TEACHER PROFESSIONAL LEARNING FOR TECHNOLOGY INTEGRATION IN MATHEMATICS CLASSROOMS THROUGH ONLINE LEARNING COMMUNITIES

A thesis presented in partial fulfilment of the
requirements for the degree of
Doctor of Philosophy in Information Technology
at Massey University, Albany
New Zealand

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2018

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ABSTRACT

The new school curricula in Indonesia emphasise the integration of technology into instructional practices. The infusion of technology in mathematics education requires teachers to align their teaching practices with ongoing technological innovations. Integrating technology into mathematics classrooms requires teachers to have a good knowledge of mathematics content, technology and pedagogy. Teachers also need to consider their school environments. Existing teacher professional development programmes are seen to be failing to meet teacher needs regarding content delivery that sometimes does not match the existing school conditions.

The premise underlying this research is that the use of an online learning community (OLC) may present a possible solution to the current challenges. Thus, the intention of this study was to investigate the potential of OLCs to help develop teachers' learning to fulfil their professional needs in integrating technology with the teaching of mathematics.

An ethnographic approach was used to investigate the phenomenon of teacher learning within an OLC and the implementation of the new knowledge acquired in their mathematics teaching practices. Empirical data from five case studies were used to examine how participation in the OLC affected teaching practices for five teachers. The results revealed that teacher participation in an OLC offered opportunities and challenges. Teachers de-privatized their practices as they actively engaged in social learning interactions to share knowledge and help each other with the appropriate use of technology in teaching mathematics. Teachers also faced some challenges, which impeded them. These challenges included differences in school policies, such as restrictions on using social media and limited technical infrastructure, which hindered teachers from fully leveraging the OLC. Teachers with less experience in teaching with technology and with low levels of technology skills tended to be passive in the OLC. Cultural contexts revealed that lack of experience and caution about expressing opinions made teachers feel *ewuh pakewuh*, a shyness in openly expressing their thoughts. Despite these barriers, the study provided evidence that teachers improvised and dealt with situations as they rose.

The findings of this study provided evidence that participation in the OLC had significant impacts on teachers' professional learning. Teachers altered their mode of using technology either as a partner or as an extension of self as they gained more confidence in their own learning. The teachers gradually transformed their participation from peripheral to full participation in promoting the use of technology for teaching mathematics. The research provides new insights into ways teachers can be helped to develop their professional learning in the use of technology for teaching mathematics through participation in OLCs. Particularly for Indonesia, the findings of this research provide an OLC-based model that could be implemented in other contexts that share similar technology landscapes and sociocultural heritages.

ACKNOWLEDGEMENTS

My PhD journey has been amazing in many different ways, and would not have been possible without the exceptional people around me, whom I would like to thank.

All praises to Allah SWT, the Almighty God. I have been blessed by His mercy and His grace to undertake my doctoral study in New Zealand. I am thankful for His guidance and for the strength He has granted me to accomplish this PhD journey.

My sincere gratitude goes to my supervisors Dr. Anuradha Mathrani and Professor Roberta Hunter. I am truly thankful for their support, guidance, patience, dedication and encouragement in working with me on this PhD journey and the meticulous process of writing. I would also like to thank Dr. David Parsons and Dr. Suriadi, who supervised me during the first year of my PhD; they always inspired and encouraged me by providing honest and constructive feedback.

I would like to thank all the teachers who so willingly allowed me to enter their world and journey with them as they transformed their teaching practices with technology. Their willing participation in the online learning community, their ability to openly grapple with change and continue with the journey, and the excitement they expressed as their journey progressed were a source of strength, which sustained my own journey.

I wish to thank the Project Management Unit of Universitas Negeri Semarang, which provided an Islamic Development Bank scholarship for my doctoral study. I would also like to thank the Indonesia Endowment Fund for Education (LPDP) of the Ministry of Finance of the Republic of Indonesia for granting me a dissertation scholarship and Massey University for the doctoral completion award for the completion of this thesis.

A special tribute and thanks to my parents, who never had the chance to attend formal schooling, but always hoped, encouraged and trusted that one day I would

be the one they were dreaming of. Thanks also to my beloved wife, Indri Puspitaningtyas, who has always supported me to live my dream and complete this PhD to the highest level; without her support, this long distance relationship would have been more stressful and difficult to cope with. My lovely and precious children, Nafeeza Zaina Azkadina Mecca, Zealand Zayeda Zain, and Liam Kenzo Zain; I offer the hope that this will inspire and motivate you to face your future endeavours. I am so sorry for not being able to give you as much attention as I would have liked during my PhD study. I do hope we can enjoy more things together in the forthcoming period. I will also be forever grateful to my in-laws and other family members for their endless prayers and support during my study in New Zealand.

I am also grateful that I have been surrounded by supportive and helpful people: Joshua, Sibghat, Baryalai, Rahila, Jumbo, Jun, Azadeh, and Hakim. Stay in touch!

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LIST OF ACRONYMS AND ABREVIATIONS AND DEFINITIONS

3D	Three-dimensional. In the context of geometry, 3D objects are objects with three dimensions (height, width and depth)
CONINCON	Connection, Integration and Contextual, a learning model
CoP	Community of Practice
CK	Content Knowledge
F2F-ZPA	Face-to-Face – Zone of Promoted Actions
FB	Facebook
FBMG	Facebook Messenger Group
GPS	Global Positioning System
ICT	Information and Communication Technology
JPNN	Jawa Pos News Network. Jawa Pos is an Indonesian national daily newspaper, and JPNN is Jawa Pos' newspaper networks.
JSIT	*Jaringan Sekolah Islam Terpadu* (Integrated Islamic Schools Network)
K-13	*Kurikulum* 2013 (the 2013 Curriculum)
KTSP	*Kurikulum Tingkat Satuan Pendidikan* (School-Based Curriculum)
LCD	Liquid Crystal Display
LPMP	*Lembaga Penjamin Mutu Pendidikan* (Institute for Educational Quality Assurance)
NCTM	National Council of Teachers of Mathematics
OECD	Organisation for Economic Co-operation and Development
OLC	Online Learning Community
OLC-FB	Online Learning Community – Facebook
OLC-IM	Online Learning Community – Instant Messenger
OLC-ZPA	Online Learning Community – Zone of Promoted Actions
PAKEM	*Pembelajaran Aktif, Kreatif, Efektif, dan Menyenangkan* (Active, Creative, Effective, and Joyful Learning)
PCK	Pedagogical Content Knowledge
PLC	Professional Learning Community
PK	Pedagogical Knowledge

PKB	*Pengembangan Keprofesian Berkelanjutan* (sustainable professional development)
PMRI	*Pendidikan Matematika Realistik Indonesia* (Indonesian Realistic Mathematics Education)
PPPG	*Pusat Pengembangan Penataran Guru* (Teacher Upgrading Centre for Mathematics)
PPPPTK	*Pusat Pengembangan dan Pemberdayaan Pendidik dan Tenaga Kependidikan* (Centre for the Development and Empowerment of Educators and Educational Personnel)
SNS	Social Networking Site
ToT	Training of Trainer
TPACK	Technological Pedagogical Content Knowledge
TPD	Teacher Professional Development
UNBK	*Ujian Nasional Berbasis Komputer* (computer-based national examination)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO-UIS	UNESCO Institute for Statistics
UKG	*Ujian Kompetensi Guru* (Examination of Teachers' Competency)
WA	WhatsApp
WAG	WhatsApp Group
Wi-Fi	A technology for wireless local area network with devices based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards. It is a trademark of the Wi-Fi Alliance, a non-profit organization that promotes Wi-Fi technology and certifies Wi-Fi products if they conform to certain standards of interoperability.
ZFM	Zone of Free Movement
ZPA	Zone of Promoted Action
ZPD	Zone of Proximal Development

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The pervasive nature of digital technologies triggered by the Internet and evolving social media tools, has transformed the way we learn, communicate and interact with each other. Technological advancements have penetrated almost every aspect of our social and professional lives. Emerging technologies have also served as a catalyst for expansion, transformation and innovation in education. Integration of technology into education practice has transformed teaching and learning environments, and empowered individuals to seize new learning opportunities to become lifelong learners. Educational technologies have re-conceptualised teaching and learning strategies and current teaching deliveries are being augmented with screen-based and online social interactions to engage learners in the learning process.

In mathematics education, integration of technology can alter the way in which mathematics content is delivered. Technology allows use of innovative teaching resources and it can give a positive impact on the overall learning experience if used effectively. There is considerable demand for technology interventions to be added to current teaching and learning practices. However, for teachers to bring about such change they need first to familiarize themselves with relevant technologies before they can have confidence in using technology effectively in mathematics classrooms. Teaching with technology can be improved with practice in a collaborative and supportive learning environment. Therefore, participation in professional learning environments can provide teachers with new learning opportunities to help them engage better with technology and develop new skills. One of the many ways to help bring about a collective professional learning experience for teachers is through setting up online learning communities (OLCs).

An OLC can be better understood as any virtual learning environment where people share information and learn, typically through online social interactions (Ke & Hoadley, 2009; Preece, 2001). The OLC also offers opportunities for teachers to reflect on their practices, keep themselves updated with new knowledge, and keep abreast of changes in the field of education. The OLC can provide teachers a forum for sharing their teaching experiences with other teachers and offer them collaborative learning opportunities.

The use of technology in schools is not widely available in developing worlds where it is still considered a novelty. A report by the OECD (2013, p. 12) states that "disadvantaged schools may need additional resources as the challenging socio-economic profiles and varying needs of the students tend to push up teaching costs". Therefore, it is important for educators and education stakeholders to take into account the growing relevance and implications of technology in order to create technology-based innovations to enhance teaching and learning capabilities (OECD, 2010). Schools as learning environments have a responsibility to prepare the new generation of learners with skills and capacities for 21st century citizenship, including technical know-how, creative use of knowledge, ability to collaborate globally, solve real-world problems and have self-direction. These goals are not sufficiently achieved through traditional forms of education (Groff, 2013). Reinvention of learning environments needs to be considered to prepare each individual for effective life-long learning. Advances in educational technology offer new ways for learners to engage in social learning activities in virtual spaces to enhance their professional learning experiences.

The purpose of this research was to investigate teachers' professional learning in online learning communities with regard to using technology for teaching mathematics in secondary schools. Teachers' professional learning involves a personalized process whereby individuals internalize experiences that help them to create professional knowledge (Timperley, Wilson, Barrar, & Fung, 2007) through participation in professional development programmes. Professional development of teachers should be provided by conducting ongoing development programmes in school-based contexts, and teachers should be given time and proper opportunities to implement their newly learned practices (Goos, Dole, & Makar, 2007). To date there appear to be few small-scale studies (Duncan-Howell, 2010; Trust, 2015) that have suggested that OLCs have an influential role in facilitating teacher professional development.

This section has laid the foundation of the study and explained the relevance of conducting research in teacher professional learning in a developing country (i.e., Indonesia). Section 1.2 elaborates on this to give a more in-depth background to the study. The current situation with regard to teacher professional development in Indonesia, followed by the significance of current technology integration in schools, is presented in the two subsections. The research questions are presented in Section 1.3, followed by the rationale for the study in Section 1.4. The study adds to and significantly extends existing research on how OLCs have enabled teachers' professional development in integrating technology with mathematics teaching practice. The contribution of this study is described in Section 1.5. A roadmap of this study's investigation is presented in Section 1.6, and finally, an overview of the thesis structure is provided in section 1.7.

1.2 Background to the Study

This section presents the teacher professional development (TPD) programmes in Indonesia and the importance of integrating technology into mathematics education practice. Teacher professional learning programmes have been done primarily in a traditional manner in developing worlds. For example, Hairon and Dimmock (2012) investigated the systemic implementation of a professional learning community in Singapore schools. Kong, Looi, Chan, and Huang (2017) have investigated teacher development for e-learning in school education in Singapore, Hong Kong, Taiwan, and Beijing. However, scaling-up methods of TPDs in these regions are different from Indonesia because the school systems of these countries are different. Further, the teacher professional developments in Indonesia must comply with a Law Number 14 regarding teachers and lecturers, which has been set up to alleviate problems commonly faced in the teaching profession in an education system of a developing world (Kusumah & Nurhasanah, 2017). This law mandates all school teachers have appropriate academic qualifications (bachelor's degree or 4-year diploma), competencies (pedagogical, social and professional), national teaching certification, good physical and spiritual health, and a commitment to achieving the national education goal.

The importance of incorporating technology into mathematics practices cannot be ignored anymore. More and more technologies are being introduced that can help to digitally simulate physical real-world scenarios and provide us with a learning platform to better understand the practicality of mathematics applications. By using technology, teachers can easily link mathematical concepts with contextual problems in real-world settings so that students can relate mathematical theories with these situations while problem solving (Sawaya & Putnam, 2015). Teachers can effectively design innovative instructional practices within technology-enhanced mathematical learning environments. In this regards, teachers rely not only on their capabilities and familiarity with technological tools, but also their assessment on the suitability of their proposed subject delivery within the current student environments (Yu, Yuen, & Park, 2012). In the implementation of innovative pedagogies, teachers need to first consider their schools technological infrastructure, that is, how prepared their schools are in providing proper technological access.

The following subsection describes TPD in Indonesia and current technology integration in schools.

1.2.1 Teacher professional development in Indonesia

The Indonesian government has introduced various policies and programmes to strengthen the quality of education. One programme is focused on creating an environment of change in teacher professional development (TPD). A number of studies related to TPD in Indonesia have been conducted (Ekawati & Kohar, 2016; Kusumah & Nurhasanah, 2017; Sari, 2012; Widodo & Riandi, 2013). Kusumah and Nurhasanah (2017) traced the chronological development of TPD in

Indonesia, including some aspects that have emerged since the implementation of recent government policies. The TPDs mentioned in their study were conducted by government (e.g., pre-service education, and national teaching certification for in-service teachers and pre-service teachers), and some education agencies (e.g., lesson study courses; training in the teaching model "PAKEM", which stands for active, creative, effective, and joyful instruction; and Indonesian realistic mathematics education). The effectiveness of these programmes is challenged by various issues, one of which is poor attendance. Not all mathematics teachers are able to participate in these programmes because they need to take leave to attend. Moreover, attendance incurs costs for travel and accommodation, which are borne by the school. Therefore, only a limited number of representatives are sent to participate. In addition, education agencies such as the Institute for Educational Quality Assurance (*Lembaga Penjamin Mutu Pendidikan* – LPMP), the Teacher Upgrading Centre for Mathematics (*Pusat Pengembangan Penataran Guru* – PPPG Matematika) and some other institutions that engage in providing professional development programmes for mathematics teachers are unable to serve the professional development needs of all mathematics teachers in the country.

Ekawati and Kohar (2016) investigated TPD in Indonesian realistic mathematics education (*Pendidikan Matematika Realistik Indonesia* – PMRI). The study was conducted through a number of stratified workshops to help teachers to design and implement PMRI lessons and to strengthen the mathematics teaching community. Ekawati and Kohar claimed that the study succeeded in generating ideas from teachers on how to change "the way of teaching" to "the way of making students learn" (p. 9). The results of their study revealed that there were improvements in teacher's conceptions of pedagogical strategies, mathematics content knowledge and skills, and the use of simple teaching aids that were readily available (such as coins, straws, pieces of paper, bottle-covers, coconut shells, and plastic bottles). However, some challenges were identified, including the fact that PMRI had not been explicitly integrated into the Indonesian mathematics curriculum, and not all mathematics teachers had the opportunity to attend PMRI workshops because invited schools usually only appointed one or a limited number of teachers as participant representatives.

Widodo and Riandi (2013) examined the results of a two-year research project aimed at developing a TPD model in Indonesia. A dual-mode TPD that combined face-to-face sessions and online sessions was developed to identify teachers' professional needs. A needs assessment using questionnaires was conducted on 102 science teachers from Bandung and Sumedang, West Java in the first year of the study. The findings revealed that 45.1% were interested in having online TPD, and 89.2% expected to have face-to-face TPD. Thus, a pre-TPD programme was conducted to provide teachers with basic computer and Internet skills, and a combination of face-to-face and online training was designed. The administration of the dual-mode TPD programme was done in the second year. The study showed that regardless of teachers' interest in online learning modes, their participation in online sessions was still low. Given these facts, Widodo and Riandi suggested that the Indonesian government should look into teachers' motivation to keep on learning, encourage the integration of bottom-up (based on teachers' individual needs) and top-down (based on institutional goals) teacher development and be more open to collaborating with universities and other training centres. Widodo and Riandi only reported the results of the questionnaire (the needs analysis instrument), and did not discuss the findings from field notes, Internet access records, and interviews. In view of the gaps in Widodo and Riandi's study and the wider literature, the current study has the potential to contribute new learning about how teachers who were actively involved in online TPD developed their professional learning and implemented their new knowledge in the mathematics classroom.

Sari (2012) investigated the implementation of an OLC for TPD in Indonesia. Design-based research was used to examine the feasibility of an OLC as a concept to support ongoing professional development and to improve teaching and learning. A number of tools, including a web portal, Skype, Facebook, and other synchronous and asynchronous apps were used to manage the interaction between researchers and participants (i.e., teachers, teacher educators, and education leaders). Of the tools, Facebook was the most prominent medium, which led to significant growth in numbers of participants who engaged in the study (Sari & Tedjasaputra, 2013). From the findings it can be seen that there were three benefits of an OLC. An OLC allowed all participants to work together and reflect upon their profession. The OLC helped the participants deal with any issues related to financial support, human resources and geographical limitations. Lastly, the OLC encouraged the creation of new knowledge to tackle real world professional issues. The findings also showed how participants constructed their social knowledge, and how social learning interactions happened in the OLC. However, this study did not fully examine the impact of teachers' participation in the OLC, or investigate the changes this caused to their classroom teaching practice.

The current TPD programmes in Indonesia are often performed in a face-to-face environment and focus mainly on improving teachers' understanding and competencies. These TPD programmes do not give attention to whether or not teachers will be motivated to keep on learning. The studies shed light on the challenges faced by teachers when participating in face-to-face TPD. The use of OLC for professional development can help teachers overcome some of these challenges. Currently, there appear to be few studies that have investigated how teachers develop their professional learning through participation in an OLC and how they implement the new knowledge obtained from the OLC into their classroom teaching practices. Nor do there seem to be studies that have investigated the affordances and barriers to participating in an OLC as a way to re-envision the model of TPD. As such, the current study investigates those two issues to frame its discussion.

1.2.2 Technology integration in schools

Technology can provide a platform for schools to empower teachers and make students more receptive to learning. Baskerville (2012) suggests that technology should be applied in a manner that gives opportunities to students and teachers to make meaningful personal learning experiences (for example, an exploration of digital media for information to generate new ideas and construct knowledge). This builds enthusiasm and intellectual curiosity as together they raise pertinent questions, and reflect in an interactive environment. Lim, Zhao, Tondeur, Chai, and Tsai (2013) are of the view that the increasing demand for the use of technology requires specific changes in schools, including revising standards for teaching and learning. With technology becoming a big part of our everyday lives, they add that schools need to integrate technology appropriately in classrooms for mathematics teaching, otherwise students may become disassociated from teaching and learning activities. They assert that teachers are no longer the sole source of information, and technology, if used properly, can potentially help students take ownership of their own learning processes by exploring new areas of inquiry (e.g., Google, Amazon, and Facebook).

Teachers play an important role in the success of technology integration in the mathematics classroom. Their role is not only to help students to construct knowledge, but also to structure student engagement with the knowledge, and support students to make the knowledge their own by practising high-level cognitive skills (Gunter & Reeves, 2017; Laurillard, 2008). Thinking through the future of technology integration in the classrooms, it is important for teachers to have a good understanding of the use of technology. Having proper understanding enables teachers to facilitate meaningful learning strategies so that students can construct mathematical knowledge, which can be applied to real situations (Ertmer & Ottenbreit-Leftwich, 2010). Further, teachers are also expected to be able to design rich and relevant learning contexts for students by integrating technology into mathematical activities. Since teachers are key figures for the successful integration of technology, preparing teachers to be able to use technology is an essential component of educational reform efforts (Angeli & Valanides, 2009; Somekh, 2008).

At the moment, Indonesia is still in transition in a curriculum shift. The new curriculum, known as Curriculum 2013 (K-13), emphasises the use of technology (Ministry of Education and Culture, 2013a) and offers opportunities for students to access technology as a means of learning. Therefore, the expectation is that teachers, as the main actors in mediating and facilitating students to engage with technology, should be able to create a learning environment that supports the successful integration of technology. However, technology integration in Indonesian schools faces some challenges, including the lack of facilities and the low-level technology skills of teachers (UNESCO-UIS, 2014). Further, a survey conducted by UNESCO-UIS (2014) also revealed that the level of technology use in teaching in Indonesia is still low. Therefore, it is important to promote initiatives to improve teacher capabilities with technology, through professional learning programmes for teachers.

1.3 Research Questions

This research examined teachers' professional learning journeys in an OLC in which teachers shared their practices related to the integration of technology in the mathematics classroom. The study aimed to identify the affordances and barriers faced by teachers during their participation in an OLC and establish what factors promoted teachers' professional learning in the use of technology in mathematics classroom. The focus of the investigation was on the social learning interactions of mathematics teacher participants in various online learning communities. The study narrates the different journeys embarked on by five secondary school teachers as they integrated technology in their mathematics classroom lessons and describes the way they collaborated to improve their teaching practice. It also details how the OLC contributed to teachers' professional learning and motivated them to continue with innovative teaching practices.

Therefore, the main research question posed in this thesis is:

How do teachers develop their professional learning in using technology in mathematics classrooms through their participation in online learning communities?

This question is influenced by the following subsidiary questions:

1. What were the facilitators and barriers to teachers' participation in the OLC?
2. How did participation in the OLC help teachers in the process of acquiring knowledge, and promote professional learning in using technology in mathematics classrooms?

1.4 Rationale for the Study

Educational innovation is an ongoing process. Teachers pursue professional development to meet the new social and knowledge demands facing changing educational systems (S. Zhang, Liu, & Wang, 2017). Professional development offers opportunities for teachers to make changes in the curriculum, their teaching practices, and their assessment of student learning. Widodo and Riandi (2013) argued that although TPD has been adopted to improve teacher competencies, the existing TPD currently pays insufficient attention to how to keep teachers motivated and continuing with their own learning. Widodo and Riandi's research results showed that the existing TPD workshops in Indonesia, teachers are not treated as the subjects of the programme. Consequently, while teachers may participate in TPD, they are not empowered to take what they learn back to their mathematics classrooms; nor do they actively engage with or critically reflect on the programme agenda. Further, government policy on teacher education and teacher certification demands that teachers become professionally independent (Jalal et al., 2009). The enactment of the Regulation of Minister Administrative and Bureaucratic Reform Number 16 Year 2009 (Ministry of Administrative and Bureaucratic Reform, 2009) provides ample opportunities for teacher to be more professional through the Sustainable Professional Development programme (*Pengembangan Keprofesian Berkelanjutan* – PKB). The intent of this programme is that teachers are able to achieve and improve their competencies. These include pedagogical, personality, social and professional competencies (Ministry of National Education, 2003).

With the advancement of technology, an online learning environment can be created to support teachers' professional learning (S. Zhang et al., 2017). The literature shows that the use of online teacher professional development programmes provides opportunities for teachers to apply reflective practice, get feedback from each other, and construct learning communities (Kao, Tsai, & Shih, 2014; Lee et al., 2011). An online professional learning community enables teachers to engage in social learning interaction and gives them opportunities to develop their professional skills (Brian, 2013). However, limited studies have been undertaken to investigate the impact of OLCs on teachers' professional development (Duncan-Howell, 2010); moreover, the outcomes in classrooms have not been fully explored. Also, the potential of using social media software for building an OLC for teacher professional development programmes is not well understood (S. Zhang et al., 2017).

