technology in the classroom (Desimone, 2009). According to Louws *et al*. (2017a), PD opportunities that are ongoing tend to have a positive impact on teachers' professional growth. Darling-Hammond *et al.* (2017) have expressed a similar view that**,** before a new teaching method is developed and put into practice in the classroom, teachers need up to 50 hours of training, practice, and training.
Evaluation and feedback	Teachers need to be provided with feedback and evaluation in the TSCL PD.	By encouraging self-reflection and requesting feedback, top-notch professional development programmes offer teachers dedicated time to contemplate, receive input on, and enhance their instructional practices (Desimone, 2009). The literature on teacher PD shows

		that teachers must be tested after engaging in PD in order to determine the effect of their learning (Wanner & Palmer, 2015). Both feedback and reflection can assist teachers to correct errors and improve performance in the future.
Teachers' values and principles	The TSCL PD must be structured to provide a respectful environment among teachers while also encouraging an open and critical exchange of ideas.	When a teacher accepts the distinctiveness of colleagues and treats them kindly and fairly, their values and principles are realised in PD.

The guidelines presented in Table 1 highlight the importance of introducing TSCL PD with a needs analysis, which assists in establishing what the requirements of the teachers are for the PD. The PD should have a clear focus and objective which addresses the teachers' needs and is aligned with relevant literature. Relevant curriculum-based content and tasks which are well-structured should be included in the TSCL PD. An active teaching-learning strategy such as CL, where the five elements of CL are incorporated, encourages the active involvement of participants. Ideally the TSCL PD should be implemented gradually over a long period and should be a continual process of development. This allows for the acquisition of knowledge and skills that can increase teachers' levels of expertise. Feedback and evaluation are essential aspects that need to be addressed regularly in effective TSCL PD to assist teachers to correct errors and improve their performance. Finally, the TSCL PD environment should be respectful and should adhere to ethical standards, where each individual feels comfortable to share their opinions and ideas.

8. Conclusion

The purpose of this research was to challenge traditional PD and provide guidelines on the implementation of TSCL PD to enhance teachers' SDL. Based on the findings of this research, the provision of using technology to acquire and exchange information, as well as the ability to engage with and work in small, structured groups in order to enable teachers to participate in a PD that is intensive and flexible while still being affordable, and ongoing, is necessary. The findings revealed that teachers valued the practical PD sessions and considered them to be very beneficial. It was also found that TSCL as a PD strategy can promote continuous, lifelong learning by allowing teachers to collaborate and share ideas and materials in order to develop their teaching methodologies, regardless of their geographical proximity. One may argue that TSCL offers a novel method of teacher PD that enables teachers to learn how to execute tasks to the best of their abilities while acknowledging and respecting one another's skills and in so doing, gain a greater sense of control over their learning. This study adds to the expanding body of literature that contends that using technology in conjunction with CL strategies leads to a more personalized learning environment that may enhance teachers' professional growth.

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