International studies illustrate that with the rapid development of Internet technologies, professional development programmes have changed from face-to-face TPD to professional development activities in an online environment (Y. Chen, Chen, & Tsai, 2009; Rolando, Salvador, & Luz, 2013). In Indonesia there appears to be little research that has examined the potential of online learning communities for teachers' professional development (Patahuddin & Logan, 2015; Sari, 2012). Therefore, a direct focus that matches the Indonesian social and cultural context will evaluate the impact on teacher professional development of participation in an OLC focused on the use of technology in mathematics classrooms.

This study investigated teachers' social participations in the OLC and examined how the OLC contributed to teachers' professional learning. Geiger (2017) stated that partnerships between teachers and researchers hold the potential for improving teaching and learning practices in mathematics education. During the trialling of tasks to integrate technology in mathematics classroom practices in five Indonesian schools, this study provided a teacher–researcher partnership perspective to improve understandings of the pedagogical approaches undertaken. Teachers' task designs and possible changes in their classroom practices were analysed from a sociocultural theoretical view appropriate to their classroom context.

1.5 Contribution of the Thesis

This research study empirically examined teachers' professional learning through their participation in an OLC. Widodo and Riandi (2013) explain that while online teacher professional development programmes have been gradually introduced, their impact on teachers' professional development has not been investigated; nor have their outcomes in classrooms been explored. In order to increase understanding of the impact of teachers' participation in an OLC on their professional learning, this study investigated both the professional learning of the teachers and also how they transformed their mathematics classroom practices using technology.

The contribution of this thesis can be summarised as follows:

1. Identification of factors that impeded and enhanced teachers' participation in the OLC. The inhibiting factors are significant in the development of an OLC-based model. These factors provided new insights into ways teachers could manage any situation that may hinder their participation in the OLC. Further, the affordance factors can be leveraged to optimise the potential offered in OLCs for teachers' learning.
2. The research study provided social network patterns of the community members in the OLC. The network patterns portrayed the relationships and interactions of community members in the OLC, which are important to examine social presence, or a person's level of awareness in an interaction. This study provided evidence that some teachers gradually shifted towards more central positions and eventually replaced the role of the researcher as a mediator and social host in the OLC. These teachers showed a sense of ownership towards the OLC as they took the roles of mediators. However, all teachers found value in community interactions and contributed to nurturing the OLC.

3. The research study provided evidence that OLCs have potential for ongoing informal professional development. Empirical evidence from this study showed that teachers continually leveraged the OLC to gain additional learning in the use of technology for teaching mathematics.
4. Technology was an essential medium for teachers, enabling them to maintain their engagement in the OLC in both a flexible and a reflective manner. This indicates that an OLC can be considered a promising model for ongoing teacher learning because of the flexibility it provides and because it does not require a personal presence.
5. This study provided an empirical assessment of Valsiner's (1997) zone theory approach in the development of teachers' professional learning in integrating technology into mathematics teaching practice. This study also extended Goos' (2013) study of the use of Valsiner's zone theory, and applied zone theory to professional learning within the OLC, while Goos applied zone theory to understand teachers' learning within face-to-face professional development settings. This study also adapted Tu and Corry's (2002) model of online learning community, which helped to increase the understanding of social learning interactions between community members in the OLC, while Valsiner's zone theory provided guidance in interpreting the process of professional learning while integrating technology into mathematics classrooms.

1.6 Roadmap of the Study

Figure 1.1 depicts the roadmap of this study in order to answer the proposed research questions. More details of the theoretical and methodological models used in this study are included in Chapters Two and Three.

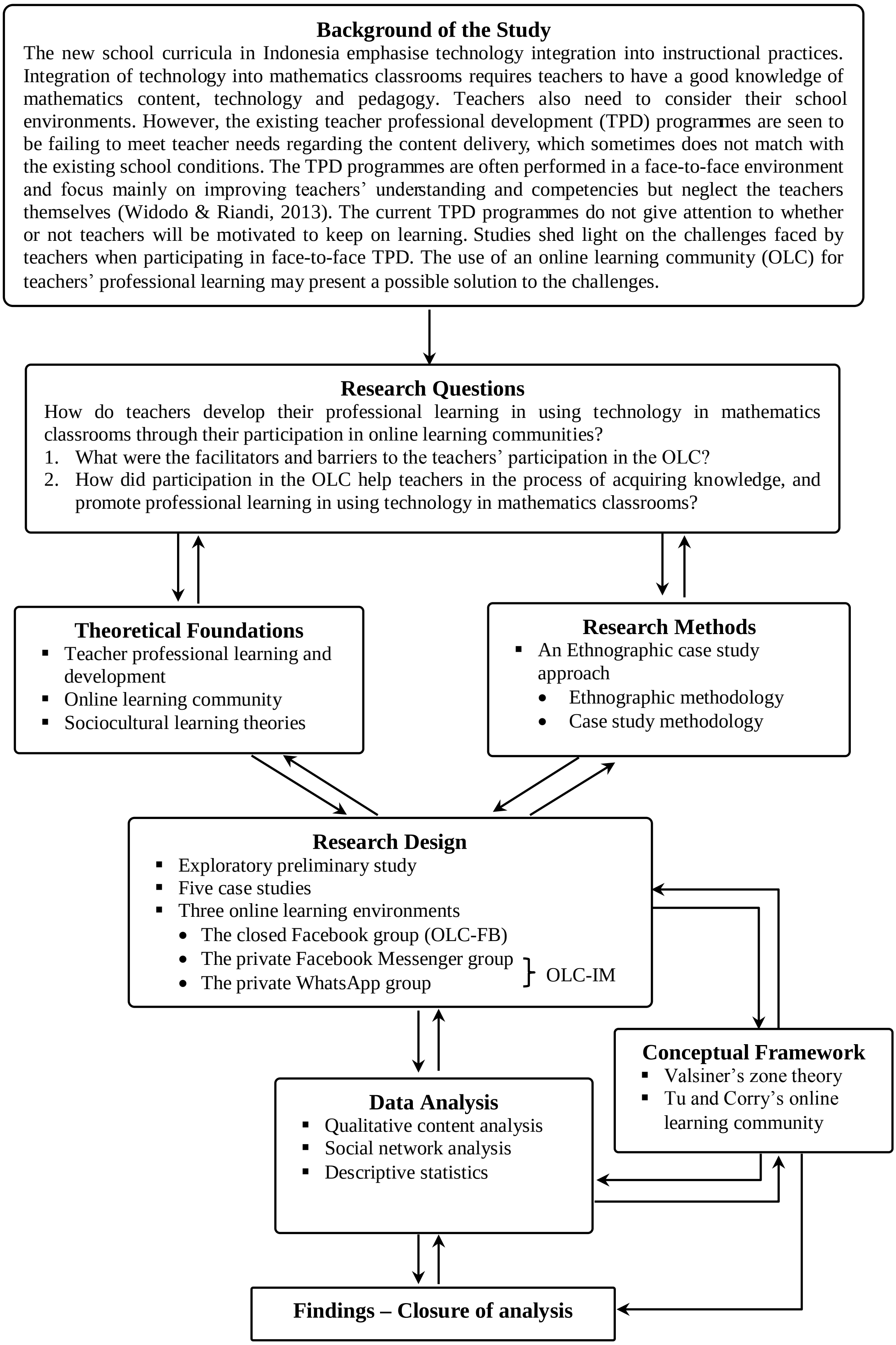

Figure 1.1 Roadmap of study

1.7 Overview of the Thesis

The thesis is divided into eight chapters. This chapter has set the scene and described the significance of the study. Chapter Two provides a review of the literature. It includes critical readings of four main bodies of literature: teacher professional learning and development; professional learning communities; online learning communities; and sociocultural learning theories.

Chapter Three describes the use of an ethnographic case study approach and discusses the methods used to collect and analyse data. Ethical considerations and a summary of the methods used to ensure reliability and validity of the analyses are outlined.

Chapter Four presents the results of a preliminary study conducted in April-June 2015. The potential and challenges of using mobile technology in Indonesia are identified to gain insights into current technology-based teaching practices in the mathematics classroom.

Chapter Five explores the social learning interactions that occurred in online learning environments.

Chapter Six outlines the journey of the five teachers during their engagement in the OLC as they brought about changes to their teaching practices and learned to integrate technology into their instructional practices.

Chapter Seven elaborates on factors that facilitate or impede teacher participation in the OLC and identifies those activities that promote teacher professional learning in an OLC. Analyses of the development of teacher professional learning using zone theory are also presented to investigate how mathematics teachers learned from the OLC in adopting the technology.

Chapter Eight presents the conclusions, contributions, limitations, and implications of this study, and proposes recommendations for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The previous chapter introduced the importance of teachers' professional learning as a way to enable teachers to integrate technology into their mathematics teaching practices. The need to look beyond traditional face-to-face teacher workshops was emphasised, and building online learning communities was seen as viable. Recognition was given to the way online social interactions help in peer learning, where teachers can share views across diverse teaching and learning activities. For this reason, this chapter closely examines social learning theories in mathematics education. These theories have informed the theoretical framework used in this study. OLC and sociocultural learning theories that underpin this investigation are presented.

Section 2.2 provides a description of teacher learning and teacher professional development. The changes in teachers as they embrace technology is described in detail, together with dimensions related to the change, including attitude, knowledge, self-efficacy, pedagogical beliefs, and culture.

Section 2.3 outlines professional learning communities and describes aspects of how communities of learners collaborate and learn together. In Section 2.4, the OLC and its four basic elements, including community, learning, network, and technology, are discussed. Finally, Section 2.5 presents existing sociocultural learning theories that have guided this study. This includes a description of Valsiner's zone theory and the possibilities it offers for teachers' professional learning.

2.2 Teacher Learning and Teacher Professional Development

There are various interpretations of what teacher professional learning and teacher professional development is and how they complement each other. Witterholt, Goedhart, Suhre, and van Streun (2012) see professional development and professional learning as being very closely intertwined. They state that without professional learning, there will be little impact on professional development. Teachers need to integrate practical knowledge with experiential knowledge so that they are able to learn from their own experiences, which can then be applied to further develop their teaching practice. Therefore, professional development experiences should be designed to build teachers' knowledge and skills to high standards, so that their teaching has a positive impact on student learning (Kyriakides, Christoforidou, Panayiotou, & Creemers, 2017). For teachers, professional development is part of the continual process of becoming a better educator. The term "professional development" implies "delivering some kind of information to teachers in order to influence practice" whereas "professional learning" is "an internal process through which individuals create professional knowledge" (Timperley et al., 2007, p. 3). Guskey (2000) defines TPD as a development programme associated with in-service training, provided by an educational institution and designed to enhance the professional knowledge, skills and attitudes of teachers so that they might, in turn, improve student learning. Borko (2004) describes professional learning as a process by which teachers move towards expertise by participation in multiple instructional practice situations, including their classroom, school communities and teacher professional development programmes. Teachers themselves can independently undertake professional learning by discussing ideas and materials related to their work that support critical examination of teaching.

Teacher change is directly linked to the planned activities in teacher professional development (Goos et al., 2007). Change can be defined as an “evolutionary process that can be supported by giving teachers opportunities to engage with mathematical concepts and focus on their own students’ thinking as they struggle to understand these concepts” (Goos et al., 2007, p. 26). Hall and Hord (2005) describe change as “a process through which people and organisations move as they gradually come to understand and become skilled and competent in the use of new ways” (p. 4). Clarke and Hollingsworth (2002) draw attention to the notion of teacher change as being open to multiple interpretations. These could be associated with particular perspectives such as undertaking training, adapting in response to some event, developing new skills, responding to local reforms, or participating in learning activities for professional development reasons.

According to Geiger (2017) technology can be considered a catalyst for change in teachers’ instructional practices. In this respect, the use of technology can be used to transform teaching practices from traditional to student-centred instructional practices. Teachers must master the use of technology for mathematical activities and experience for themselves the potentials and pitfalls of technological tools in mathematics learning, thereby gaining knowledge about how students can learn mathematics in various technology-rich environments (Leung, 2017). In this regard, teachers not only learn how the technology works but also learn how technology changes their teaching practices to promote student learning.

2.2.1 Teachers change as they embrace technology

Technology has changed practices at individual and institutional levels, influencing the social mechanisms of engagement with persons, local activities and scholastic events as we strive to catch up with material progress (Singh, Díaz Andrade, & Techatassanasoontorn, 2018). In the context of teaching with technology, teachers must be able to design innovative instructional practices with technology to make the teaching and learning process more effective. Some researchers (Angeli & Valanides, 2009; Cennamo, Ross, & Ertmer, 2010) suggest that in order to integrate technology that targets student learning, teachers should be able to identify which technologies are needed to support specific curricular goals. Teachers need to be able to identify teaching strategies that are difficult to implement using traditional means. Also, they need to be able to identify topics to be taught with technology in ways that show the added value of technological tools. Teachers should support students to use appropriate technological tools in all phases of the learning process, including observation, posing questions, exploration, analysis, and communication (Ministry of Education and Culture, 2013b).

The role of teacher in integrating technology into the classroom is crucial. Teachers who use technology in their teaching practices need to be able to change their role from the “sage on the stage” to the “guide on the side” (Watson, 2001, p. 182) to support students’ learning. Goos, Galbraith, Renshaw, and Geiger (2003) use four metaphors of master, servant, partner, and extension of self to categorize teacher activities when they are using technology in the classroom. Goos et al. (2003) explain that technology can be considered a *master* if teachers are subservient to technology. Their knowledge and competencies to use technology are limited to a narrow range of operations, especially in situations where an external authority has imposed upon them the need to implement technology in their classroom teaching practices. This may be perpetuated in the classroom. Teachers may lack competence in technology use, but they retain tight control of the lesson agenda by providing mathematical commentary and explanations accompanying the students' work. In this situation, teachers often call on a student "expert" to demonstrate procedures for the technology. Students are not encouraged to explore technology for mathematics inquiry in their own learning processes.

Technology is considered a *servant* if it is used as a fast and reliable replacement for pen and paper, but the nature of classroom activities remains the same. Here, teachers identify the way in which technology can help students to complete tasks quickly and efficiently, rather than being used to transform instructional practices (Geiger, 2009). In this category, teachers may be knowledgeable, but technology use is limited to ways to support their preferred teaching methods. For example, presentation slides are restricted to providing media for teachers to deliver materials to the class, and a graphics calculator is limited to producing fast and reliable answers to routine exercises.

Technology becomes a *partner* when teachers use the technology to facilitate students to gain more power over their own learning (Tan & Forgasz, 2011). When technology is used in this way, the students are provided with two different ways to approach mathematical tasks. These include providing students with creative ways, like applying an exploratory approach to gain a different perspective of a mathematics problem. The provision of scaffolding to facilitate students' understanding of mathematical concepts is also used (Geiger, 2009).

Technology becomes an *extension of self* if it is used to extend teacher's thinking and reasoning capacities. Teachers integrate their technological expertise as a natural part of their repertoire (Goos et al., 2003). The use of technology in this context is considered the most intellectual approach. However, Goos et al. (2003) suggest that a relationship between teacher and technology is not often seen at this level in mathematics classrooms. From the teacher's point of view, making video tutorials about ways of using mathematics software to enhance understanding of mathematical concepts would be an example of operating at this level.

Ertmer and Ottenbreit-Leftwich (2010) note that when using technology, teachers need some degree of change including "(a) beliefs, attitudes, or pedagogical ideologies; (b) content knowledge; (c) pedagogical knowledge of instructional practices, strategies, methods, or approaches; and (d) novel or altered instructional resources, technology, or materials" (p. 258). All these degrees of change can be achieved through professional development programmes that focus on technological skills and support for pedagogical change to embed technology (Somekh, 2008). Despite an increase in technology professional development, teachers may still be reticent to use technology to support their instructional practices. This is a result of their existing attitudes and beliefs, lack of relevant knowledge and skills, and low level of technological confidence (Ertmer & Ottenbreit-Leftwich, 2010; Mueller, Wood, Willoughby, Ross, & Specht, 2008).

The culture and organisational context in which teachers' work may also constrain their efforts (Somekh, 2008). The following subsections share some of the current research on how these factors affect teachers.

2.2.1.1 Attitude

The construct of 'attitude' has its origin in social psychology (Allport, 1935) in connection with the preferences and behaviours of individuals towards a specific class of social object, which may lead to or determine social behaviour. Hew and Brush (2006) suggest that attitudes can be understood as specific feelings of an individual. Di Martino and Zan (2010) describe attitude as a "predisposition to respond to a certain object either in a positive or in a negative way" (p. 28). In the context of technology integration, teacher attitudes toward technology may be conceptualized as teachers responding to the technology either in a positive or in a negative way. Albirini (2006) contends teachers' attitudes are a key factor affecting the implementation of technology in the classroom. Other researchers (e.g., Sang, Valcke, Braak, & Tondeur, 2010; Teo, 2011; Teo, Lee, & Chai, 2008; Teo, Luan, & Sing, 2008) note that teachers' attitudes play an important role in educational interactions and are fundamental in examining the outcome of technology integration in the classroom. Teachers who have positive attitudes towards technology feel comfortable in incorporating and using it in their instructional practices (Buabeng-Andoh, 2012; Kersaint, Horton, Stohl, & Garofalo, 2003). Besides attitudes, professional development also offers an opportunity for teachers to gain new knowledge for the successful integration of technology in the classroom.

2.2.1.2 Knowledge

Teaching with technology can be a challenge for some teachers. The challenges may include uncertainty about how to infuse technology in the classroom and how to make it more effective to support their instructional practices. Koehler, Mishra, and Yahya (2007) note that effective technology integration for teaching and learning activities requires understandings related to content, technology, pedagogy, and their relationship to each other. Borko and Putnam (1995) contend that teacher knowledge influences how teachers change. They suggest that teacher change can be achieved by expanding and elaborating teacher knowledge systems.

Shulman (1986, 1987) conceptualized knowledge as encompassing *content knowledge* (CK, knowledge of the subject matter that is to be learned/taught), *pedagogical knowledge* (PK, knowledge of teaching methods, and classroom management strategies and organisation that appear to transcend subject matter), and *pedagogical content knowledge* (PCK, the blending of content and pedagogy into an understanding of how particular content is taught to specific learners in specific contexts). Other researchers have extended Shulman's (1986, 1987) concept of PCK in similar conceptions of a more content-specific orientation to technology integration through the introduction of the concept of *technological pedagogical content knowledge* (TPACK) (e.g., Graham, 2011; Koehler & Mishra, 2009; Koh, Chai & Lim, 2017; Niess, 2005). TPACK describes the interaction between teachers' understanding of educational technologies and pedagogical content knowledge to produce effective teaching with technology. In other words, teachers require an understanding of the technology and what it can offer to realise how and when technology should be used to support student learning (Angeli & Valanides, 2009).

In using technology, teachers seek to expand their knowledge of pedagogical practices across multiple aspects of the planning, implementation, and evaluation processes to facilitate student learning. Teachers must develop plans for students to use technological tools, identify appropriate applications that fit with the learning objectives, manage the tools, and establish how learning objectives are to be met (Hennessy, Ruthven, & Brindley, 2005). Learning about technology is similar to asking teachers to hit a moving target, as the technology is always in a state of flux (Ertmer & Ottenbreit-Leftwich, 2010). Teachers will never have complete knowledge about the technological tools available, and this causes them to be perpetual novices in the process of technology integration (Mueller et al., 2008). As a result, teachers need to have strong self-efficacy to deliver their teaching effectively with technology.

2.2.1.3 Self-efficacy

If teachers do not have the confidence to use their knowledge of technology, there is no guarantee that they will be able to use it effectively as an instructional tool. Confidence to perform specific tasks is called self-efficacy (Albion, 1999b). Bandura (1997) defines self-efficacy as “belief in one's capabilities to organise and execute the courses of action required to produce given attainments" (p. 3). Bandura stresses that self-efficacy is strongly related to behaviour, and more importantly, to behavioural change. Self-efficacy is always forward-thinking about making judgments based on beliefs in a personal capability. Teacher self-efficacy is an essential element that accounts for individual differences in teaching effectiveness. A high level of self-efficacy makes teachers open to new ideas and they are more willing to experiment with new teaching strategies, pursue improved instructional methods, and experiment with different teaching materials (Sang et al., 2010).

According to Albion (1999b), the ideal approach for developing teachers' self-efficacy in technology use is teacher professional development programmes. George Watson (2006) noted that teachers' self-efficacy levels improved after a teacher workshop and their levels remained high even years after their involvement in the programme was over. However, relatively few studies have focused on the development of teacher self-efficacy in OLCs.

Sang et al. (2010) caution that the strong influence of both confidence and attitudes in relation to the prospective educational use of technology suggests that self-efficacy by itself may not be enough. Technology as an instructional tool must be understood and be valued by teachers. Therefore, how teachers beliefs inspire and support meaningful technology use should be investigated.

2.2.1.4 Pedagogical beliefs

Teachers' pedagogical beliefs related to a range of teaching aspects may have an effect on their technology use in the classroom and in their roles as mediators as they help develop their students' technology skills. Kagan (1992) described teacher beliefs as "tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught" (p. 65). Pajares (1992) explains that a belief system is "complex and intricate" and is "composed of beliefs connected to one another and to other cognitive/affective structure" (p.

316). Hermans, Tondeur, van Braak, and Valcke (2008) further explain that belief systems “consist of an eclectic mix of rules of thumb, generalisations, opinions, values, and expectations grouped in a more or less structured way” (p. 1500).

One teaching aspect that is important to consider is teachers’ beliefs about the nature of learning and teaching (Karaseva, Siibak, & Pruulmann-Vengerfeldt, 2015). Some researchers (Hermans et al., 2008; Windschitl & Sahl, 2002) claim that belief systems influence how teachers integrate technology in their classrooms. Teachers with more traditional beliefs tend to implement “low-level” technology use, but teachers with constructivist beliefs will adopt “high-level” technology use and maintain a dynamic student-centred learning focus (Ertmer & Ottenbreit-Leftwich, 2010). For example, in a study of three teachers, Windschitl and Sahl (2002) describe how the ways in which the teachers learned to integrate technology were “powerfully mediated by their interrelated belief systems about learners in their school, about what constituted ‘good teaching’ in the context of the institutional culture, and about the role of technology in students’ lives” (p. 165).

The increasing use of technology in education has raised important questions about the relationship between cultures and technologies (Sang et al., 2010). People from different cultures may have different perceptions and uses of technology (Li & Kirkup, 2007). Therefore, it is important to investigate how institutional culture affects teachers’ classroom practices with regard to the use of technology.

2.2.1.5 Culture

Teachers' use of technology for teaching and learning depends on the interlocking cultural, social, and institutional contexts in which they live and work (Ertmer & Ottenbreit-Leftwich, 2010). For instance, Zhao and Frank (2003) identify some school issues that affect technology integration into schools, such as limited classroom space, teacher's unwillingness to take students to the computer lab, teachers' negative attitudes and lack of expertise with technology, and conflicting ideas about the educational values of technology. Schools also naturally and necessarily resist changes that will put pressure on practices. Moreover, the constantly changing nature of technology makes it difficult to keep up with.

In the use of technology, school culture plays a significant role in how managerial processes are defined and in influencing individuals' feelings, thinking and actions (Hofstede, Hofstede, & Minkov, 2010). Understanding the notion of culture will help to explain how individuals or social groups interact with technology and how the technology is employed. Nistor, Lerche, Weinberger, Ceobanu, and Heymann (2014) define culture as "patterns of thinking, feeling and potential acting, which have been learned throughout a lifetime, and which are likely to be used repeatedly and unlikely (or difficult) to be changed by the individual" (p. 38). In the context of technology integration in school, Goodson and Mangan (1995) describe a subject culture as a "general set of institutionalised practices and expectations which have grown up around a particular school subject and shapes the definition of that subject as a distinct area of study" (p. 614). The subject content, subject pedagogy, and subject assessment typically shape subject cultures, and they are reinforced by generations of school practices

(Hew & Brush, 2006). Hew and Brush's study showed that subject culture indirectly affected technology integration through the teachers' attitudes and beliefs, and the institution. They claimed that attitudes, beliefs, and subject culture are interrelated variables that influence technology use in schools.

Teachers are essential to the successful integration of technology. Somekh (2008) argues that it is necessary for teacher professional development to focus on providing both technology skills and support for bringing about pedagogical change in order to embed technology effectively.

2.2.2 Effective teacher professional development

Successful professional development activities are determined by the extent to which teacher's activities have made changes in creating a positive learning environment which support student learning. Guskey (2000) describes effective TPD as "those processes and activities designed to enhance the professional knowledge, skills and attitudes of educators so that they might, in turn, improve the learning of students" (p. 16). Borko (2004) draws attention to three characteristics of TPD that affect teacher change: *knowledge of subject matter* (as this helps teachers to develop deeper understanding of subject content); *understanding of student thinking* (so that teachers can explore student's thinking process and plan ways to build on students' knowledge); and *instructional practices* (which are interdependent with the two previous characteristics). Thus by having a rich knowledge of subject matter and an understanding of student thinking, instructional practices can be improved. Goos et al. (2007) identify three key characteristics for effective TPD to support teacher change. These characteristics include: *ongoing development programmes* (because teacher change is a long-term process); *school-based contexts* (to enable teachers to try out and validate the ideas of TPD in their classrooms); and *time and opportunities to implement new practices* (to support teachers to have time and opportunities to deliberate any pedagogical and curricular issues with supportive colleagues before implementing the new teaching practices in their classrooms).

Guskey (2002) provides a teacher change model to guide the creation of more effective professional development. Guskey describes the key outcomes of TPD as the need to expand teachers' knowledge and skills and their ability to apply the new learning directly to day-to-day classroom activities and improve their effectiveness with students. Guskey (2002) emphasises that the crucial point of the model is that:

> ...it is not the professional development *per se*, but the experience of successful implementation that changes teachers' attitudes and beliefs. They believe it works because they have seen it work, and that experience shapes their attitudes and beliefs. Thus…the key element of insignificant changes in teachers' attitudes and beliefs is clear evidence of improvement in the learning outcomes of their students (p. 384).

Guskey suggests that after engaging in professional development activities, teachers should be supported to change their classroom practices and apply new instructional approaches, use new materials, or simply modify teaching procedures or classroom formats. The goal is to affect student learning. As Fishman, Marx, Best, and Tal (2003) explain, teachers who have succeeded in helping students in their learning process are likely to believe that their new instructional strategies are productive for student learning. They suggest that the positive change in students' learning can be seen as a prerequisite for causing changes in the attitudes and beliefs of many teachers.

The learning outcomes in Guskey’s model include “whatever kinds of evidence teachers use to judge the effectiveness of their teaching” (Guskey, 2002, p. 384). The significance of Guskey‘s model applies not only to teachers and how they change, but also to the practice and ongoing improvement of professional development.

2.3 Professional Learning Community

The concept of a professional learning community (PLC) has gained considerable attention as a strategy to improve teaching quality (Pang & Wang, 2016). PLC constitutes a paradigm shift from conventional TPD organised by external educational agencies to ongoing professional learning in the workplace where teachers share their teaching experiences and knowledge within a community (Tam, 2015). There is no single, authoritative definition of a professional learning community. A PLC may have many interpretations in different contexts, but there appears to be a consensus that it suggests the collaborative pursuit of on-going learning (Schuck, Aubusson, Kearney, & Burden, 2013; Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). Kruse, Louis, and Bryk (1995) suggest five essential characteristics of a professional learning community, as follows:

1) *Collaboration*. This characteristic represents cooperative practices among teachers. Teacher collaboration is a manifestation of a strong professional community. Pang and Wang (2016) state that teacher collaboration leads teachers to improve their teaching practices to support students’ learning. Sawyer and Rimm-Kaufman (2007) extend the concept of collaboration to include the reciprocal relationships between collaboration and shared values and vision.

2) *Reflective dialogue*. Tam (2015) describes reflective dialogue as “the extent to which teachers engage in professional dialogue about specific educational issues” (p. 24). Being involved in reflective dialogue about teaching and learning allows teachers to test the assumptions basic to quality practice (Louis & Marks, 1998).

3) *De-privatized practice.* De-privatization of practice makes teachers’ practices more exposed and visible, causing teachers to work with other teachers and share ideas, skills, and practices (Campbell, Saltmarsh, Chapman, & Drew, 2013). Teachers observing teachers is a form of de-privatization of practice (Tam, 2015) that can potentially improve teachers’ instructional practices and reinforce collegial relationships (Scott & Scott, 2010; Shah, 2012).

4) *Collective focus on student learning*. This characteristic is central to a professional learning community in which teachers are required to continually focus on positive student outcomes. An analysis of existing literature (Pang & Wang, 2016; Stoll et al., 2006; Tam, 2015; Vescio, Ross, & Adams, 2008) suggests that a PLC does not merely focus on teaching quality but also improves student learning outcomes.

5) *Shared values and sense of purposes*. Having shared values and sense of purposes are important in a professional community (Stoll et al., 2006). Teachers with a strong shared vision and sense of purpose are more likely to collaborate than teachers who lack school-wide consensus on educational goals and values (Sawyer & Rimm-Kaufman, 2007).

These characteristics are not hierarchical; they are intertwined and operate together (Stoll et al., 2006). Tam (2015) simplifies the five characteristics into two categories: one is learning (1 – 3) and the other is the shared goal (4 and 5). Through participation in learning communities, teachers are supported to reaffirm educational goals including supporting student learning, knowledge sharing, learning from communities, and problem-solving as a group (Vangrieken, Meredith, Packer, & Kyndt, 2017; Vescio et al., 2008). These goals allow teachers to become more reflective, and critical about their instructional practices, which in turn improves the quality of practices. In the current study, the five essential characteristics are examined to explore community social learning interactions in the online learning environment settings.

2.4 Online Learning Community

Online learning communities (OLC) rely firmly on Web 2.0, which is the second generation of the World Wide Web. This second generation allows people to actively collaborate and share knowledge and information online. Teachers are now increasingly turning to online learning communities to satisfy their professional or personal needs (Anwaruddin, 2015). Teachers participate in a formally-organized and informally-developed OLCs to get professional support, guidance and inspiration (Duncan-Howell, 2010; Lantz-Andersson, Lundin, & Selwyn, 2018). They can get together to share their resources, solve problems, develop working strategies, and improve their teaching performance (S. Zhang et al., 2017). Participating in the OLC allows teachers to efficiently stay up to date with the latest teaching techniques, pedagogies, and changes in the field of education (Macià & García, 2016; Prestridge & Tondeur, 2015; Trust, 2012). Preece (2001) defines an online learning community as “any virtual social space where people come together to get and give information or support, to learn or to find company" (p. 348). Ke and Hoadley (2009) describe an online learning community as "a virtual learning environment in which the process of learning takes place outside the boundaries of face-to-face contact, typically online" (pp. 488-489). Drawing on these definitions, an OLC is thus any virtual learning environment where people typically participate online in the process of learning. Participating in an OLC allows teachers to learn through social interactions and is mediated by technology in the process of knowledge building (Ke & Hoadley, 2009). Tu and Corry (2002) explain that when activities and interactions of people in the learning process occur electronically, it can be accepted as an OLC. Further, Conrad (2005) defines community in the online environment as

> a general sense of connection, belonging, and comfort that develops over time among members of a group who share purpose or commitment to a common goal. The creation of community simulates for online learners the comforts of home, providing a safe climate, an atmosphere of trust and respect, an invitation for intellectual exchange, and a gathering place for like-minded individuals who are sharing a journey that includes similar activities, purpose, and goals (p. 2)

Tu and Corry (2002) adapt the concept of online learning communities developed by the Office of Learning Technologies (1998) based on its four basic elements: community, learning, network, and technology, as shown in Figure 2.1.

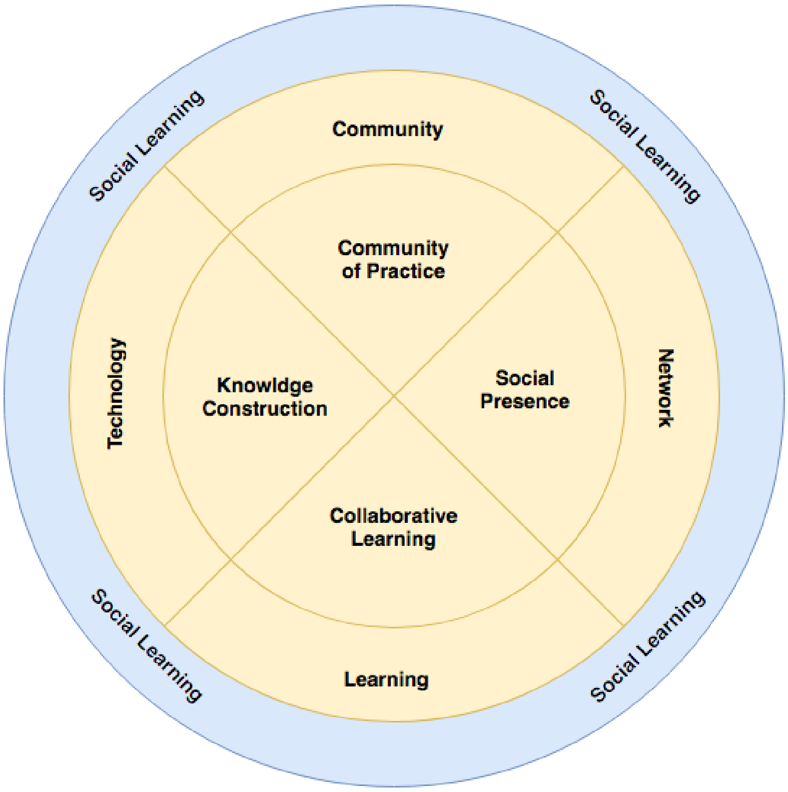

Figure 2.1 The theoretical framework for online learning community
(Tu & Corry, 2002, p. 6)

The basic elements of online learning communities are outlined in the following sections.

2.4.1 Community (Community of practice)

Tu and Corry (2002) describe how notions of communities stem from the concept of communities of practice (CoPs), which was initially proposed by Lave and Wenger (1991). Wenger, McDermott, and Snyder (2002) define CoPs as “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis” (p. 4). Lesser and Storck (2001) define a CoP as

> a group whose members regularly engage in sharing and learning, based on their common interests. One might think of a community of practice as a group of people playing in a field defined by the domain of skills and techniques over which the members of the group interact. Being on the field provides members with a sense of identity (p. 831).

Together these definitions include common concerns, a common set of problems or common interests, and also a process of co-participation and learning. OLCs are thus groups of people who share and learn together in online environments through some shared connection based on their common concerns, common interests or a common set of problems within an atmosphere of trust and commitment. OLCs become favoured learning spaces for many educators (Anwaruddin, 2015; Dean et al., 2017) because they provide opportunities for educators to make collaborations to support continuous improvement in their professionalism. To discover whether such collaboration exists and what is actually being achieved, Wenger (1998b) conceptualises three key dimensions of practice: *mutual engagement*, *joint enterprise*, and *shared repertoire*.

Mutual engagement refers to shared interaction among community members (Wenger, 1998b). The members of the community shape the community's culture and its practices through their interactions. Mutual engagement has the capacity to deal with difference and diversity (Carpenter & Krutka, 2015; Clarke, 2008). However, it does not imply homogeneity within the community. With various individual differences, community members may have distinct roles and make complementary contributions to their enterprises. Membership in a CoP is defined by the knowledge of the members (Wenger et al., 2002). In the context of the current study, membership of the community is determined by profession. Since the focus of the study is teacher professional learning in using technology for teaching mathematics, mathematics teachers or mathematics teacher educators are appropriate members of the community.

Joint enterprise is better understood as the common purpose that links community members together (Wenger, 1998b). In practice, a joint enterprise sometimes comprises elements that are not exactly what the community intends. Through mutual accountability, community members can negotiate a shared understanding to develop a concept of their joint goals (Clarke, 2008). Explicit statements are required to reify some aspects of accountability. Those statements need clear interpretation, and practice grows around this process of interpretation. Wenger (1998b, p. 82) said that "being able to make distinctions between reified standards and competent engagement in practice is an important aspect of becoming an experienced member". In the context of the current study, the joint enterprise is teacher professional learning in the use of technology for teaching mathematics.

Shared repertoire refers to the common resources that community members create (Wenger, 1998b). Repertoire is developed and shaped over time by the community members. It can be said that the community members are part of their shared repertoire and create a sense of ownership (Borgatti, 2004). In the field of teaching, for instance, timetables, assessments, lessons, curriculums, assemblies and staff meetings provide coherence within the teachers' joint enterprise. Within this coherence, the elements of a shared repertoire may include procedures, techniques, shortcuts, words, tools, stories, symbols, mental categories, gestures, actions, and concepts that the community has created in the course of its existence, and which have become part of its practice (Wenger, 1998b). Wenger further highlights that the repertoire is shared in dynamic and interactive ways and it is essential for a shared practice (Sfard, 1998).

2.4.2 Learning (Collaborative learning)

Learning occurs primarily through formal education, but attitudes, knowledge, and skills can also be advanced through informal interactions during social activities. Learning is an internal process and only can be seen in changes in a learner's knowledge, beliefs, attitudes, and skills (Bereiter & Scardamalia, 2003). Kirkpatrick and Kirkpatrick (2009) explain that changes in knowledge, beliefs, attitudes or skills must come before seeing a change in behaviour. The notion of learning comprises two metaphors, the *acquisition metaphor* and the *participation metaphor* (Sfard, 1998). The acquisition metaphor views learning as the process of developing concepts and the acquisition of knowledge, while the participation metaphor describes learning as a process through which an individual becomes a member of a certain community. Learning in an OLC also encompasses these two metaphors. The acquisition of knowledge takes place through social interactions among community members. Social learning occurs as new members move through the stages of development by interacting with experienced members (Duncan-Howell, 2010). Learning in a community allows people to collaborate in building new knowledge, solving problems, and changing their practices (Darling-Hammond, Hyler, and Gardner, 2017; Sari, 2012). In the context of this study, that is, teacher professional learning in an OLC, sharing videos of teaching practices can be considered an appropriate way of learning.

To enhance teacher professionalism, sharing of practices is one of the important learning activities for teacher-as-learners in a learning community. An effective way for teachers to share practices is by visiting each other's classrooms. However, in practice, visiting each other's classrooms is not always easy to manage. Barab, MaKinster, Moore, and Cunningham (2001) claim that the use of video can address this limitation. Video has become progressively more popular as an artefact of practice in TPD because of its unique capability to capture the richness and complexity of classroom practice (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Major & Watson, 2018). In the context of collaborative learning, video can be an effective tool for teacher reflection and also provide alternative pedagogical strategies regarding a shared common experience (Borko et al., 2008). The classroom is a dynamic place where many things happen simultaneously. When teachers view a video excerpt, they learn to notice significant classroom practices. Noticing is a teacher's skill to identify what is relevant in a classroom situation (van Es & Sherin, 2008). Frederiksen, Sipusic, Sherin, and Wolfe (1998) use the term "call out" to refer to points when teachers see something important to them. Goodwin (1994) introduces the term "highlighting" which is similar to the notion of making a call-out or the act of determining what is noteworthy and deserves further attention.

2.4.3 Network (Social presence)

A social network in the context of an online learning community can be understood as "the graph of relationships and interactions within a group of individuals" (Kempe, Kleinberg, & Tardos, 2015, p. 106). Within the social network, one thing that needs to be considered is a social presence; that is, a person's level of awareness in an interaction and their consequent appreciation of an interpersonal relationship (Tu & McIsaac, 2002). A person with a high level of social presence in online learning environments tends to engage more interactively in the online activities (Tu & Corry, 2002).

In a social network, the position and role of an individual within the network are of key importance (Wang, 2010). Network positions are like tiles, they are connected; an individual within a network is related to others in their social activities, social relations, or social interactions. Wang (2010) outlines that there are some positions that have particular significance as subjects of an online learning community study, one of which is a *central position*. A centrally positioned person has links with many community members and becomes the very centre of a social network. In the central position, an individual gives invaluable assistance and social support in the process of learning. A sociogram, a graphical representation of all participant interactions in a social network (De Laat, Lally, Lipponen, & Simons, 2007), can show the members in an OLC who have central positions. The sociogram shows that the centrally positioned members not only have many linkages but also they are more active in comparison with peripheral members (Wang, 2010).

A network in a community does not grow by itself. Ke and Hoadley (2009) state that an OLC is the result of incremental development, which is fluid in nature, and grows as a result of nurturing conditions. In this regard, nurturing the OLC must be done first, prior to ensuring sustainable support for its members. Fostering active online discussions can make the community grow (Feenberg, Xin, & Glass, 2002). Discussions in an OLC are a form of conversation among members of the community. Conversation can be considered an appropriate way to transfer and generate knowledge because the connections among community members and the back-and-forth nature of the conversation provide the greatest context for information (Hoadley & Kilner, 2005). Like many other conventional discussion forums, online discussion forums are most successful when skilfully led. Feenberg et al. (2002) contend that it is important to have members who can actively mediate and facilitate the online discussions. Through mediating and facilitating functions, social interactions in the OLC can be maintained. In the current study, mediating and facilitating functions are investigated to explore the role of a mediator in nurturing the OLC.

2.4.4 Technology (Knowledge construction)

Technology is the main medium used in OLCs to connect community members with the resources. With use of the available technology, the community members can easily connect and interact with other members in order to construct knowledge. The advancement of Web 2.0 tools has generated, among other things, social networking sites (SNS). The important of SNS is that people can make their social interactions visible and, therefore, promote potential connections between more individuals (Prestridge, 2017). Each individual has opportunities to make contributions and can quickly find the best resources to support knowledge construction.

2.4.4.1 Facebook and Facebook Messenger

Facebook has become one of the most prominent of the social networking sites that have created a paradigm shift. Such a shift is predicted by the opportunity to gather a range of information about individuals and the ties that bind these individuals together (C.W. Chen & Lin, 2014). Facebook was created in 2004 with a mission to build community and bring the world closer together. It has since grown and had 1.32 billion daily active users as of June 2017 (Facebook, 2017a). Indonesia is the fourth largest user of Facebook in the world as of January 2018, with 130 million Facebook users (The Jakarta Post, 2018). Facebook provides a feature that allows the creation of Facebook groups to support collaboration and discussion among a group of people who have similar interests (Ahern, Feller, & Nagle, 2016). Since the feature was revamped and re-introduced in 2010, people have created over 50 million groups on Facebook, and it has grown quickly because of its social design, in which an individual can create a particular group, and all members of the group can use it (Bennett, 2011).

Facebook Messenger (sometimes abbreviated as Messenger) was developed as a Facebook chat in 2008 and subsequently released as a standalone app in 2011. Using the Messenger app, people can reach their friends by text, voice call, and video call. The Messenger app also enables users to create group conversations. Using this app, people can share photos videos, stickers, gifs and more (Facebook, 2017b).

Facebook has attracted considerable attention from educators as they believe it has significant potential to enhance professional learning (Rutherford, 2010). Several studies related to the use of Facebook as a vehicle for teacher professional development have been conducted (Bissessar, 2014; Çevik, Çelik, & Haşlaman, 2014; Rutherford, 2010; Van Bommel & Liljekvist, 2015). All these studies suggest that further exploration in this area is warranted. There is still not enough empirical evidence of how teachers' participation in an OLC changes their classroom teaching practices. Specific to Indonesia, a limited number of studies have been conducted to explore the use of Facebook in the field of education (e.g., Sari & Tedjasaputra, 2013; Susilo, 2014a, 2014b). Sari and Tedjasaputra (2013) investigated Facebook use for promoting teacher engagement in TPD. They explored the use of Facebook for sharing, learning and reflecting on the current issues of education among participants (i.e., teachers, teacher educators, and education leaders). Since the topics discussed were current issues in education, the topics became varied and broad. Susilo (2014a, 2014b) examined the use of Facebook and WhatsApp to uncover the characteristics, opinions, and perceptions of students at Indonesia's Open University. Susilo's study explored both teacher-student and student-student participations. The findings showed that Facebook increased student participation in the course being taught. In addition, the role of the teacher transformed from merely being an instructor to a facilitator, as they now provided further guidance whenever it was demanded.

An analysis of the aforementioned studies suggests that more research needs to be done on the use of Facebook for teacher professional learning. In particular, a focus needs to be placed on how being part of this community causes teachers to change their practices using technology in the mathematics classrooms.

2.4.4.2 WhatsApp

WhatsApp is an instant messaging application that operates on nearly all current types of mobile devices across different operating systems. WhatsApp (2017) supports sending and receiving a variety of media, such as text, images, videos, documents and locations, as well as voice and video calls. Its features have rapidly transformed the way people communicate and stay connected (Susilo, 2014b). To date, more than one billion people use this application to stay in touch with friends and family (WhatsApp, 2017). About 40% of the population in Indonesia are active WhatsApp users as of January 2018 (Pertiwi, 2018). WhatsApp allows the user to create a group. These can promote social practices, such as building social networks, supporting brainstorming and fostering mutual understanding through sharing opinions (Rambe & Bere, 2013). Therefore, WhatsApp improves productive communication among group members.

Some studies have been conducted on the use of WhatsApp in the field of education (Bansal & Joshi, 2014; Barhoumi, 2015; Rambe & Bere, 2013). However, these studies appear to mainly examine the use of WhatsApp for supporting students' learning rather than focusing on the use of WhatsApp as a tool for promoting teacher professional learning.

The next section will explore the literature related to sociocultural learning theories. These are relevant to the current study given the social and cultural nature of online learning environments and teacher professional development.

2.5 Sociocultural Learning Theories

Teacher learning does not always take place in formal professional development programmes; it also occurs in informal settings (for example, participation in social learning interactions). In such instances, teacher learning can take place during participation in a community of teachers and across the various contexts of teachers' lives. Lerman (2013) builds on and extends the work of Vygotsky (1978) and followers in conceptualising teacher learning as being better understood as changing participation in social practices. From a sociocultural perspective, teacher learning can be understood as a teacher's movement from peripheral (novice) to full (expert) participation in the specific working practices and ways of knowing, thinking and valuing that define effective participation in the community of teachers (Lave & Wenger, 1991). A discussion of teacher learning theories cannot be separated from the nature of what constitutes teacher knowledge. Kelly (2006) asserts that experts view problems differently within their field because they have more knowledge than novices. Experts adopt representations of phenomena that are accurate and inclusive, and their abilities to plan ahead are better than novices. They can identify ways in which each of the relevant dimensions interacts in problems, together with their typical interaction patterns, and they categorise problems based on their underlying principles. Knowledge of underlying principles makes experts are better able to solve problems, which while are structurally same, may still be different. Novices adopt representations of the phenomena without considering the underlying principles. They only identify the individual elements of phenomena as unidimensional operations, without considering their interactions. Kelly (2006) emphasises that novices must first learn the underlying defined body of knowledge to become experts. Only then will novices be able to apply their professional expertise into practice.

Lave (1996) argues that learning may be represented as increasing participation in a community of practice, but a mechanism for learning should consider the goals of the individual in participating in the social practice, and the specificities of the practices with regard to situated meanings and situated ways of being. In this respect, learning mechanisms can be defined as “ways by which learning comes about” (Lerman, 2000, p. 33). Lerman explains that a learning mechanism needs to consider the contributing factors that influence the individual’s trajectory through the practice, including what an individual brings to the practice. One key element in a mechanism for learning is the creation of a zone of proximal development (Lerman, 2000). Vygotsky (1978) defines the zone of proximal development (ZPD) as “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers” (p. 86). Vygotsky (1978) explains that learning and development differ and that learning not only leads to development but it also creates a zone of proximal development. Valsiner (1997) borrowed the notion of the ZPD and reconstructed the concept to fit with two zones he built for a new theoretical system called zone theory.

2.5.1 Valsiner’s zone theory

In addition to Vygotsky’s notion of ZPD, Valsiner (1997) introduces two additional zones; the zone of free movement (ZFM) and the zone of promoted action (ZPA). The ZFM and ZPA represent structures through which thinking and acting may be constrained or promoted (Blanton, Westbrook, & Carter, 2005). Valsiner (1997) explains that these three zone concepts are the organisers of development of individual either interpsychologically (between individuals) or intrapsychologically (i.e., a semiatic regulation of the individual’s own thinking, feeling, and acting). These three zone concepts can account for the process of development and its dynamic relationship among them.

Valsiner (1997) describes the ZPD as a set of possibilities for development of an individual in the context of their interaction with their learning environment and with other human beings. The ZFM is a function of what is permitted or enabled by the individual to assist them to undertake cognitive activities within an accessible area. When the ZFM is set up within an individual's choices of thinking, feeling and acting, then the ZFM becomes internalised. When it is internalised, the ZFM provides a structural framework for an individual's cognitive activity and emotions. It also regulates the relationship of an individual with the environment. The ZPA is a set of activities, objects, or areas in the learning environment that promotes an individual's actions. The ZFM and ZPA form a ZFM/ZPA complex that interactively generates the environment in which that individual develops (Geiger, Anderson, & Hurrell, 2017; Goos, 2013). Valsiner (1997, p. 200) contends that the ZPD requires "the sets of possible next state of developing system's relationship with the environment, given the current state of the ZFM/ZPA complex and the system". The ZPD is, therefore, able to capture individual development aspects that have not yet moved from the sphere of the possible into that of the actual but are currently in the process of becoming actualised.

The ZPD needs to be mapped on the ZFM/ZPA system to extend the immediate present constraining structures out toward the immediate future. The ZPD provides a link between the ZFM and ZPA, so it has a decisive role to play in individual development. That link can be characterised as follows (Valsiner, 1997, p. 200).

1. If the ZPA is set up in ways that have no overlap with the ZPD, then any effort to promote the individual's development within the ZPA thus set will necessarily fail.

2. Where the range of the ZPA exactly matches the range of the ZPD, the instruction provided for individuals by others can have the maximum possible effect.
3. The relationship among ZFM, ZPA, and ZPD is constantly “filled in” with new content that depends on what is important in the life of the particular individual at a given time.

Although zone theory was developed to explain child development, Valsiner (1997) notes that the ZFM/ZPA complex is observable in education contexts too. A number of studies in the field of education have used zone theory as an analytical approach (e.g., Blanton et al., 2005; Geiger et al., 2017; Goos, 2013; Patahuddin, 2013).

2.5.2 Using zone theory in teacher professional learning

In the Vygotskian perspective on learning, the ZPD symbolises a space where one’s potential for learning will take place. One view of the ZPD suggests that it is a space in which, for example, there is a task that an individual cannot yet do alone but could do with the assistance of more competent peers (Slavin, 2003). Within this frame, in the context of teacher learning, the ZPD can be understood as a symbolic space where the teacher’s emerging skills are developing under the guidance of or in collaboration with more experienced or knowledgeable teachers. In a more contemporary view of the ZPD, other researchers (e.g., Goos, 2004; Lerman, 2001; Roth, 2014) suggest a more symmetrical relationship in which learning occurs when levels of competence of all members in the ZPD are evenly distributed. Learning occurs through mutual engagement in the shared activity. In this regard, the ZPD offers a useful analytical tool to explain how individuals mutually appropriate each other's actions and goals in activity settings (Hunter, 2009). At the same time, contextual constraints are also influential and need to be considered (Goos, 2005; Shabani, 2012).

When applying zone theory to teacher professional learning context, the ZPD can be better understood as "a set of possibilities for the development of new knowledge, beliefs, goals and practices created by the teacher's interaction with the environment, the people in it, and the resources it offers" (Goos, 2013, p. 523). The ZFM defines the environment or professional context of teacher and determines which teaching actions are *allowed*. The ZPA represents a set of activities offered in teacher educational programmes, formal teacher professional development, or informal learning interaction with peers that *promote* certain teaching methods. Goos (2013) argues that tension will be created when the ZPD does not map onto the ZFM/ZPA complex in ways that promote desired development. Goos argues that productive tensions can provide opportunities for teacher change. The productive tension of teachers occurs between their thinking, action, and their professional environments.

Several researchers (e.g., Blanton et al., 2005; Geiger et al., 2017; Goos, 2013; Patahuddin, 2013) have conducted substantial research, extending Vygotsky's ZPD by drawing on Valsiner's two additional zones, the ZFM and the ZPA. Blanton et al. (2005) used Valsiner's zone theory to interpret the ZPD of teachers in mathematics and science. Classroom discourses were employed to identify what teachers' actions were promoted and allowed in the classrooms. These led to better understanding of the potential of teachers' development. Blanton et al.

explained that identifying the ZFM and ZPA in the classroom were significant for analysing practice.

Goos (2013) adapted Valsiner's zone theory to analyse teacher learning and development. Goos presented two analyses of zone theory, one from the perspective of understanding teacher learning in incorporating digital technologies into their practice while the other from the perspective of teachers changing their classroom practice. In both analyses, Goos stated that productive tensions between teachers' belief, contexts, and goals were a trigger for learning and development.

Patahuddin (2013) developed a model for mathematics teacher professional development with respect to technology. Patahuddin used Valsiner's zone theory as an analytical tool to identify the inhibiting and supporting factors to understand the potential of the Internet for professional learning. The use of zone theory helped Patahuddin to design the intervention to stimulate teacher's engagement in exploiting the Internet for learning.

Geiger et al. (2017) investigated the characteristics that typify an effective mathematics teacher and the environments that support effective teaching practices. Geiger et al. used Valsiner's zone theory as an analytical tool to illustrate how the relationship between affordances and barriers emanating from school culture and organisational structure result in the alignment and focus of teaching practice within one school. A finding of their study was that the school context and cultural practices that had been developed by school leaders and teachers affected the success of teaching practice in optimising student learning opportunities.

Goos' (2013) and Patahuddin's (2013) studies investigated teachers' learning in using technology in their teaching practices while studies from Geiger et al. (2017) and Blanton et al. (2005) have not included the use of technology in teachers' learning. The settings of teacher professional learning in these studies are limited only to individual schools. There appear to be few studies that have investigated how Valsiner's zone theory can be employed to examine teacher professional learning in OLCs.

Goos (2013) identifies different types of knowledge and experience, which represent elements of teachers' ZPD, ZFM, and ZPA to influence technology integration, as shown in Table 2.1.

Table 2.1 Factors affecting teachers' use of technology (Goos, 2013, p. 524)

Valsiner's zones	**Description**	**Factors influencing teachers' use of digital technologies**
Zone of proximal development	possibilities for developing new teacher knowledge, beliefs, goals, practices	▪ Mathematical knowledge ▪ Pedagogical content knowledge ▪ Skill/experience in working with technology ▪ Beliefs about mathematics, teaching, and learning
Zone of free movement	structures teachers' access to different areas of the environment, availability of different objects within an accessible area, ways the teacher is permitted or enabled to act with accessible objects in accessible areas	▪ Perceptions of students ▪ Access to resources ▪ Technical support ▪ Curriculum and assessment requirements ▪ Organisational structures and cultures
Zone of promoted action	activities, objects, or areas in the environment in respect of which the teacher's actions are promoted	▪ Pre-service teacher education ▪ Professional development ▪ Informal interaction with teaching colleagues

Goos (2006) suggests that the relationship of the three zones offers a useful way of analysing the extent to which teachers adopt technology into their teaching practices. Goos also notes that the relationship of elements of the three zones provides a way of interpreting teachers' actions in the classroom and offers a useful way of identifying conditions that support or constrain teachers' learning and embracing of new technology. Given that teacher learning and development is complex because it is influenced by many factors that are interacting together, the zone theory is useful to support analysis of these interactions between people and their environments, while still emphasising individual agency (Goos, 2013). Zone theory is appropriate as an analytical tool to understand the process of teacher professional learning in relation to learning activities used in the current study.

2.6 Summary

This review has provided a theoretical background to the current study. It began with a description of teacher learning and teacher professional development. Teacher professional learning is closely related to teacher professional development, which stimulates teacher change. The advancement of Web 2.0 has altered the ways in which teachers develop their professional learning. It allows teachers to collaborate with other teachers online. Through social interactions, teachers can stay up to date on the latest teaching techniques, pedagogies, and changes in the field of education. The concept of the OLC has frequently been used to facilitate social learning interaction among teachers, including for teacher professional learning.

An OLC is conceptualised as a group of people who share and learn together in online environments through some shared connection based on their common concerns, common interests or a common set of problems, in an atmosphere of trust and commitment. The four basic elements of an OLC discussed include community (CoP), learning (collaborative learning), network (social presence), and technology (knowledge construction).

Teacher learning is described as increasing social participation in OLCs; therefore a sociocultural perspective approach is used to understand how teachers develop their professional learning in the use of technology in the mathematics classroom in an OLC. An extension of sociocultural theory is Valsiner’s zone theory. Valsiner (1997) reconceptualised Vygotsky’s zone of proximal development (ZPD) by narrowing it to accommodate the zones of free movement (ZFM) and promoted action (ZPA). Valsiner considered the ZPD a space for potential development of an individual, defined by their knowledge and beliefs and shaped by past interactions with others and their environment. The ZFM was described as the ways in which an individual is allowed to act within their learning environment and the ZPA as the influences within an environment that promote action. Valsiner’s zone theory was applied to the teacher professional learning context to help improve understanding of the process of teacher professional learning in relation to social learning activities in OLCs.

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CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the research methods applied in conducting the investigation and the subsequent analytical methods used to answer the research questions. A combination of ethnographic methods and case study approach was used. The ethnographic case study approach enabled the researcher to be directly immersed in the study's setting and examine the phenomenon under investigation from inside; that is, in its natural setting (Freebody, 2003b) and by employing multiple methods of data collection.

Section 3.2 states the main research question posed and the associated subsidiary questions. Section 3.3 describes the role undertaken by the researcher as both a participant observer and a mediator. Section 3.4 provides explanations as to why the ethnographic case study research was used in the current study. In Section 3.5 the research design used in the study is elaborated. The unit of analysis, determination of how the data would be linked to the propositions, criteria to interpret the findings, and a conceptual framework of teacher professional learning within the OLC in using technology in the classroom are outlined.

Section 3.6 describes how ethical issues that arose during the conduct of the research were addressed. Section 3.7 outlines how study participants were invited to participate in two stages of the study; that is, the preliminary study and the main study. Section 3.8 provides descriptions of the data collection methods used at the different stages and outlines the research methods used at these stages. Section 3.9 describes the approach taken to analyse the empirical data. Section 3.10 outlines how the study's findings are presented to give the reader a holistic picture. Finally, section 3.11 provides an explanation of how validity and reliability were ensured in the data analysis.

3.2 Research Questions

The study addressed one key question:

How do teachers develop their professional learning in using technology in mathematics classrooms through their participation in online learning communities?

This question is influenced by the following subsidiary questions:

1. What were the facilitators and barriers to teachers' participation in the OLC?
2. How did participation in the OLC help teachers in the process of acquiring knowledge, and promote professional learning in using technology in mathematics classrooms?

The first subsidiary research question aimed to investigate aspects that facilitated or impeded teachers' participation in the OLC in promoting their professional learning. The second subsidiary question was concerned with examining how participation in the OLC impacted on promoting teachers' professional learning in their use of technology in the mathematics classrooms. Together, these two questions helped to build an empirical knowledge base about teachers' professional learning based on their participation in OLCs.

3.3 Researcher's Role

Before undertaking an actual research project, researchers need to identify potential researcher biases and ensure that the methods proposed work in practice as well as guiding the development of the research plan (Kim, 2011). Kim suggests that researchers conduct a preliminary study to get an understanding of their role in the research setting. Therefore, a preliminary study was conducted, which guided the research and helped to identify the researcher's roles during the period of the study.

In this study, the researcher took two main roles: (1) participant observer; and (2) mediator. Being a participant observer meant that the researcher was immersed in the teachers' professional learning activities either in their classrooms or in the OLC. In this respect, the researcher became what DeWalt and DeWalt (2011) have described as an observer and a participant at the same time. Immersion in teachers' everyday activities "can intellectualise what [the researcher has] seen and heard, and put it into perspective, and write it convincingly" (Bernard, 2017, p. 274). In doing participant observation, Mead (as cited in DeWalt & DeWalt, 2011, p. 21) suggests that a participant observer needs to have specific skills, such as:

> memory for faces, ability to reproduce nonsense material from memory, ability to reproduce sensible material from memory for things seen and things herad, ability to write and observe simultaneously, width of vision, ability to predict what will happen behind one by the expression on the faces of those in front, tolerance for continuous observation of the same type, ... ability to attend to an unpleasant situation, susceptibility to

> disqualifying disgust reactions, ability to resist the impulse to interupt an unpleasant or disturbing sequence of behaviour, tendency to identify in a partisan fashion with preffered individuals, etc.

These skills can guide the researcher to select the most effective questions, venues, and recording techniques for any particular participant observation.

The researcher also acted as a participant observer in the OLC environment by overtly observing interactions and by directly participating in ongoing online discussions. DeWalt and DeWalt (2011) provide four categories of participation: *passive participation*, when the researcher is on the spot, but acts as a pure observer; *moderate participation*, when the researcher is present at the scene of the action, but does not participate actively or maybe interacts occasionally with people in it; *active participation*, when the researcher engages in almost everything that other people are doing. To be an active participant, the researcher takes on some or all the core members' roles; and *complete participation* when the researcher becomes a member of the group that is being studied. DeWalt and DeWalt argue that complete participation is different from "going native"; rather this is a temporary event during which, while other roles are suspended, the researcher continues to record observations by making field notes and by adopting an analytical stance, partially during the research period and more completely after the period of participation. In the current study the researcher applied an *active participation* style in the classroom and in the OLC.

The researcher also played the role of a mediator in the OLC. In this role the researcher encouraged open and interactive discussion, but still monitored it and brought everyone in, and steered the community away from irrelevant topics. The researcher tried to ensure that every participant got a chance to contribute to relevant discussions in the OLC.

3.4 An Ethnographic Case Study Approach

Qualitative research studies can be conducted using different approaches. An action research approach was used at the initial stage of the study. After four weeks of data collection, the researcher realised that each teacher faced different challenges when using technology in the classroom. They also had their own pace in learning about the use of technology for teaching practice. Since the current study sought to uncover and describe how teachers developed their professional learning through social interactions in the OLC, the cyclical process of the action research was not easy to manage. The approach of the current study then changed into an ethnographic case study. The study was ethnographic because it looked at teacher professional learning as a sociocultural process. It was also a case study because it reported an in-depth description and analysed multiple functioning units (i.e., the professional learning journeys of five teachers in integrating technology in the classroom). Using this approach, the study examined how participation in the OLC promoted teachers' professional learning in their use of technology in the mathematics classroom. The next subsections outline how these methods were employed in this study.

3.4.1 Ethnographic methodology

Studies on teacher learning in a sociocultural context emphasise that learning is an initiation into social practice in which teachers become part of practices and the practices also become part of them (Lerman, 2001). This study employed an ethnography approach to understand the nature of social participation in the OLC to promote teachers' professional learning in mathematics education. Ethnography has an "intimate nature" (Miller & Russel, 2005, p. 57), whereby the researcher is immersed in the chosen field setting for some time and participates in interactions with people in their daily activities. Such an approach enabled the researcher to explore aspects of the phenomenon of the teacher learning process. Ethnographic study also offers a range of procedures that give applicability and flexibility in educational settings (Freebody, 2003a).

Unlike typical quantitative methods, ethnography usually does not follow a pre-defined linear process (Burns, 2000). As Allan (1991, p. 180) states "ethnography especially does not have [the] tidy, relatively linear progression of discrete stages common in experimental or questionnaire survey design". However, a systematic way of collecting data and testing ideas is required in ethnography (Hammersley & Atkinson, 2007). In this study, data were gathered using multiple techniques: surveys, interviews, participant observations, documents and online posts.

A case study method was used, as discussed in the next section, in order to understand the ways in which teachers implement the professional knowledge obtained from the OLC into their technology-based teaching practices.

3.4.2 Case study methodology

Case studies share some common characteristics with ethnography, but they also differ from ethnography in several ways (Merriam, 1998). Ethnography can provide a complete description of a culture-sharing group, which may be representative of the entire group or a subset of a group (Creswell, 2013). An

OLC can be considered a culture-sharing group and a detailed investigation of the group can help understand their social interactions and limitations. However, Creswell explains that a case study account is more concerned with describing the events occurring in the group rather than reporting on shared behavioural patterns, which is more likely to be found in an ethnographic study. Moreover, case studies seem less focused on cultural studies. In the current study, the professional learning journeys of the teachers in the OLC can only be understood through the teachers' social participatory process. Therefore, the case study method was suitable in the context of this study as it provided opportunities for systematically examining the teachers' professional learning within the OLC in their quest for better use of technology in mathematics classroom teaching.

Yin (2014) defines a case study as an empirical enquiry that investigates a contemporary phenomenon in depth and in its real-life context, using multiple sources of evidence. The case study method is useful when the boundaries between the phenomenon and context of the study are not explicitly stated, and when the phenomenon consists of complex social units.

Yin (2014) contends that a case study can be *exploratory*, *descriptive* or *explanatory*. This study was an exploratory case study as it sought to give a detailed account of how participation in the OLC contributed to the improvement of teaching quality in teachers using technology in the classroom. The teacher participation in the OLC was a central focus of teacher professional learning in the current study.

Case study research may be conducted as single- or multiple-case studies (Yin, 2014). This study used multiple-case studies in which mathematics teachers from five different junior high schools actively participated in the OLC and classroom-based research. Creswell (2013) and Yin (2014) recommend the use of multiple-case studies to help in gaining an in-depth understanding of the case from multiple perspectives. Using multiple-case studies also allows the researcher to reiterate the cases to contrast or replicate results (Yin, 2014).

The current study complied with a qualitative interpretive research paradigm (Myers, 1997) and drew on a sociocultural perspective. It began with the assumption that learning occurred within the community and that knowledge gained from the learning process was a product of social interactions. Klein and Myers (1999) argue that when studies begin with the assumption that knowledge is "gained only through social constructions such as language, consciousness, shared meanings, documents, tools, and other artefacts" (p. 69), the studies can be classified as interpretive.

3.5 Research Design

A research design is the set of methods and procedures used to integrate the different components of the study and to ensure that the evidence obtained effectively addresses the research problem (De Vaus, 2001). Yin (2014) identified five essential components of research design: (1) the study's questions; (2) study propositions; (3) unit(s) of analysis; (4) the logic linking the data to the propositions; and (5) the criteria for interpreting the findings.

The first component is described in Section 3.2. The rest of the components are addressed in the following subsections.

3.5.1 Study Propositions

Propositions are statements that help direct attention to point to what should be examined in the case study (Yin, 2014). The following are the propositions of the current study:

- Teachers can develop their professional learning in using technology in mathematics classes through participation in the OLC.
- There some facilitators and barriers which affect teachers' participation in the OLC.
- Teachers' acquire knowledge and skills as they engage with each other in the OLC to develop their professional learning in using technology in mathematics classes.

3.5.2 Units of analysis

The notion of a unit of analysis refers to defining what the "case" is (Yin, 2014). The concept of what constitutes a "case" in case study remains a subject of debate but at a minimum is accepted to be "a phenomenon specific to time and space" (Johansson, 2003, p. 5). The unit of analysis refers to the level at which evidence is collected during the investigation. Having a clear definition of the unit of analysis helps to define the boundaries within which the proposed theory will be applied (Dubé & Paré, 2003). Moreover, the unit of analysis can be easily derived if the study has clarity on what the research wants to contribute at the end of the study.

The units of analysis identified in the current study were the five participant teachers who learned technology integration for teaching mathematics with the

OLC. In this regard, the teachers' participation in the OLC and aspects related to their learning journeys during their engagement in the OLC were investigated.

3.5.3 Determination of how the data were linked to the propositions

Data were collected through open-ended surveys, participant observations, interviews, documents and online posts (see Section 3.8). Figure 3.1 illustrates how the four data instruments were linked to the propositions. Rich data generated from participant observations, interviews, documents, online posts and open-ended surveys provided rich and detailed accounts of individual teacher journeys. An enquiry stance underpinned by OLC elements (namely community, learning, network, and technology) and zone theory (comprising ZPD, ZFM, and ZPA) has helped interpret each teacher's professional learning. Within the OLC, teacher communities engaged in social learning interactions to form communication network patterns over the technology platforms (i.e., Facebook, Facebook Messenger and WhatsApp). Zone theory supported in understanding of facilitators and barriers that affected teachers' ZPD, ZFM and ZPA, as teachers integrated technology into their mathematics classrooms.

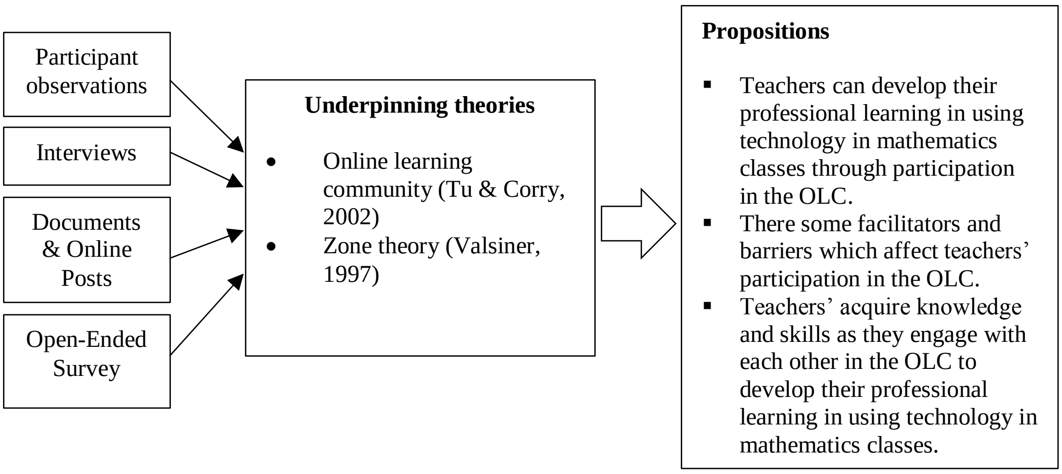

Figure 3.1 Determining how the data are linked to the propositions

The *participant observation* (see Section 3.8.2.1) was analysed using narrative and content analysis. The analyses were guided by Valsiner's zone theory, which was further developed by Goos (2013). Zone theory enabled identification of factors affecting technology usage, and provided ways to make observations on how teachers embraced technology-based practice. It also provided insight into teachers' potential to enhance their knowledge and skill sets, and bring about changes to their attitudes and beliefs. Narrative and content analysis were used to investigate the learning journey of teachers during their participation in the OLC. Hence the participant observations as a data source are clearly linked to the research question and its propositions (aims), and the two elements of the conceptual frameworks.

The *interviews* with the five teachers (see Section 3.8.2.2) are linked to both elements of the conceptual framework and to the research questions and propositions. The interviews, as data sources, were concerned with examining teachers' professional learning in the OLC and how it related to using technology in their teaching practices. The interviews included discussion of teachers' experiences in implementing technology-based teaching practices and teachers' perceptions of their participation in the OLC.

The *documents* and *online posts* (see Section 3.8.2.4) were linked to the research question and propositions, and both elements of the conceptual framework. The documents included posts, comments, reactions, videos, images and files posted on the OLC. All these data were extracted from the OLC. Specific data from teachers' (inter)actions were analysed using social network analysis to see the social interaction patterns of the teachers in the process of learning in the OLC.

The final data instrument was an *open-ended survey* (see Section 3.8.2.3). This was linked to the research questions and propositions through its five open-ended questions (refer Appendix E). The open-ended survey as a data source revealed the potential of the OLC as a medium for teachers' professional learning.

3.5.4 Criteria for interpreting the findings

The criteria for interpreting a case study's findings correspond to the elements of the conceptual framework; that is, the online learning community, and zone theory, which (as noted in Section 3.5.4) also formed a cornerstone of the methodological approach for the current study.

Table 3.1 Elements of the conceptual framework

Criteria to interpret the online learning community	**Criteria to interpret the zone theory**
▪ *Community*: members of the OLC ▪ *Learning*: the social learning interaction in the OLC ▪ *Network*: patterns that are formed based on the relationships and communications between members of the OLC ▪ *Technology*: a medium used for communication in the OLC	▪ Zone of Proximal Development o Mathematical knowledge o Pedagogical content knowledge o Skill/experience in working with technology o Beliefs about mathematics, teaching, and learning ▪ Zone of Free Movement o Perceptions of students o Access to resources o Technical support o Organisational structures and cultures ▪ Zone of Promoted Action o Professional development o Informal interaction with teaching colleagues

Table 3.1 presents the criteria used to interpret the findings. The criteria to interpret the OLC consisted of four elements, namely community, learning, network, and technology. The element of community describes how members of the OLC participated in the three online learning environments that had been established. The second element is learning that provides an explanation of how

social learning interactions of teachers occurred in the OLC. The dissemination of information through sharing of teaching experiences and exchanging knowledge includes in the element of learning. The element of network illustrates the patterns that are formed based on the relationship and communications between members of the OLC. This element helps to identify the members of the community who have significant position in nurturing the community. The last element to interpret the OLC is technology. This element outlines how the three technology platforms (i.e., Facebook, Facebook Messenger and WhatsApp) were used to connect community members with the resources.

The criteria to interpret the zone theory comprises of ZPD, ZFM, and ZPA. Each aspect of these three zones is used to better understand of elements of teachers' ZPD, ZFM and ZPA. The relationship of the three zones is significant to analyse ways used by teachers to integrate technology into their mathematics classrooms and identify conditions that afford or impede teachers' learning while embracing new technology.

3.5.5 A conceptual framework of online learning community for teacher professional learning

The literature reviewed in Chapter Two helped lay the theoretical foundation and informed the conceptual framework. However, in this study, a conceptual framework was developed not only based on theory but also from empirical evidence gathered in the preliminary study. Dubois and Gadde (2002) refer to this as "systematic combining" (p. 555), in which mere theory is not sufficient to understand a phenomenon without empirical observation and vice versa. Thus, a framework might evolve over time according to what is discovered in the empirical fieldwork. A conceptual framework is often used in the research to explain "either graphically or in narrative form, the main things to be studied — the key factors, concepts, or variables— and the presumed relationships among them" (Miles & Huberman, 1994, p. 18). The conceptual framework of this study is visualised in graphic form as depicted in Figure 3.2.

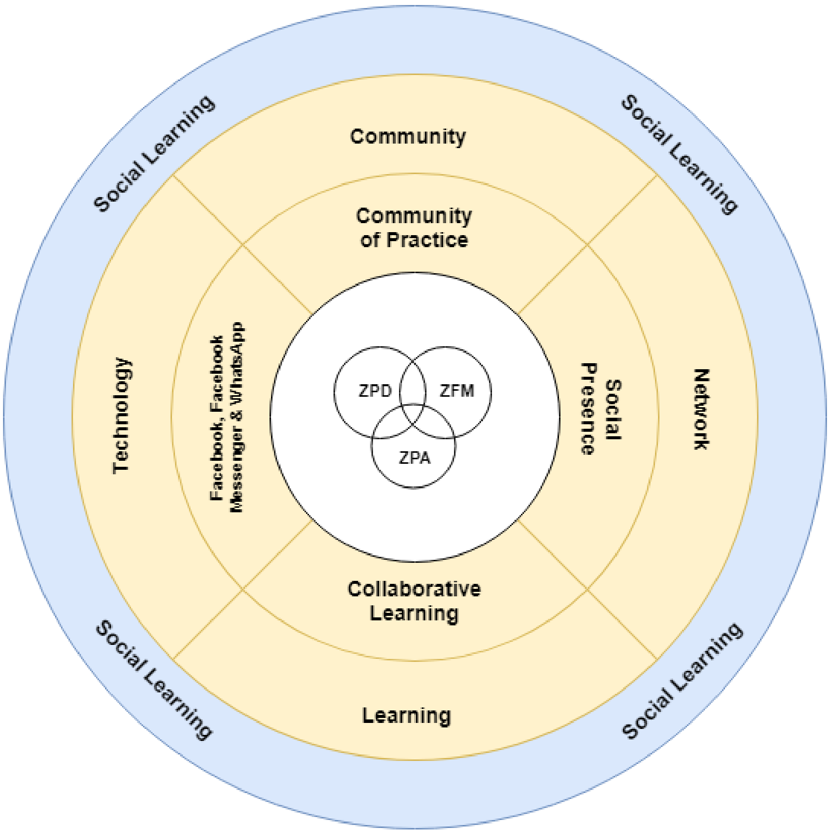

Figure 3.2 Conceptual framework for an online learning community for teacher professional learning (adapted from Tu & Corry, 2002; Valsiner, 1997)

In this study, the conceptual framework was developed based on Tu and Corry's (2002) model of online learning community. The conceptual framework comprises: (1) *community* – members of the OLC; (2) *learning* – which occurred through social interaction; (3) *network* – patterns that were formed based on the relationships and communications between and among members of the OLC; and (4) *technology* – a medium used for communication in the OLC.

The innermost circle is zone theory, which provided an analytical tool to understand the process of teachers' professional learning in using technology in the mathematics classroom. Three zone concepts – the ZPD, ZFM, and ZPA – were used to support understanding of how professional learning evolved within the OLC in promoting the use of technology for teaching mathematics. Valsiner's ZFM/ZPA complex provided a way for the researcher to observe how teachers learn and gave insight into the potential for professional development of teachers' ZPD (i.e., increased teacher knowledge, skills, and change in attitudes and beliefs).

3.6 Ethical Considerations

When research involves collecting data from people, the researcher should first anticipate the ethical issues that may arise during the conduct of the research study (Creswell, 2012). The ethics of social research are concerned with ensuring no participants are harmed, protecting their anonymity and privacy, developing trustworthy relationships, and guarding against misconduct and transgression that might reflect on their institutions (Israel & Hay, 2006; Punch, 2005). Therefore, in entering school and classroom communities to conduct research, the researcher wanted to avoid any potential harm to the participant teachers and their students.

This study was also conducted in online settings. This raised some of the same ethical issues regarding research as noted in conventional face-to-face research techniques (DeWalt & DeWalt, 2011). There were ethical issues related to observing members of the OLC and participating in the OLC that needed to be carefully considered. Hine (2000) states that “online interactions are sufficiently real for participants to feel that they have been harmed or their privacy infringed by researchers” (p. 23). Therefore, the researcher was careful and protected the participants from invasion of privacy through the use of pseudonyms, gaining informed consent, and obtaining permission for the use of quotes from the OLC.

The current study was granted full human ethics approval from the Human Ethics Committee of Massey University (Reference Number NOR 15/160 date 13 January 2016) (see Appendix A). The following subsections describe how ethical issues in the conduct of the research were addressed.

3.6.1 Informed consent

Participants need to be fully informed and provided with a set of elements that acknowledge and assure them of the protection of their human rights before the research is conducted (Creswell, 2012). The researcher provided the participants with an information sheet and a consent form. The information sheet was provided to the participants to give them complete understanding of the research process. The consent form elaborated the participants’ rights, including how they could participate in the study and its implications, and provided assurance that the participants could withdraw from the study at any time (see Appendices C – D).

In the current study, the teacher participants also engaged with their students. With respect to working with students, informed consent is also a key issue. Important factors include full cognisance of what participation in the research implies for them (Habibis, 2006). In this study, the permission was acquired by way of signed student and parent consent forms and information sheets that provided additional information about the research were provided to all students.

3.6.2 Anonymity and confidentiality

Anonymity and confidentiality of participants are central to ethical research practices in social research (Crow & Wiles, 2008). Christopherson (2007) said that anonymity in Internet social interactions can result in either positive or negative behaviors depending on the context. The negative effects of anonymity is that it leads to a deindividuated state where an individual loses their sense of self-awareness and makes it more likely for that individual to engage in anti-normative or anti-social behavior. This behavior will affect social learning interactions of members of the community. Meanwhile, the positive effect of anonymity is that individuals can openly express their thoughts and ideas without fear of being identified.

The primary method a researcher uses to maintain the anonymity and confidentiality of the participants, or the location of the research, is the use of pseudonyms. In this study, the use of pseudonyms to assure anonymity was problematic, given that the teachers in the OLC were aware of who the other participants in the study were. Also, information posted on the OLC was in the public arena and could have caused what Saunders, Kitzinger, and Kitzinger (2015, p. 130) call a “risk of cross-link” information because posts made in the OLC were commonplace, and such information could be easily reposted and shared in various ways.

In the current study, requesting permission for direct quotes was done prior to beginning the study, through the use of informed consent forms. Pseudonyms were used for each direct quote used in the analysis of this study.

Habibis (2006) explains how anonymity overlaps with confidentiality.

> However, while anonymity is considered with the identification of individual respondents, confidentiality is concerned with ensuring that the information they provide cannot be linked to them. Even if the respondents in a study are identified, the principle of confidentiality means that their specific contribution cannot be identified. (p. 67)

In the current study, a closed Facebook group comprising 420 teachers was formed. While the teacher participants could view posts (e.g., video excerpts) on this closed Facebook group, further discussions related to the excerpts were conducted cautiously. General discussions were conducted in the closed Facebook group (OLC-FB), while more in-depth discussions were conducted in a private Facebook Messenger group and a private WhatsApp group (OLC-IM). Beyond these groups, the specific contributions made by individual participants could not be linked back to them. In addition, interviews and further discussions pertaining to lessons occurred on one-to-one basis with the concerned participant so that each person’s confidentiality in relation to others in the current study was protected.

3.7 Participants

Participants in the study were mathematics teachers and mathematics educators who had expressed keenness to participate in the preliminary study and in the main study. The following sections describe the study participants.

3.7.1 The preliminary study participants

Before beginning the research project, the researcher conducted a one-day technology workshop. The preliminary study used the one-day technology workshop in April 2015 to obtain the perceptions of the mathematics teacher community with regard to mobile technology integration in the classroom. During the workshop, teachers practised how to use the mobile apps and shared their thoughts about the usefulness of the tools if they were implemented in the mathematics classroom. This was followed by a survey. A total of 213 mathematics teachers from 129 different junior high schools participated in the preliminary study.

After the analysis of the survey data, the researcher selected 15 teachers for further semi-structured interviews. The selection of participants followed strategy what Patton (2002) calls "mixed purposeful sampling" (p. 244) that is the combination of "convenience sampling" (p. 244) and "criterion sampling" (p. 244). Convenience sampling was related to school location; the schools were located in Semarang district at not very far distances, therefore were convenient and were easy for the researcher to access them. Criterion sampling is related to teachers meeting the following criteria, that is, all participants should be mathematics teachers in junior high schools, and also that their schools should be supportive to enable their participation in this research study. Of the 15 mathematics teachers interviewed, seven wanted to participate in the main study. Following appropriate research procedures, the researcher next sought the approval of "gatekeepers". These were individuals (or school authorities) who provided access to the site (school) and allowed or permitted the research to be done (Creswell, 2014). Five of the seven schools agreed to support the study and allowed the researcher to undertake further investigation in this area of technology-based teaching practices with their mathematics teachers. Therefore, five teachers from these schools who had participated in the preliminary study became participants in the main study.

3.7.2 The case study participants

The five teachers from the five different junior high schools who participated in the current study were a diverse group. The group included three schools (School A, B and C) that had limited technology resources. These schools had implemented the 2006 curriculum, which is well known as a school-based curriculum (*Kurikulum Tingkat Satuan Pendidikan* – KTSP). The other group of two schools (School D and E) had better technology resources and had implemented the 2013 curriculum, also known as K-13. The K-13 curriculum emphasises technology use across all subject areas, unlike the KTSP curriculum. Table 3.2 presents a brief description of the schools where this research study was conducted.

Table 3.2 Demographic information of the schools

Name	School status	Location	Curriculum	Technology resources
School A	Public school	Rural area	2006 (KTSP)	Limited
School B	Public school	Rural area	2006 (KTSP)	Limited
School C	Public school	Urban area	2006 (KTSP)	Limited
School D	Public school	Urban area	2013 (K-13)	Adequate
School E	Private school	Rural area	2013 (K-13)	Adequate

The five teachers who engaged in the current study also had different demographic information. Four male teachers (Joko, Edi, Udin and Setyo) and one female teacher (Nana) participated in this study. The class sizes across the schools were around 30, except for the private school, which had 16 students in the class. The teachers were asked to rate their technological skills as basic, advanced or intermediate (refer Table 3.3).

Table 3.3 Demographic information of the five teachers

Name	Gender	Years of exp.	Degree	School	Class size	Level of technological skills
Joko	Male	20	Master’s degree	School A	32	Basic
Edi	Male	15	Bachelor's degree	School B	32	Advanced
Udin	Male	13	Master’s degree	School C	27	Intermediate
Nana	Female	13	Bachelor's degree	School D	30	Intermediate
Setyo	Male	3	Master’s degree	School E	16	Advanced

3.8 Data Collection

An essential process in research is how the data are recorded. This section elaborates on the data collection process undertaken during the preliminary study and the main study, as presented in Table 3.4.

Table 3.4 Timeline of data collection

Research Phase	Purposes	Methods
Preliminary study		
(April – June 2015) ▪ One-day technology workshop	▪ Investigated teachers' experiences in using mobile devices either in their daily activities. ▪ Investigated current issues in school environments regarding technology-based teaching practice	▪ Survey ▪ Interview
Main Study		
Phase 1 **(January-February 2016)** ▪ Technology Workshop ▪ Trialling technological tools in teaching practices	▪ Introduced and simulated student response systems (Socrative app, Plickers app, and Kahoot app) ▪ Observed and Investigated the five teachers' competencies in the use of technology in their teaching practices	▪ Participant observation ▪ Document ▪ Interview
Phase 2 **(March-August 2016)** ▪ Classroom teaching practices with technology ▪ Social learning interactions in the OLC	▪ Observed teachers' classroom activities with technology ▪ Investigated the impacts of the OLC on teacher professional learning ▪ Participated actively in the OLC-FB and OLC IM and observed how social learning interactions were progressing	▪ Participant observation ▪ Interview ▪ Document ▪ Online post
Phase 3 **(September 2016-May 2017)** ▪ Social learning interactions in the OLC	▪ Observed how social learning interactions were going ▪ Investigated sustainability of social learning interactions in the OLC	▪ Open-ended survey ▪ Document ▪ Online post

3.8.1 Data collection in the preliminary study

The preliminary study helped to gain a broad understanding of the problem domain and identified contextual aspects related to technology-mediated strategies in Indonesian schools. This helped to plan appropriate methods that would work in practice and guide the development of the research idea. The preliminary study used both quantitative and qualitative methods for data collection after getting low risk approval (see Appendix B). The preliminary study procedure, in terms of how data were collected, is explained in more detail in Section 4.3.

The empirical data thus gathered was analysed to understand what educators perceived to be opportunities or challenges facing mobile learning platform implementations in Indonesian school contexts. This helped to plan the next stage of the study for which full ethical approval was first sought. Empirical findings from the preliminary study helped recognize the need to set up an OLC and led to identifying suitable members to join the OLC. This process further enabled the identification of five teachers who were willing to participate in the main study.

3.8.2 Data collection in the main study

Data collection in the main study was guided by two factors: (1) investigating aspects that facilitated or impeded teachers' participation in the OLC in promoting their professional learning; and (2) examining how participation in the OLC impacted on teachers' professional learning in the use of technology for teaching mathematics. This section outlines the different sources and formats of data collection applied in the current study.

3.8.2.1 Participant observation

The practice of participant observation offers several advantages to researchers (DeWalt & DeWalt, 2011). It enhances the quality of data gathered during fieldwork, improves the quality of the interpretation of data, and encourages the formulation of research problems and hypotheses grounded in on-the-scene observation. In this study, the participant observation method was used as a descriptive approach to observe the five teachers in their engagement with the OLC and in the process of integrating technology into their mathematics classrooms.

The researcher took the role that De Laine (1997) describes as a participant observer to capture, from the teachers' standpoint, what was occurring in an observation. Field notes were used to record observational and interview data. Field notes recorded any information that was relevant to the research problems. This aligns with Hammersley and Atkinson (2007), who state "field notes are always selective: it is not possible to capture everything [...] What is recorded depends on one's general sense of what relevant to the foreshadowed research problems, as well as on background expectations" (p. 142).

3.8.2.2 Interviews with teachers

The researcher conducted semi-structured and informal interviews during the main study. Semi-structured interviews were scheduled twice over the course of the main study. The first semi-structured interview was held one month after Phase 2 was started (April-May 2016). In this interview, the five teacher participants described their experiences in implementing technology-based teaching practices and their overall perceptions regarding their participation in the OLC. The second semi-structured interview took place near the conclusion of the study (July-August 2016). This interview explored how the shifts in the social interactions patterns were challenging the teachers' beliefs about their professional learning journeys in the implementation of technology-based teaching practices. The teachers also made direct comparisons with their early experiences in using technology in the classroom, their confidence levels in using new technological tools, and how participation in the OLC had influenced their professional learning journey. Each semi-structured interview took approximately 20-30 minutes.

Informal interviews were also held following each lesson observation, to discuss the teaching and learning activities, identify issues that emerged during the technology implementation process in the classrooms and find solutions to resolve these issues, and to seek information about teachers' plans for the next lesson. Each interview took 10-15 minutes. Interviewing offers flexibility for the researcher to collect detailed views from participants. Myers and Newman (2007) suggest that the interviewer should "situate themselves" and "minimise social dissonance" (p. 16). When interviews take place it is important to make the interviewee comfortable; this "in turn affects the extent to which the interviewee discloses important information which in turn affects the quality of the data" (p. 12). Creswell (2013) advocates that during the interview, the interviewer should use "good interview procedures" and become a "good listener" (p. 166). In this regard, the interviewer stays with the questions, completes the interview within the time specified, is respectful and courteous, and offers few questions and advice.

3.8.2.3 Open-ended survey questions

Open-ended survey questions were used in the current study. The questionnaire was administered to members of the OLC, and consisted of five open-ended questions (see Appendix F).

Open-ended survey questions are a close analogue to open-ended interviews and are beneficial to “elicit detailed, in-depth accounts of the interviewee’s experiences and perspectives on specific issues, situations, or events” for large groups of participants (Kaplan & Maxwell, 2005, p. 40). Responses to open-ended survey questions in the current study were intended to corroborate the analysis of the potential of an OLC for teachers’ professional learning.

3.8.2.4 Documents and online posts

In the current study, the teachers engaged in online communication and interactions in the OLC-FB and OLC-IM, as they shared experiences, stories, videos and photos of teaching activities, and document files. Such posts, comments, reactions, videos, images and files posted on the OLC can be considered to be what Flick (2014) terms artefacts or documents.

In the current study, the documents also included teachers’ lesson plans, students’ worksheets, and material the teachers used to support their teaching practice with technology. In addition, the five teachers also completed informant diaries. The five teachers could not regularly complete diaries because of lack of time and pressure in their daily life as teachers. The diaries recorded their learning journey in using technology for teaching practices through participation in the OLC.

3.8.2.5 Exit from the field

Withdrawing from a relationship which had been built over months-long collaboration was an important process. In addition to exiting from classroom observations, the researcher met the school principals, accompanied by the teachers from their respective schools. The researcher conveyed findings that could have postitive implications for the school and for the enhancement of teacher professional learning through participation in OLCs. In that meeting, the teachers also expressed their own perspective regarding their engagement in the OLC, and its influence on their professional learning and development. All the principals had similar views towards this research. They considered that such collaborative research provided positive support for teachers to engage with technology in their classroom teaching. All the principals conveyed that their schools were always keen to get involved in such collaborative research. They also expected that the teachers could inspire their peers by sharing their experiences. The principals also allowed the participant teachers to stay in touch in the OLC. All participant teachers' activities after the reseacher exited when all classroom observations were captured are presented in Section 6.5.

3.9 Data Analysis

Data analysis was conducted on all obtained data. This section is divided into two subsections. Section 3.9.1 describes analyses of the preliminary study data while Section 3.9.2 describes analyses for the main study data.

3.9.1 Data analysis of the preliminary study

Quantitative data gained from the survey were first coded and then analysed using descriptive statistics. The results were used to understand the experiences of respondents in their use of mobile technologies in teaching and learning activities. The interview data were wholly transcribed and analysed. Categories were identified by dividing each type of the gathered data into segments and examining these segments for similarities and differences. Next, each response was coded to a number of categories. After coding the responses, the categories that had the most responses were marked as prominent. The next step was to see which categories were related and whether any patterns and trends could be identified. Once the more prominent categories were identified, they helped identify trends to give a holistic view of potentials offered and challenges faced by teachers as they leveraged mobile technology for mathematics instruction in their teaching delivery.

3.9.2 Data analysis of the main study

At the completion of data collection in the main study, the data set was analysed in its entirety. This is a key element in validating findings to determine the accuracy or credibility of the findings (Creswell, 2012). The qualitative analysis was conducted in the early stages of data collection. Y. Zhang and Wildemuth (2016) state that early involvement in the analysis phase helps the researcher to move back and forth between concept development and data collection, which in turn directs the subsequent data collection toward sources that are more useful for addressing the research questions. Vaismoradi, Turunen, and Bondas (2013) suggest that when using qualitative methods, data collection and analysis are conducted concurrently to add to the depth and quality of data analysis. In the current study, data collected from multiple resources consisted of two types of data; quantitative and qualitative.

Quantitative data from the main study were gathered from the quantification of the number of posts, comments, and reactions made by the five teachers on the OLC-FB and OLC-IM. Particularly, data from the OLC-FB were extracted using the Facebook application Netvizz (Rieder, 2013, May). Meanwhile, data from

OLC-IM were backed up in CSV format and then the backup file was processed using Power Query in Microsoft Excel. The data were analysed using descriptive statistics. The data were also analysed using social network analysis to investigate what Shum and Ferguson (2012, p. 11) describe as “the network processes and properties of ties, relations, roles and network formations”. This supported understanding how members of the OLC-FB and OLC IM developed these relationships to support teacher professional learning. The network patterns, which represented social interactions of members of the OLC-FB and OLC-IM, were visualized with the open-source social network analysis software Gephi (Bastian, Heymann, & Jacomy, 2009).

The analysis of qualitative data began with a data management strategy. Each interview was transcribed and then linked together with data collected from field notes, open-ended survey questions and other documents, which were collectively managed using NVivo (see Appendix H). This tool was used to organize and keep track of the many messy records that are accumulated in a qualitative project. Bazeley and Jackson (2013) contend that NVivo is useful for managing ideas, querying data, visualising data, and creating a report from the data.

In this study, qualitative content analysis was used as a qualitative descriptive approach in data analysis. Hsieh and Shannon (2005) define qualitative content analysis as “a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (p. 1278). Qualitative content analysis constitutes a process designed to reduce raw data into categories or themes based on valid inference and interpretation. The categories or themes can be developed both inductively and deductively (Hsieh & Shannon, 2005). In inductive content analysis, coding categories are derived directly from the text data. In deductive content analysis the initial coding begins with a theory or relevant research findings. Then, during data analysis, the researchers immerse themselves in the data and allow themes to emerge from the data. The aim of a deductive content analysis approach is to validate or extend a conceptual framework or theory (Y. Zhang & Wildemuth, 2016).

Bazeley and Jackson (2013) suggest that the process of qualitative content analysis is begun by "building knowledge" (p. 70) of the data through developing categories and a coding scheme. Coding, in this respect, can be understood as a process of "tagging text with codes, of indexing it, in order to facilitate later retrieval" (Bazeley & Jackson, 2013, p. 70). A code is an abstract representation of an object or phenomenon (Corbin & Strauss, 2014). In NVivo, coding is stored in "nodes", and they become "points at which concepts potentially branch out into a network of subconcepts or dimensions" (Bazeley & Jackson, 2013, p. 75).

In the current study, initial codes were created as they emerged from data. The underlying theories helped to inform on relevant categories and the codes were refined iteratively. Y. Zhang and Wildemuth (2016) suggest that coding sample text, checking coding consistency, and revising coding rules are conducted iteratively and continue until sufficient coding consistency is achieved. When sufficient consistency has been achieved, the coding rules can be applied to an entire corpus of text. In this process, checking coding was repeatedly performed in what Schilling (as cited in Y. Zhang & Wildemuth, 2016, p. 322) has suggested prevents “drifting into an idiosyncratic sense of what the codes mean”. Checking for consistency of the coding was also undertaken as the coding progressed.

After all the data were coded, the subsequent step was to draw conclusions by making sense of the themes or categories identified and their properties. The categories involved subcategories and covered both single lines of words and action, and chunks of text. At this stage, conclusions and reconstructions of meanings across elements of the OLC (i.e., community, learning, network, and technology) and the three zone concepts including the ZFM, ZPA and ZPD were derived from the data. Activities at this stage included exploring the attributes and scope of emerging categories, identifying relationships between various patterns, and testing the categories against the full data range. List of categories data can be seen in Appendix G.

The next step was clarifying patterns of relationships in the concepts, some of which were not relevant to the emerging theoretical constructs and were discarded. For example, data analysed in regard to the implementation of mathematical literacy concepts in the first month of the main study were not relevant when viewed again, since the current study’s focus had changed to the use of technology in mathematics classrooms. Therefore, results of analysis from this data were eliminated. In the final iteration, the underlying patterns and themes were used to develop a conceptual understanding of how teachers developed their professional learning through their participation in the OLC in using technology in the mathematics classroom.

3.10 Data Presentation

Qualitative research depends on the presentation of descriptive data so that readers have a clear understanding of the meaning of the experience under study (Janesick, 2015). The findings are reported in a composite multi-case format. Direct quotations were used in the findings, drawn from the interview data, online discussions in the OLC, and informal discussions during lesson observations, as well as open-ended survey questions. The teachers' voices provided a way to attain deeper understanding of the process of teacher professional learning within the OLC in using technology in the classroom.

Brief case descriptions are presented to inform readers about the five teachers, including their school context, availability of and accessibility to technology facilities, and their teaching experiences and skills in the use of technology (see Chapter Six). Detailed textual descriptions of the five teachers' experiences using technological tools during classroom sessions, and their participation in the OLC, revealed aspects of their professional learning journeys. In this respect, the social participation of the five teachers in the OLC (see Chapter Five) were described with brief vignettes to illustrate *mutual engagement* among members of the OLC. The vignettes also illustrated the content of posts (stories, images, and videos) that became part of the community's *shared repertoire* associated with *joint enterprise,* which is the common focus of the community (Wenger, 1998b). The enterprise proposed in the current study was an approach to help teachers to use technological tools for mathematics teaching practices.

Yin (2014) suggests that case studies should maintain a chain of evidence, without burdening the narrative with too many methodological treatises, and such shortcomings can be overcome by the use of footnotes, textboxes, tables or figures. In the current study, tables and textboxes were used extensively to illustrate exemplars of practices and of social interactions in the online learning environments.

3.11 Trustworthiness and Validity

Examination of trustworthiness is crucial to ensure reliability and validity in qualitative research. Seale (1999) states that to evaluate the quality of research through reliability and validity in qualitative research, the "trustworthiness of a research report lies at the heart of issues conventionally discussed as validity and reliability" (p. 467). Some qualitative researchers (Patton, 1999; Y. Zhang & Wildemuth, 2016) argue that the criteria used to evaluate the quality of research in qualitative studies differ from the conventional criteria used in quantitative studies. These researchers refer to valid and reliable qualitative research as research that is "plausible, credible, trustworthy and therefore defensible" (Johnson & Christensen, 2008, p. 275). In qualitative research, "the researcher is the instrument" (Patton, 1999, p. 1198) so that the credibility of the research depends on the ability and effort of the researcher. Johnson and Christensen (2008) argue that one potential threat to validity is researcher bias, which is the fact that researchers are likely to find information and results that support the researcher's proposition. The current study adopted a stance of reflexivity, in which the researcher actively engaged in critical self-reflection about his potential biases. The next sections describe how interpretive validity, internal validity, and external validity were maintained during the study.

3.11.1 Interpretive validity

Interpretive validity refers to the extent to which the researcher portrays accurately the research participants' viewpoints, thoughts, feelings, intentions and experiences in the research report (Johnson & Christensen, 2008). Maxwell (1992) states that "interpretive validity is inherently a matter of inference from the words and actions of participants in the situations studied" (p. 290). In this regard, the interpretations are based on the research participants' perspectives. Johnson and Christensen (2008) suggest that research has to get inside the heads of the participants, look through their eyes, and see and feel what they see and feel in order to get accurate interpretative validity.

The researcher has been working in a teacher higher education institution for over thirteen years. The researcher's work involves collaborating with mathematics teachers from many different schools where he contributes to teacher professional development programmes. Having had prior engagement with schools helped the researcher in gaining access to the schools and in the implementation of this study. In addition, the researcher is a native Indonesian language speaker; therefore, was in a good position to understand the local dialect and hidden nuances expressed by the research participants over online discussions, interviews and classroom observations.

In order to validate the interpretation, the researcher used participant feedback in interviews, online discussions, and surveys to eliminate any misrepresentation. The researcher also used verbatim quotations as the lowest-inference descriptor, in which direct quotations were translated from Indonesian to English to support the findings of this thesis. The translated direct quotations were back-translated into Indonesia to verify the initial translation. The back-translation is useful to reveal or amplify mistakes in each forward translation, and make inferences about the quality of translation (Epstein, Santo, & Guillemin, 2015). In this study, the back-translation procedure was conducted by comparing the back-translated version with the original language version and by addressing any mismatches found during error checking.

3.11.2 Internal validity

This validation refers to the extent to which the findings of the study match reality (Merriam, 1998). Johnson and Christensen (2008) described internal validity as the degree to which a researcher is justified in concluding that an observed relationship is causal. Merriam (1998) suggests some strategies to improve internal validity of analysis, one of which is triangulation.

In the current study, the researcher used the triangulation method to increase internal validity. For method triangulation, the current study used multiple and different methods of data collection. Therefore, the use of surveys, interviews, follow-up interviews, OLC posts (e.g., comments, videos, pictures and emojis) and online discussion forums, amongst others, contributed to strengthening the analysis and making inferences that correctly reflected reality.

3.11.3 External validity

External validity is concerned with the extent to which a study's findings can be applied to other situations (Yin, 2014); that is, whether the findings are generalizable beyond the immediate case studies. Generalizability refers to the ability to apply the theory resulting from the study across wider situations

(Maxwell, 1992), which Walsh (2003) puts under the heading of transferability. Creswell (2013) suggests that “rich, thick description allows readers to make decisions regarding transferability” (p. 252). Thick description means that the researcher provides details when describing a case. Creswell states that such detailed description allows readers to transfer information to other settings and to determine whether the findings can be transferred “because of shared characteristics” (Erlandson, Harris, Skipper, & Allen, 1993, p. 32). In the current study thick description was used to provide enough description for each case.

3.12 Summary

This chapter began by outlining the research questions used in this study. It described the use of case study research from a sociocultural perspective. The ethnographic case study approach was presented as a suitable approach for answering the study’s research questions. Multiple-case studies were undertaken to gain an in-depth understanding of the case from multiple perspectives.

Descriptions of the data collection methods were provided, along with how these captured the teachers’ perspectives in terms of promoting teacher professional learning through the OLC in using technology for teaching mathematics. A case study design was determined to be appropriate through the use of an exploratory preliminary study, investigator triangulation methods, and a sociocultural approach to understand the process of professional learning in relation to the model used in the current study. This ensured research quality and reliability, and resulted in detailed case study reports, case study analyses, and conclusions.

The next chapter presents the preliminary study used for the systematic combining of theory and empirical evidence for development of the conceptual framework before commencement of the main study.

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CHAPTER FOUR

POTENTIALS AND CHALLENGES OF MOBILE TECHNOLOGY INTEGRATION IN THE MATHEMATICS CLASSROOM: A PRELIMINARY STUDY

4.1 Introduction

This chapter presents the findings of a preliminary study conducted in April-June 2015. Section 4.2 describes the background to the study detailing actual conditions across secondary schools in Indonesia regarding the use of mobile technology in mathematics instruction. Section 4.3 outlines the research methods employed while conducting the preliminary study. This section also provides the demographic information for the participants.

Section 4.4 presents the results of data analyses. The potentials and challenges of mobile technology are identified. Section 4.5 describes teachers' personal use of mobile devices and also some ethical considerations that should be taken into account when using mobile devices in the classroom. Section 4.6 discusses the implications of the preliminary study for development of the main study.

4.2 Background to the Study

A regulation (Reference Number 68 in the curriculum year 2013) of the Ministry of Education and Culture of Indonesia states that all subject disciplines (including mathematics) are to be integrated with technology (Ministry of Education and Culture, 2013a). Teachers are required to develop the necessary skills to integrate technology into instruction. To achieve this, mathematics teachers require appropriate guidance and support. Specifically, this study looked at the mathematics discipline to explore how mobile technology can be used as an aid to deliver mathematics concepts. Technological devices deliver a range of functionalities, such as rich graphical interfaces, which provide visual representations of logical evidence suitable for enhancing the process of teaching and learning mathematics, and computational capabilities to motivate and support problem-posing activities (Abramovich & Cho, 2015; Niss, Blum, & Galbraith, 2007). Including technologies in instructional methods while presenting mathematics concepts helps create an environment where students can engage with mathematics in a meaningful way (Jung & Conderman, 2013; Lew & Jeong, 2014). The National Council of Teachers of Mathematics (NCTM) acknowledges that technology can be leveraged effectively by teachers if they know how to make good use of technological tools as facilitators (NCTM, 2011). Therefore, a good understanding of how the technological platform grounds the underpinning teaching pedagogy and assists in delivery of the curriculum content is critical (Koehler et al., 2007). Technology can then be used as an enabling intervention tool across different teaching and assessment strategies for improving student learning skills.

Despite policy expectations and the proven value of technological tools in the mathematics classroom, the majority of teachers in Indonesia lack adequate technology skill levels (Copriady, 2014). The results of the national examination of teachers' competency (*Ujian Kompetensi Guru* - UKG) of Indonesia, conducted online in 2011 and 2012, corroborate this. The national average score for UKG in 2012 was 47.84/100, far below the passing grade of 70/100. This low result does not reflect on teachers' lack of teaching experience; rather it illustrates teachers' lack of awareness, particularly in terms of understanding the necessary technicalities in online examinations (Yusri & Goodwin, 2013). The Centre for Information and Communication Technology in Education and Culture reported that, although the use of information technology has been part of the curriculum at all school levels, no specific instructional hours have been allocated at primary level, while about 1 to 5 hours per week are generally allocated at secondary level (Pannen, 2014; UNESCO-UIS, 2014). In 2013, Indonesian schools indicated a willingness to integrate technology in their curriculum (Ministry of Education and Culture, 2013a), but a survey conducted by UNESCO-UIS (2014) revealed low technology usage in teaching practice, along with poor infrastructural support. Consequently, the integration of technology into the school curriculum in Indonesia is still far from meeting expectations.

The presence of technology has made teaching and learning mathematics easier (Eng, Han, & Fah, 2016). The advancement of feature-rich mobile technologies and the emergence of new theories in mobile learning have directed a lot of attention to the way mobile technologies can transform and reconstruct educational practice (Crompton & Burke, 2014). However, using mobile technology for learning has also raised some ethical issues and concerns (Thomas, O'Bannon, & Bolton, 2013). For instance, many teachers have expressed concern about using mobile devices in their classrooms since they may distract students from engaging responsibly in learning activities (Dyson, Andrews, Smyth, & Wallace, 2013; Keengwe, Schnellert, & Jonas, 2012). Consequently, many schools have banned students from using mobile devices (Thomas et al., 2013). It is important therefore to understand mobile learning challenges as well as their capabilities.

4.3 Research Method Employed for the Preliminary study

This study employed both quantitative and qualitative methods in collecting, analysing, and integrating data to understand the perceived potential of and challenges in using mobile devices (Creswell, Fetters, & Ivankova, 2004) in Indonesian schools. Quantitative methods were employed through a survey that was subjected to statistical analysis. The survey consisted of 14 items including both closed and open-ended questions. Further semi-structured interviews were conducted with school teachers to gain insight into current issues in school environments regarding mobile teaching practice and to assess teacher readiness to use available technologies.

The study was conducted in Semarang, Indonesia. The sample size of the survey was determined by a formula proposed by Yamane (1967, p. 886). There were 462 mathematics teachers in Semarang municipality, so by using Yamane's formula with a margin of error of 0.05 the desired sample size was 214 teachers. In this study, 213 teachers from 129 different junior high schools participated, which was very close to the target number. Participants were 61.5% (131) female and 38.5% (82) male. Most of the teachers were from urban areas (195 or 91.5%), with only 18 (8.5%) from rural areas. The majority of participating teachers (157 or 73.7%) had a teacher's certificate from the teacher certification programme (i.e., a programme designed by the government of Indonesia to establish a quality benchmark for both in-service and pre-service teachers (Jalal et al., 2009).

After analysing the survey data, the researcher selected a purposive sample of 15 mathematics teachers for further interviews. The researcher wanted to ask these teachers about their overall school and classroom experiences with regard to mobile teaching and learning practice. Each interview took approximately 20 minutes. Four teachers were interviewed face to face at their schools while eleven teachers were busy with school-related work, so they were interviewed over the phone.

4.4 Empirical Findings from the Preliminary study

This preliminary study investigated teachers' perceptions about the use of technology. The researcher specifically investigated the current use of mobile technologies to understand teachers' perceptions regarding the potentials offered or challenges faced with the use of mobile technologies for teaching and learning in the classroom.

4.4.1 Leveraging mobile technology affordances

Before asking the teachers about their experiences using mobile devices either in daily activities or in schools, the researcher enquired how many teachers currently used mobile devices, and if they used more than one mobile device. Findings revealed that over a half of the teachers owned a smartphone (124 or 58.22%), while others used a tablet (28 or 13.15%), or Internet-enabled basic phone (23 or 10.80%). However, some of the teachers (40 or 18.78%) did not have mobile phones with Internet capabilities. The researcher enquired how often teachers currently used mobile devices to support their daily activities. Almost half of the teachers (104 or 48.83%) reported that they mostly used mobile devices for texting or sending messages. Some teachers (82 or 38.50%) occasionally used mobile devices for social networking activities and some of them (51 or 23.94%) used them for all sorts of social and computing activities. A minority of teachers (85 or 39.91%) further used mobile device for activities related to email. These findings show that mobile devices are mostly used as tools for communication and collaboration among teachers. Some teachers' responses in the survey stated:

> *I use my mobile phone only to keep in touch with my family and friends.*

> *Anytime I need to communicate with my friends, I use my mobile phone*.

Most of the teachers with mobile devices also used them for obtaining information such as reading content files (106 or 49.77%), searching for information (100 or 46.95%), and listening to music or watching videos (122 or 57.28%). The teachers commented that they sought relevant information from the Internet via mobile phones to get the latest information to supplement material obtained from books.

> *I usually use my mobile phone at home to find any information from other sources when I could not find them in the books.*

> *At school, I use my mobile phone for searching materials that do not exist in the books and also seeking for mathematics-related questions for practices.*

In terms of the potential of mobile devices as tools for constructing and creating, few teachers (23 or 10.80%) used them for creating and uploading content (e.g., images, or videos) as a general practice. However, some of them (96 or 45.07%) said that they did this occasionally. Regarding the basic practice of capturing and collecting information using mobile devices, some teachers (96 or 35.21%) responded that they occasionally used their devices to view maps to get driving directions to required locations by using GPS-enabled mobile apps. Table 4.1 presents teachers' activities (in percentages) in their day-to-day use of mobile devices.

Next, the teachers were asked about their experiences in using mobile devices for mathematics instruction. The survey revealed that only 31.9% (68) of teachers had used mobile devices in teaching and learning activities. They used mobile learning in all sorts of activities, both indoor (28 or 13.1%) and outdoor (19 or 8.9%), as well as in either formal (24 or 11.3%) or informal (3 or 1.4%) settings.

Table 4.1 Teachers' activities in the use of mobile devices

Activity	**Never (%)**	**Seldom (%)**	**Occasionally (%)**	**Always (%)**
Social networking	28.6	8.9	38.5	23.9
Reading content files (e.g., e-book, article, etc.)	27.7	10.3	49.8	12.2
Accessing emails	28.6	15.0	39.9	16.4
Text messaging	21.1	4.7	25.4	48.8
Searching for information	22.0	1.9	46.9	29.1
View map and get driving directions	35.7	24.9	35.2	4.2
Creating and Uploading content (e.g., image, video, etc.)	32.4	11.7	45.1	10.8
Playing games	38.5	28.6	27.7	5.2
Listening to music or watching videos	23.5	11.7	57.3	7.5

With respect to the use of mobile devices in mathematics class, teachers shared many experiences.

> *I use the Quipper School* [a web-based application]. *For example, I give an instruction to them like this: "Ok everyone, I have posted a homework* [these consist of 10 multiple choice questions related to the material taught today] *in the Quipper School, you have one week to complete them just take a look at your own account". Then, they are able to do the work in one week* [since to complete this homework, students will require computers/mobile devices to answer the multiple choice questions posted in the Quipper School]. *One week after, I can immediately check the*

> *results. I can also determine which students are in upper, middle and lower level*.

> *I even applied this method* [mobile learning] *in my classes. I even asked the IX grade students to bring their mobile phones and I gave them a web address where they were able to do some exercises and they could also match their answers by looking at the discussions of national exam made by the government. Besides, I also applied this method for the VIII grade students.* [Using a mobile application] *we placed some points* [in a GPS-enabled map]. *Students were then asked to approach these points by following a map, and in each point there was a mathematics real-world problem to be solved. The result was they were very interested in this kind of activity*.

These views indicate that the teachers perceived mobile phone usage in instruction to be beneficial. Mobile technologies enable teachers to enrich the overall learning experience as they create innovative teaching and learning strategies for delivering mathematics instruction.

> *I usually use my phone to see if there are any emails. I often get much information about online training from the email. Sometimes I use it to find some terms in mathematics via Google, and sometimes I also seek some materials to motivate the students at the beginning of the learning, so they will feel excited before the actual learning takes place*.

4.4.2 Challenges in using mobile devices for mathematics instruction

The potentials of technologies (mobile devices) can create both positive and negative perceptions for individuals (teachers) about how their usage will impact the classroom environment (Gibson, 1977). On one side, the benefits afforded by mobile devices in classrooms, such as bringing in new technology interfacing capabilities, are positive; while on the other side, mobile devices also introduce challenges, such as changes to instructional practice in teaching. Teachers were asked to identify the challenges in the use of mobile learning in mathematics instruction. Based on the survey, 58.2% (124) of teachers responded that they considered that mobiles would disrupt the class (e.g. phones ringing during class, texting and checking incoming phone messages in the classroom). The second challenge related to cyberbullying and sexting (106 or 49.8%), followed by cheating (87 or 40.8%). One teacher opined:

> *I think the parents' awareness about bringing the mobile phones into the school is caused by uncontrolled pornographic contents, but in my opinion if they* [teachers] *are able to control and monitor their students carefully, these unwanted problems might not happen. Therefore, the students should hand in their mobile phones to the homeroom teachers. In this way we can anticipate and resolve many negative impacts for them*.

Some schools have banned mobile phones. At the beginning of each new academic year the school invites all parents and presents the school's policies; one of which is that children (especially freshmen) are not allowed to bring mobile devices to school. The parents are asked to sign an agreement stating that they will comply with the school's policy.

> *In my school the students must not bring their mobile phones* [...] *This prohibition is written in the school's rules which are delivered explicitly* [in the meeting with the students' parents] *and they are asked to sign a form of willingness that their kids will obey this rule*.

> *For the freshmen, during PPD* [the new students' orientation], *we made the rules. There were some agreements between us and their parents. There was an item stating that the students must not bring their mobile phone. The reason* [of this rule] *was also stated [in that meeting] and it had finally become one of the rules.*

The above quotes indicate that the schools impose restrictions whereby students are not permitted to bring mobile phones to school, which could be a reason why teachers are reluctant to use mobile phones in classroom teaching. With such restrictions in place, teachers are not able to apply creative teaching methods.

Prohibiting the use of mobile phones at school thus limits teachers in expressing themselves in the exploration of mathematics concepts using mobile technology.

Apart from the teachers' concerns about using mobile devices in instruction, the findings show that the limited availability of technology (e.g. students do not have mobile devices, schools have insufficient/do not have mobile devices) is also a barrier to the implementation of mobile learning. When questioned, some teachers (70 or 34.3%) confirmed this to be a challenge:

> *The challenge* [of mobile learning] *is that not all students have an Android phone or a smartphone*.

Another challenge described by teachers is the limited availability of wireless connectivity in schools. To engage with mobile technology in instruction, Wi-Fi has to become ubiquitous. However, not all schools have good Wi-Fi connection and when they do have it, the connection may only cover a few areas within a school. Two teachers voiced this issue:

> [Wi-Fi signal] *does not cover the whole* [school] *area, but is only available within a certain area*.

> *The second challenge is the overload of Wi-Fi networks usage leading to slower access time in loading resources* [from the Internet].

In this regard, poor wireless connectivity is considered as another hindrance to the implementation of mobile learning. These findings are similar to those of Muir (2013) who suggests that although there are various Internet data packs offered by companies, mobile learning implementation is costly.

With respect to ethical issues that led to the emergence of a ban on mobile phone usage in schools, two teachers shared their recommendations.

> *The representatives of the school committee, representatives of the students' parents, representatives of the guidance and counselling, and representatives of the classroom teachers should discuss this rule* [using mobile phones for learning] *together to find the best solutions. Then after this discussion, we will be able to execute the discussion results in the learning process*.

> *In my personal opinion, if the students are very excited in using mobile technology in the learning process, first thing to do is consulting or coordinating with the homeroom teachers, preceptors of intra-school organization, and of course to the school principal… after that, all stakeholders* [must] *agree on what have just been delivered and we also need to tell the parents. We make a notification letter that from now, the students are allowed to use their mobile phones for the purpose of learning process*.

These teachers shared similar views that mobile learning could still be implemented in teaching and learning activities by involving all stakeholders, and by adjusting schools' policies to relax restrictions on mobile devices. These findings are similar to those of Dyson et al. (2013), who suggest that the involvement will encourage ownership of the policies at all levels.

The readiness of teachers to engage in mobile learning is also a positive step towards making this endeavour successful. One teacher said

> *The first challenge is about the teachers' readiness. All teachers must be more progressive in preparing the learning materials. The second is monitoring the students* [during the mobile learning process], *and the last is the learning process must be conducted as creatively as possible*.

Readiness in this view can be interpreted in terms of the skills teachers possess and the extent to which teachers feel comfortable about using mobile devices in their teaching practice. Therefore, in this regard, readiness for mobile learning needs to consider three aspects: technological, pedagogical, and psychological (Stockwell, 2008). These three aspects will help teachers resolve any concerns that might arise when implementation of mobile learning does eventually take place.

4.5 Discussion and Recommendations

This preliminary study provided insights into how mathematics teachers view the potential of mobile devices as instructional tools to support out-of-school or in-school activities in Indonesia. The preliminary study also investigated the challenges teachers face in implementing mobile technology in mathematics classrooms.

4.5.1 Teachers' personal use of mobile devices

The data show that most teachers own mobile devices and some of them have more than one mobile device. The teachers leverage the features of mobile devices to get driving directions using GPS-enabled mobile apps. However, many teachers do not use their mobiles for teaching and learning activities; rather, devices are used on a daily basis for out-of-school activities. The majority of teachers use mobile devices for communication and collaboration either with family or peers, via texting, social networking and email exchanges. The presence of mobile devices has transformed the way teachers connect with each other. Two-way communication can easily be performed either synchronously or asynchronously. Text messages, social media, and email are forms of communication that make it easier for teachers to stay in touch with distant peers.

Apart from facilitating communication, mobile devices offer ease of access to information. Some teachers use mobile devices to search for relevant information on the Internet via mobile phones, to obtain the latest information about subject content to supplement textbook information. The teachers reported that they use mobile devices to create content (e.g. edited images, videos, sketches, podcasts, and posted articles) and to upload the content to public media or private storage. Mathematics-related questions are sought to enhance student learning experience (for example, embedding problems in maps, posting homework online and providing students instant feedback on right and wrong answers). This shows that the teachers also use their mobiles for professional purposes. When the teachers are able to select information that fits with their needs, they can analyse, synthesize and personalize the information to create technology-enabled subject delivery for classroom teaching.

Therefore the argument can be made that teachers can make effective use of their mobile technology for teaching purposes (Overbaugh & Lu, 2008; M. Zhang, Trussell, Tillman, & An, 2015). Those who had implemented mobile learning in mathematics classes viewed mobile devices as useful instructional tools; although they admitted that they could be more creative and innovative in delivering mathematical content with this technology. The opportunities are in front of us; we just need to identify the best route to overcome the challenges so as to achieve them.

4.5.2 Ethical considerations in mobile device use

Adopting mobile technology in education raises some ethical issues and concerns (Dyson et al., 2013). This study examined ethical considerations that might arise when students bring mobile phones into classrooms (for example, distractions from learning, cyberbullying, sexting and cheating). More than half of the teachers perceived that mobile devices can be a distraction in classrooms and almost half were concerned about cyberbullying and sexting. Some of the teachers were also concerned about cheating. The lack of technology resources was also seen by teachers to be a hindrance in infusing mobile technology into education. More than one-fourth of teachers confirmed this view. These issues were the most-cited reasons for teachers to be reluctant to use mobile learning in classroom instruction.

These challenges need to be addressed if mobile technology is to be used more effectively by teachers and their students. Regarding technology availability problems, Thomas et al. (2013) recommended that teachers should allow students who have mobile phones to work collaboratively with those who do not, and that schools could procure mobile phones for students' use in classrooms. To deal with ethical concerns, some teachers have recommended that all stakeholders need to be invited to discuss the policy. Involvement of all stakeholders refers to all those who will be affected by the policy as well as those who will enforce it (Dyson et al., 2013). Ethical issues arise as a result of concerns about misusing mobile devices for something inappropriate. Therefore, the teachers must be able to encourage students to process the information obtained while using their mobile phones only for the purpose of learning mathematics concepts. Further, teachers should encourage students to be responsible and take positive actions towards their own learning, rather than just avoiding technology due to perceived harm, danger, or ethical issues. Considering what some teachers have delivered with mobile technology, it is apparent that despite the challenges, teachers have been able to assign study tasks to students and allocate them homework online.

Instead of forbidding students to bring their mobile phones, there should be another strategy that introduces specific steps to restrict bad behaviour among students in how they use mobile phones. As stated by one teacher, rather than banning phones completely, the school can control inappropriate use of mobile phones, by making students hand in their devices to the homeroom teachers. Students can then use their devices as and when required, such as during classroom teaching and learning sessions. However, this will create an extra overhead for the school as they will be responsible for the safe-keeping of these devices.

4.6 Implications for the Main Study

The findings affirm that mathematics instruction can be augmented with technology-based learning; however, the majority of schools prohibit the use of mobile devices in classrooms. Most teachers also perceive mobile devices as a disruptive technology. Moreover, many teachers confirmed that schools have insufficient facilities with regard to mobile technology. Limited access to mobile devices in schools constitutes the main hindrance to adopting mobile technology, making teachers reluctant to use it in teaching and learning activities.

While environmental challenges have restricted the use of mobile devices in mathematics instruction, there are compelling reasons for doing so. The findings suggest that classroom teaching be infused with alternative technologies for instruction; especially those that fit better with the current social situation in schools in Indonesia. These could include web-based applications that can run on all digital devices ranging from desktop computers to laptops, tablets and mobile phones. While teachers are eager to experiment with technology for classroom teaching, the difficulties in using mobile devices can undermine their full potential. This has implications for the tailoring of teachers' skills with technology to match underlying school educational goals and priorities. Appropriate technology professional development programmes help teachers to improve their technology skills and to manifest pedagogical knowledge.

While these are initiatives to be considered by the school, teachers' professional development can also be enhanced by initiating an OLC as a means for informally learning and sharing technology-enabled teaching experiences with peers. OLCs have proven successful in teacher professional development (Schlager, Fusco, & Schank, 2002) by enabling teachers to enhance knowledge through a collaborative learning process (Kirschner & Lai, 2007; Tu & Corry, 2002) and to critically reflect on their own practices to improve their teaching (Kirschner & Lai, 2007; Yang, 2009). The findings indicate a gap in using mobile technology for mathematics instruction (e.g., few teachers use mobile technology for analytical thinking and problem solving purposes, and the majority of teachers use technologies only for content delivery). In the main study, the researcher proposed building a closed-OLC as a means for teacher professional learning that focused on the use of technology for teaching practices, providing a way for teachers to reconstruct their teaching delivery practices to help bridge the current gap as they integrated technologies into mathematics classroom instruction.

Given the fact that many schools had prohibited the use of mobile technologies in the classroom, the researcher was advised to get permission from gatekeepers, to avoid any ethical issues before conducting the main study. The empirical findings recommended focusing the research problem on teacher professional learning in using technology for teaching practices within the OLC.

4.7 Summary

This chapter has discussed the potential and the challenges of using mobile technology in Indonesia. The data analyses showed that many teachers owned mobile devices and they used them for communication and collaboration, either with family or peers. Some teachers also used their mobile devices for professional purposes. However, many teachers remained hesitant to use mobile technologies for teaching and learning activities because of insufficient technology facilities in the school, low levels of technology skills, and the existence of school policies that restrict the use of mobile technology in the school. Some ethical issues and concerns also contributed to teachers hesitating to use mobile technology in the classroom. However, the findings of the preliminary study offered some recommendations that could be used to address the challenges.

The empirical findings of the preliminary study suggested that there is a need to conduct technology professional development programmes to enhance teachers' technical skills. An OLC can be used as an alternative way to learn the technology, as it has proven successful in teacher professional development. Given the fact that many schools had prohibited the use of mobile technology in the classroom, the researcher was advised to seek the approval of gatekeepers to avoid any ethical issues when the main study took place.

The preliminary study provided insights on current teacher practices in using mobile technologies for instructional practices and narrowed the research inquiry towards teacher professional learning within OLCs.

NOTE: Chapter 4 is a partial re-print of the following article. The thesis author was the primary investigator for this article.

Abidin, Z., Mathrani, A., Hunter, R., & Parsons, D. (2017). Challenges of integrating mobile technology into mathematics instruction in secondary schools: an Indonesian context. *Computers in the Schools*. *34*(3), 207-222. doi:10.1080/07380569.2017.1344056

CHAPTER FIVE

SOCIAL LEARNING INTERACTIONS IN AN ONLINE LEARNING COMMUNITY

5.1 Introduction

The previous chapter described teachers' perceptions of the challenges faced in integrating technology into mathematics instruction in an Indonesian secondary school context. This chapter presents the social learning interactions that occurred in the online learning environments that were specifically created during the conduct of this research study.

Section 5.2 describes the process of the introduction and build-up of three online learning environments: a Facebook group, a Facebook Messenger group, and a WhatsApp group. Teachers' perceptions about sharing practices and providing feedback across these three online learning environments are also discussed. Section 5.3 outlines the social learning interactions involving the five teachers and the researcher in these online learning environments. Evidence of social learning interactions is presented to support the examination of the five teachers' participatory social processes as they developed their professional practice to improve the use of technology in their teaching practices.

Section 5.4 describes the patterns of social interactions that occurred in the Facebook group, Facebook Messenger group, and WhatsApp group. The patterns of social interactions in these three online learning environments are presented visually and then analysed. Section 5.5 outlines the views of the five teachers about their participation in the OLC. Section 5.6 provides a description of the sustainability of social learning interactions in the OLC.

5.2 Participation in the OLC

Three online environments provided the means to facilitate online teacher professional learning for five secondary school teachers in Semarang, Indonesia. These also provided an online platform where all members could discuss topics related to their use of technology in the mathematics classroom. This form of online communication provided an in-depth look at the teacher's professional learning through a participatory social process. Five teachers who engaged in the current study agreed to participate in these three online environments (i.e., the Facebook, Facebook Messenger, and WhatsApp groups).

5.2.1 Participation in the closed Facebook group

A closed Facebook group (OLC-FB) was the first online learning environment introduced. The researcher acted as an administrator in the OLC-FB and administered the membership by approving teachers from the wider teaching community who showed an interest in participating. The aim of including other teachers as participants in the OLC-FB was to let the five main research participants share their practices with the wider teaching community. It also reinforced their professional learning through social interactions.

The researcher (as a participant observer) played a specific role, which included being a host on the site as well as an administrator. The researcher further acted as a mediator, and this role consisted of mediating and facilitating discussion among members, setting up some group norms, and enabling group participation using teachers' experiences as a frame of reference or topic raiser for discussions. The role included responding and providing immediate feedback to members' entries, guiding discussions without taking control, and providing useful links to teachers' resources and learning activities.

At the initial stage of study, the OLC-FB was reserved for the five participant teachers. These teachers in turn invited their mathematics colleagues from the same school and from other schools. The OLC-FB members progressively grew with the current number of community members being 420, comprising mathematics teachers, mathematics pre-service teachers, mathematics teacher educators from various regions in Indonesia. The five participant teachers used the OLC-FB to share experiences, exchange knowledge, and discuss certain topics related to how they integrated technology in the classroom. The OLC-FB participation of some members gradually improved over time. Many of the OLC-FB members were what Wenger and Trayner (2011) have described as lurkers. They sustained a connection to the community but with minimal engagement. One of the OLC-FB members explained: *I think the community members who are passive in the Facebook group are because they do not have as much personal commitment to practice. They might just look for ideas about technology implementation in the classroom.* This statement indicated that the members who were less engaged in the OLC-FB felt that they had no obligation to carry on discussions related to their own learning regarding the adoption of technology instructional practices. However, these members may have been active elsewhere and experiencing the community as a network. Another member of the OLC-FB noted, *I think the community members are reluctant to engage in the online* *discussions on the Facebook group actively because of their concern*s *that their opinion might offend other members*. This showed that a reticent attitude to publicly posting was an option to avoid unpleasant things happening in the online discussion forum. Edi, one of the five main research participants, also expressed the same concerns: *I am not accustomed to giving comments directly on Facebook group. I feel "pakewuh"* [uncomfortable] *to give feedback in public* [a group with the wider community] ... *I am more comfortable to discuss it in person or a private group such as in the WhatsApp group or Facebook Messenger group.* Edi's statement indicates that a feeling of *ewuh pakewuh* made him unwilling to speak out about his thoughts. The feeling of *ewuh pakewuh* is a personal characteristic of most Javanese people (Wati, 2014). This characteristic creates a feeling of shyness and makes people hesitate to frankly express their thoughts. Another research participant, Udin, said: *I have been reluctant to give critical feedback to other colleagues because I was worried that my comments would offend others*. *I would rather give praise to the ability of teachers to use technology* [in their practices]. Udin's action can be categorised as *sungkanan* or *ewuh pakewuh*; that is, Udin prefers to give compliments to teachers so as not to upset or antagonize other members of the community.

5.2.2 Participation in the Facebook Messenger group and the WhatsApp group

Social interactions developed in the current study were not merely to make teachers feel positive about their current teaching practices; through interactions they were expected to make better use of technology in their subsequent teaching practices. Since the OLC-FB provided unrestricted access to all members who had subscribed to it, there was some hesitation from members about openly engaging. Hence, a Facebook Messenger group (FB Messenger group) was introduced as the second online learning environment, and comprised only the five teachers and the researcher. With just a few members, these five teachers were more open in expressing their thoughts and ideas, as well as being more receptive to receiving feedback. The five teachers communicated using the FB messenger group only after school hours. Edi explained, *I am afraid to access FB Messenger group at school because my friends will notice that I am online. They will admonish me if I get caught*. Edi's concern was due to a school policy that prohibited the use of Facebook; hence Edi tried to comply with the school policy so as not to be reprimanded by the principal. The other teachers also shared similar concerns because their schools had the same policy of prohibiting the use of Facebook during school time. To address this issue, the researcher searched for another instant messenger that could be used during school hours. The teachers and researcher came to an agreement that WhatsApp could be an alternative instant messenger for communication. The teachers said that WhatsApp was often used for communication while they were at school. The WhatsApp group (WA group) was then introduced as the third online learning environment. It soon became evident that the teachers were more comfortable using the WA group. The teachers communicated more frequently within the WA group than the FB Messenger group. For example, across the six-month period (March–August 2016), a total of 208 messages were posted on the FB messenger group in contrast to the 809 messages posted on the WA group. However, both the FB Messenger and WA were used throughout this study, since teachers used both instant messengers interchangeably. Edi and Udin for example stated that while accessing the Facebook group, they preferred to chat using FB messenger rather than via WhatsApp. The teachers were free to choose between these two messenger applications as per their convenience. For the purpose of analysis, the acronym of OLC-IM was used to indicate the use of both instant messaging applications (i.e., FB Messenger group and WA group) in the current study.

Sharing teaching experiences, exchanging knowledge, identifying issues, looking for alternative solutions, and helping each other to enhance the quality of teaching and learning in using technology occurred through the OLC-IM. In comparison with the online discussions on OLC-FB, the teachers in the OLC-IM were more receptive to other’s inputs, and they were more comfortable in giving recommendations and providing constructive feedback to each other. Thus, the five teachers’ participation in the OLC-IM complemented their participation in the OLC-FB because in the latter they had been more reticent about engaging in the online discussion. However, the role of the researcher as a mediator in the social interaction remained crucial in both domains. As previously described for the OLC-FB, the five teachers were initially passive members, and this was replicated in the OLC-IM. Their interest and motivation to engage in social learning slowly grew as the researcher shared new information to attract their interest; for example, introducing tools for outdoor classroom activities, providing solutions for emerging technical issues during the classroom observations, and sharing teaching strategies that might be relevant for certain topics. In addition, the researcher also introduced and organised online discussions on an ongoing basis to facilitate dialog and maintain some novelty thereby promoting social learning interactions.

5.3 Learning Interactions in the OLC

As members participated in the OLC, they became more engaged, leading to increased and ongoing social learning interactions. Social learning interactions led to meaningful and constructive exchanges between the five teachers and the researcher (in the OLC-IM), and also between the five teachers and other teachers in the OLC-FB. The social learning process precipitated information dissemination through exchanges of classroom experiences and collaborative knowledge sharing, and this led to many interactions on ways to better integrate technology in their teaching instruction.

5.3.1 Learning interactions in the OLC-FB

The five teachers and the researcher engaged in social learning interactions as they all participated in the OLC. Figure 5.1 illustrates the number of actions carried out by members of the OLC-FB in the period from March-August 2016.

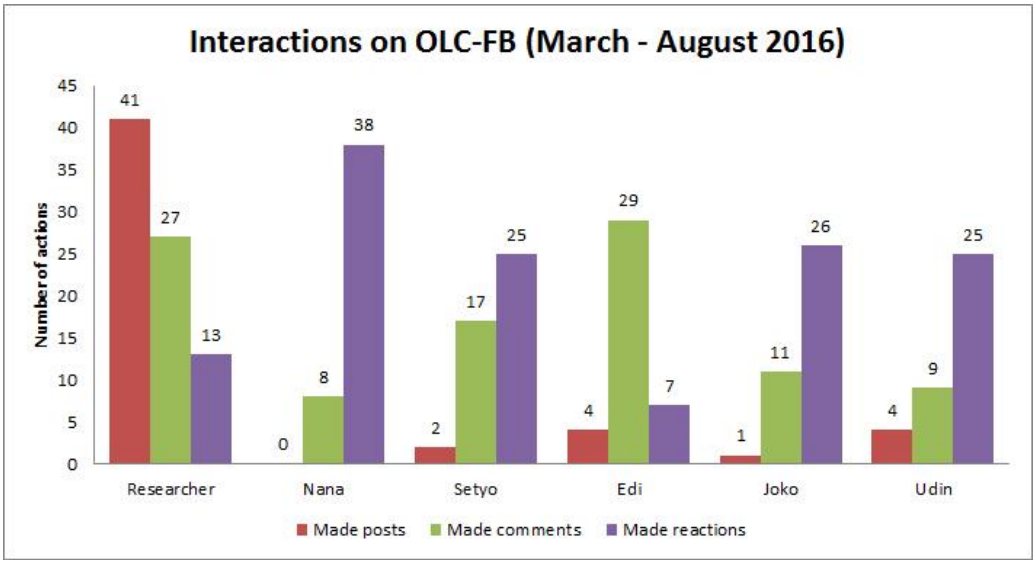


Figure 5.1 Social interactions among members of the OLC-FB
(March–August 2016)

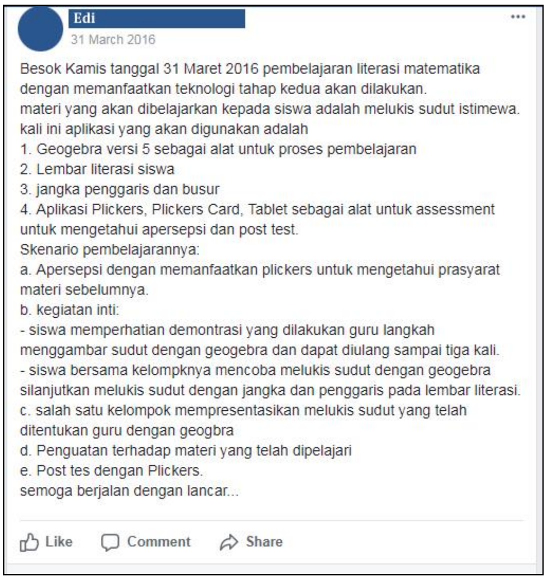
As can be seen in Figure 5.1 the actions on the OLC-FB consisted of sharing posts, commenting, and giving reactions towards particular posts. Clearly evident in this data is the way in which the researcher dominated in sharing posts on the OLC-FB (N = 41 posts). This domination could be explained as the researcher playing what Feenberg et al. (2002, p. 9) called a “social host” role. As social host, the researcher extended friendly invitations to other teachers and teacher educators to participate in online interactions. He also facilitated discussions among members, expressed compliments, made and responded to entries, and made suggestions as to what the members of the OLC-FB were qualified to contribute in promoting technology use in the classroom.

The teachers rarely shared posts on the OLC-FB (see Figure 5.1). Edi and Udin shared four posts while Setyo and Udin shared two posts and one post, respectively. Nana was the only member who never shared a post, although she engaged in the OLC-FB by making reactions (N = 38 emotive reactions). Six emotive icons, such as like (👍), love (❤), laugh (😆), wow (😮), sad (😢), and angry (😠) were used on the OLC-FB’s entries by the members. The reactions feature allowed members to give an affirmative response to particular posts. Of the five teachers, Edi was the only member of the OLC-FB who rarely made reactions (N = 7); rather he preferred to make comments (N = 29). Commenting on the OLC-FB could be performed by giving feedback and replying to other members’ comments on certain posts.

The following two examples illustrate social learning interactions on the OLC-FB.

5.3.1.1 *Example of teacher's entry on the OLC-FB*

The following example shows how social interactions took place. Figure 5.2 is a screenshot of one of Edi's entries on the OLC-FB. The OLC-FB's members who engaged in the online discussion were Edi, Ihwan, Udin, Ani, and Hadi, who were all secondary mathematics teachers (all names are pseudonyms).


Edi
31 March 2016

Besok Kamis tanggal 31 Maret 2016 pembelajaran literasi matematika dengan memanfaatkan teknologi tahap kedua akan dilakukan.
materi yang akan dibelajarkan kepada siswa adalah melukis sudut istimewa.
kali ini aplikasi yang akan digunakan adalah
1. Geogebra versi 5 sebagai alat untuk proses pembelajaran
2. Lembar literasi siswa
3. jangka penggaris dan busur
4. Aplikasi Plickers, Plickers Card, Tablet sebagai alat untuk assessment untuk mengetahui apersepsi dan post test.
Skenario pembelajarannya:
a. Apersepsi dengan memanfaatkan plickers untuk mengetahui prasyarat materi sebelumnya.
b. kegiatan inti:
- siswa memperhatian demontrasi yang dilakukan guru langkah menggambar sudut dengan geogebra dan dapat diulang sampai tiga kali.
- siswa bersama kelompknya mencoba melukis sudut dengan geogebra silanjutkan melukis sudut dengan jangka dan penggaris pada lembar literasi.
c. salah satu kelompok mempresentasikan melukis sudut yang telah ditentukan guru dengan geogbra
d. Penguatan terhadap materi yang telah dipelajari
e. Post tes dengan Plickers.
semoga berjalan dengan lancar...

Like Comment Share

Translation of the entry:

Thursday, March 31st, 2016 learning of mathematics by using technology will be conducted. The students will learn about constructing angles. The tools to be used in this learning are as follows:

1. GeoGebra software version 5 as a means for learning this process
2. A student worksheet
3. A compass, a ruler, and a protractor
4. A Plickers app, Plickers cards, and a tablet. These tools will be used for assessment, including apperception and post-test.

The teaching strategies:

a. Apperception will be performed using the Plickers app to assess students' understanding of the previous material.
b. Core activities:
   - Students pay attention to teacher's demonstration in constructing angle using GeoGebra. The teacher will demonstrate three times.
   - Students with their group then practise constructing angles using GeoGebra. Next, they continue to construct angles on student worksheets using compass and ruler.
c. One of the student groups demonstrates how to construct angles using GeoGebra.
d. Reinforcement of the material that has been learned.
e. Conducting post-test using the Plickers app

Hope everything runs smoothly

Figure 5.2 Edi's entry on the OLC-FB

Edi shared his lesson plan, which consisted of a list of tools to be used and the teaching strategy to be applied. In this example, the notion of mutual engagement as defined by Wenger (1998a, 1998b) is shaped through the social interactions within the discussions on the OLC-FB. Edi's entry can be considered as what Kruse et al. (1995) described as de-privatized practice, in which Edi made his lesson plan public before the lesson was conducted in the classroom. The de-privatization of practice gave a potential improvement on teachers' instructional practices.

This entry got eleven likes and twelve comments from the members. The following excerpt is a discussion on Edi's entry.

Online discussion on Edi's post			
1	**Ihwan**	:	FX Draw app has a virtual compass, it can be used as an alternative tool [image of FX Draw was attached].
2	**Udin**	:	Amen. Well done sir.
3	**Ani**	:	Mr. Edi is a cool and great teacher. I wish I could be like you.
4	**Edi**	:	Thank you, guys!
5	**Edi**	:	Thank you for giving me an alternative application Mr. Ihwan. I will try it.
6	↳ **Ihwan**	:	Your welcome sir. I also still need to learn more [thumbs up emoji]
7	**Hadi**	:	Agreed with Mr. Ihwan. FX Draw is a good app. Salute for Mr. Edi, a GeoGebra mania.
8	↳ **Ihwan**	:	It is like fighting in the war; the more experience with weapons the better.
9	↳ **Hadi**	:	Exactly! Combining the use of paid software with freeware make us great.
10	**Ihwan**	:	I prefer to use freeware. I do not know about the paid software [GeoGebra].

Clearly evident in the discussions is that Edi and the other teachers got new information about an alternative tool that could be used to construct angles. Ihwan introduced FX Draw as an alternative tool that could be used for constructing angles (Line 1). A further two teachers (Udin and Ani) expressed their compliments and motivations on Edi's entry (Line 2, 3) and the others (Ihwan, Hadi) voiced their preferences for the tools used (Line 7 – 10). Such compliments and motivations reinforced collegial relationships among members of the OLC-FB. Meanwhile, the descriptions of the tools enriched their insights into how the tools could be used to teach particular material.

5.3.1.2 *Example of researcher's entry on the OLC-FB*

The researcher's entry as shown in Figure 5.3 is about images of Edi's classroom activity. The OLC-FB's members who commented on this entry (Edi, Setyo, Mila, Ira, Yanto, and Rini) were all secondary mathematics teachers. Kusno, a mathematics teacher in vocational school, and Toni, a teacher educator, also commented.

Translation of the entry:

Mr. Edi is gathering students' responses in solving mathematical literacy typed tasks by scanning their Plickers cards. Do you want to know more about his performance? Stay tuned! Video is in progress.

Figure 5.3 Researcher's entry on the OLC-FB

The researcher shared images of Edi's classroom activity where the Plickers app was used for the assessment process. The entry briefly described the app and related assessment exercises, which made other members curious about Edi's teaching practices. The entry received 15 likes and 15 comments. The following excerpt is a discussion on the researcher's entry.

Online discussion on the researcher's post			
1	**Edi**	:	Today's lesson was about the relative position of two lines. The teaching strategies began with apperception by using the Plickers app, followed by student groups' discussions about the concepts of parallel lines, crossing lines, and intersecting lines, as well as alternate interior angles, alternate exterior angles, and consecutive interior angles. Afterwards, students gave presentations and we ended with a quiz using the Plickers app. It was enjoyable learning for the students and me.
2	**Setyo**	:	Well done Mr. Edi!
3	**Mila**	:	May I join to learn, sir?
4	**Mila**	:	Mr Edi, if you do such instructional practice again, can I join your classroom as a guest teacher?
5	**Researcher**	:	If you are interested, please join us anytime.
6	**Ira**	:	I want to be a guest teacher too. I am free on Tuesday, Thursday, and Saturday.
7	**Yanto**	:	I want to follow too.
8	**Toni**	:	I was curious about the Plickers app used in the learning activities. I look forward to the video.
9	**Kusno**	:	I am waiting for your recorded video, sir. Perhaps, you can share us the Plickers app the learning scenario. Thank you.
10	**Edi**	:	Anytime Ms. Mila, and Ms. Ira. We are open to members to participate.
11	↳ **Mila**	:	I look forward to getting an invitation, Mr. Edi.
12	↳ **Ira**	:	I am also waiting for your invitation.
13	↳ **Edi**	:	Next Thursday, March 31, 2016, at 7 – 9 a.m., please come to my school.
15	↳ **Ira**	:	OMG, I missed your comment.
16	**Edi**	:	Thank you Mr. Toni, and Mr. Kusno. I am still a newbie with the Plickers app. This app is very effective to be used for learning.
17	**Rini**	:	Wow, I want to learn as well. Could you tell me how to do that?

Edi was the first member to comment on the entry. He gave detailed information about the material and what he had done in his lesson (Line 1). Edi's first comment triggered other members to respond. Some of them (Mila, Ira, Yanto, and Rini) wanted to learn and collaborate with Edi (Line 3, 4, 6, and 17). Two members (Toni and Kusno) were curious about the teaching process in using the tool and indicated that they were looking forward to viewing the recorded video on the OLC-FB (Line 8, 9). Evidence provided in the comments and ideas related to the pedagogical knowledge indicate the emergence of what Wenger (1998a, 1998b) termed "joint enterprise" within the discussion. The production of joint enterprise led to a shared repertoire among members of the OLC-FB. Edi's information about his lesson (Line 1) exemplified a shared repertoire in which Edi produced a story of his teaching experience. The story became a shared resource for others to use, learn from, and implement in their teaching practices.

Evidence from Edi's actions also showed that he extended his role by not only being a member of the OLC-FB but also by acting in a way that energised and nurtured the community (Line 10, 13). The dynamic discussions on the researcher's entry also provide evidence that the teachers built what (Borko et al., 2008, p. 419) term a "professional vision" and gave impetus to other teachers to question and learn about teaching.

5.3.2 Learning interactions in the OLC-IM

The five research participants engaged in the OLC-IM beyond their participation in the OLC-FB. They actively participated in the FB Messenger group and the WA group. Figure 5.4 illustrates the number of actions performed by members of the OLC-IM in the period from March-August 2016. Actions on the OLC-IM included sending text or audio messages, emoticons, and sharing files.

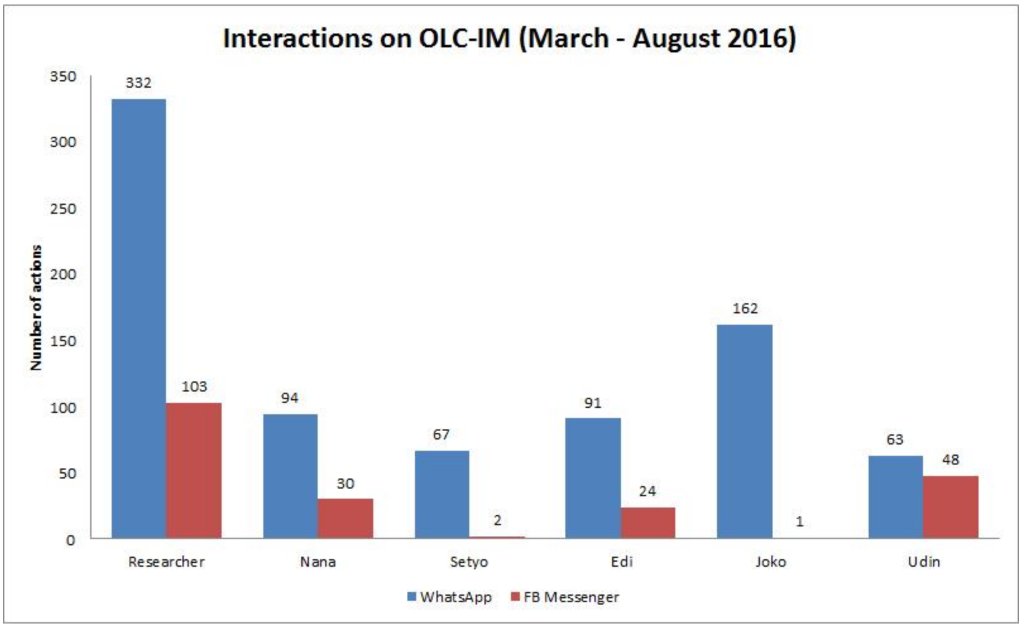


Figure 5.4 Social interactions among members of the OLC-IM
(March-August 2016)

Figure 5.4 shows the researcher's actions were very prominent in the OLC-IM. The researcher dominated discussions in both the WA group (N = 332 messages) and the FB Messenger group (N = 103 messages). Just as in the OLC-FB, the researcher played the role of mediator and motivated members to share their personal experiences. The topics discussed in the OLC-IM were quite varied. In the OLC-FB, the researcher mostly posted entries about teachers' classroom activities. In the OLC-IM, the researcher encouraged teachers to engage in discussions to improve each other's teaching capabilities in the use of technology in the classroom. For instance, discussions led to identifying technical issues and finding the solutions, exchange of ideas and knowledge about pedagogical practices in the use of particular tools, and sharing of alternative technological tools (see examples in Section 5.3.2.1 and 5.3.2.2,).

Social learning interactions in the WA group seemed to be more popular with the teachers than in the FB Messenger group. For instance, it was noted that Joko posted only one message on the FB Messenger group, while Setyo posted two messages. However, Joko was very active in the WA group where he posted many messages (N = 162 messages).

5.3.2.1 *Example of social interactions in the WA Group*

Social interactions in the WA group occurred almost every day either during school hours or after school. Figure 5.5 illustrates an online discussion in the WA group established by the researcher.

Figure 5.5 Online discussion in the WA group

The translated excerpt below shows exchanges in the WA group between Nana, Udin, Joko and the researcher, where information about using appropriate technological tools for learning about transformation was discussed.

Online discussions in the WhatsApp group			
1	**Nana**	:	Mr Udin, can FX Draw be used for learning about transformation?
2	**Researcher**	:	Yes, you can. Yesterday, I saw features of rotation and reflection [on the FX Draw], but I do not know whether there is any feature for dilation and translation. However, if you use GeoGebra, you will find all those features. They both have a free version. You can download it. There is even a mobile version [for GeoGebra]; you can download it from [Google] Play Store.
3	**Nana**	:	Thank you, sir. I will ask Mr Udin [first].
4	**Joko**	:	What about the topic of similarity, is there any application for that?
5	**Researcher**	:	For the similarity topic, you can use the apps [GeoGebra and FX Draw] or for simulation you can click on the links I sent yesterday [on the FB Messenger group]. I mean animation [not simulation]. You can also find them on YouTube, or you can ask Mr Setyo, in case he has an animation [tool] that can be used.
6	**Nana**	:	Ok, Sir. But for animation, I usually use PowerPoint, just simple [animations].
7	**Udin**	:	[uploaded a screenshot of rotation and reflection of geometric shapes using FX Draw]. I will try to find [the feature]. At the moment, I just can do kind of transformation [as shown at the screenshot].
8	**Researcher**	:	It is Ok Ms Nana. You can use PowerPoint. You can create your own [transformation animation]. From Mr Udin's picture, on the menu, there are two icons for rotation and reflection. I think I see icons for dilation and translation as well. If you use FX Draw, you can ask the program from Mr Udin. For GeoGebra, you can download it by yourself. You may compare both the programs and decide which programs you prefer to use for teaching [about transformation]?

Nana opened the discussion by asking Udin a question about FX Draw (Line 1). Udin did not respond to Nana's question immediately. In Line 7, Udin responded to Nana's question after some discussion had occurred. The researcher therefore took action by answering Nana's question (Line 2). In this regard, the researcher played the role of mediator to keep the conversation flowing. On the same occasion, Joko also asked a similar question about technological tools that could be used to explain the similarity of geometric objects (Line 3). The researcher suggested an alternative tool and encouraged the teachers to use the shared resources that had been provided on the FB Messenger group (Line 5). The alternative tool offered by the researcher was expected to give the teachers flexibility to choose the technological tools they preferred. As can be seen in Line 6, Nana stated that she preferred to use the tool that she already had experience with. Nana's response indicates the importance of teachers starting from where they are, and building on previous learning.

The researcher also referred explicitly to teachers' comments to assure the teachers that their contributions were valued and welcome (Line 8). These actions are similar to what Feenberg et al. (2002, p. 8) called "moderating functions", which are essential to the vitality of any online discussion.

5.3.2.2 *Example of social interactions in the FB Messenger group*

Teachers used the FB messenger group and the WA group interchangeably. The social interactions among the five teachers and the researcher within the FB Messenger group occurred after school hours. Figure 5.6 illustrates an online discussion by community members in the FB Messenger group.

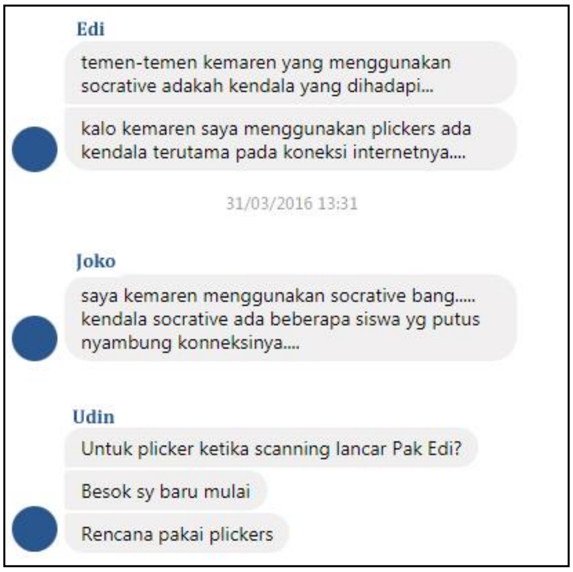


Figure 5.6 Online discussion in the FB Messenger group

The following excerpt explains the above discussion, which was held on the FB Messenger group by Edi, Udin, Joko and the researcher to discuss some technical issues faced while implementing certain technological tools.

Online discussion on the Facebook Messenger group			
1	**Edi**	:	To those who have used the Socrative app, are there any problems faced? Yesterday, I used the Plickers app. There is a problem related to Internet connection.
2	**Joko**	:	Yesterday, I used the Socrative app sir. There is a problem with Internet connection.
3	**Udin**	:	For Plickers. Is the scanning process run smoothly, Mr. Edi? Tomorrow, I am just getting started tomorrow. I am going to use the Plickers app.
4	**Edi**	:	Yesterday, I used the Plickers app. Preparation that must be done: (1) Make sure that the Internet is fine; (2) The connection between the Plickers app on the smartphone and laptop is good; (3) The Plickers card must be distributed before the lesson is started; (4) when scanning students' responses make sure that the students hold the card correctly as instructed.

In this discussion, Edi and Joko shared experiences and revealed technical issues they faced in the implementation of technological tools into their classrooms (Line 1, 2). Both Edi and Joko expressed concerns that issues with Internet connections decreased the tools' performances. Udin, in Line 3, asked about Edi's experience in using the Plickers app. Edi responded by mentioning some factors that must be taken into consideration when using the Plickers app (Line 4).

These social interactions illustrate the mutual engagement and show that responses were thoughtful and raised awareness of any technical issues that came up during the implementation of the technological tools. These shared stories were of benefit to teachers who were intending to use the same tools. Udin, for example, wanted to use the Plickers app and model his use on what Edi did. As a result, Udin was more prepared to deal with any technical issues that might arise when using the tool (see Section 6.4.4).

5.4 Social Interaction Patterns

Social interaction plays an important role in the process of teacher learning in an OLC. Lerman (2001) claims that increased participation in social interactions contributes to teacher success by building knowledge and improving teachers' professional learning. In this regard, the success of teacher learning is influenced by a combination of individual knowledge and skills, environment, use of technological tools, and ability to collaborate and work together. This cannot be understood by solely focusing on the individual's cognition or development (Shum & Ferguson, 2012). This section presents the patterns of interactions that occurred either in OLC-FB or OLC-IM. The interaction patterns were visualized using the open-source social network analysis software Gephi (Bastian et al., 2009).

5.4.1 Interaction patterns in the OLC-FB

Data from the OLC-FB's member interactions were extracted using the Facebook application Netvizz (Rieder, 2013, May). Members of the OLC-FB are shown as nodes in a graph, while their actions (e.g., liking, friending, commenting, and reacting) become edges between nodes. The extraction of the data from March-August 2016 resulted in a network of 132 nodes and 199 edges. Figure 5.7 is the resultant interaction layout produced by the Gephi program using the "Force Atlas" spatial layout algorithm. The Force Atlas is a type of force-directed algorithm, which works based on the principles of attraction, repulsion and gravity (Cherven, 2013). The force-directed algorithm assigns "attraction" forces between the endpoints of each edge and "repulsion" forces between all nodes in the network. The "gravity" determines the degree to which nodes are drawn towards the centre of the display. The structure of the interaction is then iteratively simulated using a set of configuration parameters until it converges to a balanced state.

Basic centrality measures computed for each participant were degree, in-degree, out-degree, weighted degree, closeness centrality, and betweenness centrality. The weighted degree of a node is similar to the degree (de-Marcos et al., 2016). The degree represents the number of links between the individual and other members in the network, and the weighted degree is offset by the weight of each link. It is thus the sum of the weight of the links. Therefore the weighted degree means the total number of times an individual commented and reacted to other posts, and also takes account of received replies, such as comments and reactions. The weighted in-degree refers to the total number of actions (comments, reactions) received, while the weighted out-degree describes the number of times that an individual engages in actions (sending posts, comments, and reactions). Closeness centrality is the average distance from an individual to all other members in the network (de-Marcos et al., 2016). Hernández-García, González-González, Jiménez-Zarco, and Chaparro-Peláez (2015) state that closeness centrality is related to how long it takes to propagate information from an individual to other members. Betweenness centrality measures of an individual frequency appears in the shortest paths between other members in the network (de-Marcos et al., 2016) and is therefore essential in identifying which participants (of the five teachers and the researcher) are most influential in the network.

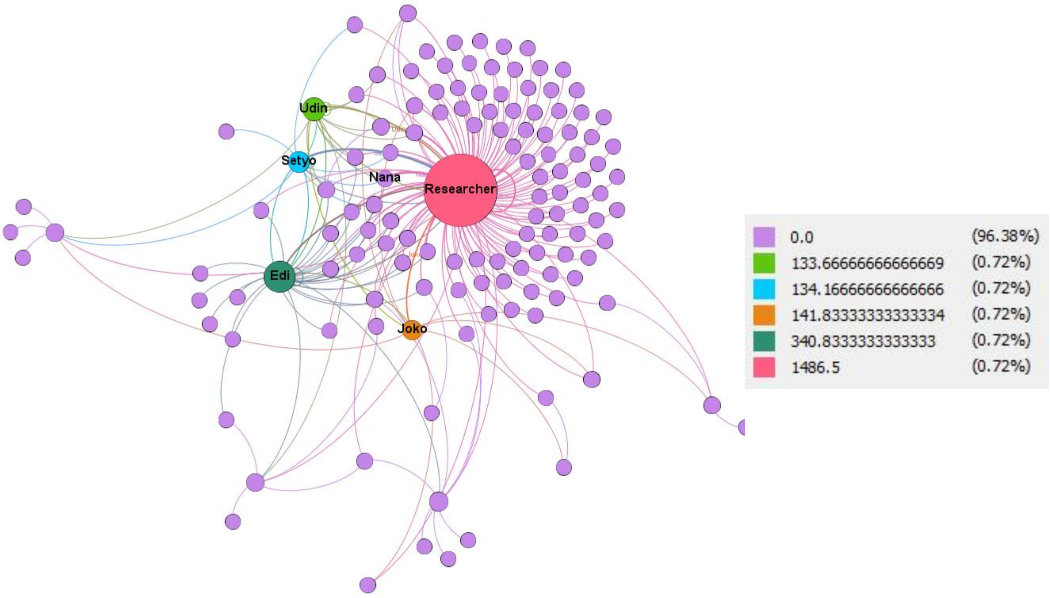


Figure 5.7 Interaction patterns of OLC-FB’s members

Figure 5.7 depicts the interactions of the OLC-FB’s members, where the visualisation has been adjusted to show node size corresponding to the weighted degree. Node colour represents the betweenness of centrality and a higher value of the beweeneness of centrality indicates higher influence for an individual, giving them more power to control flow and interactions in the OLC-FB (Wehbe, Hattab, & Hamzeh, 2016). As seen in Figure 5.7 the researcher dominated the interactions in the OLC-FB (N = 1486.5). Further, Edi had a higher betweenness centrality value (N = 340.83) than the other four teachers. Clearly, of the five teachers, Edi had a bigger influence in controlling flow and interactions in the OLC-FB.

Table 5.1 Social network parameters for interactions in the OLC-FB

Label	Posts on the OLC-FB Page	Weighted in-degree	Weighted out-degree	Weighted Degree	Closeness centrality	Betweenness centrality
Researcher	45	452	39	**491**	0.75	**1486.50**
Edi	4	58	32	**90**	0.58	**340.83**
Joko	0	1	29	30	0.68	141.83
Setyo	2	17	42	59	0.54	134.17
Udin	4	31	29	60	0.60	133.67
Nana	0	0	43	43	0.55	0

From Table 5.1, we can see that Edi was the most active member of the OLC-FB. In his participation in the OLC-FB, he commented and reacted on the OLC-FB 32 times, and he received a total of 58 reply comments and reactions. Udin and Setyo follow in second and the third place with totals of 60 and 59 actions, respectively. Nana commented and reacted to other members' posts (N = 43), but she never got any replies. Similar to Nana, Joko also commented and reacted to other members' posts (N = 29), but only received one reply. An explanation for this finding was that both Nana and Joko never posted entries on the OLC-FB page; rather they gave compliments or merely liked other members' posts. In contrast, Edi, Udin, and Setyo posted entries on the OLC-FB page, and their entries got some comments and reactions from other members of the OLC-FB.

5.4.2 Interaction patterns in the OLC-IM

Interaction patterns in the OLC-IM were constructed based on data gathered from the FB Messenger group and the WA group from March-August 2016. Members of the OLC-IM become nodes in a graph, while their actions, such as commenting and reacting, became edges between nodes. Figures 5.8 and 5.9 show the visualisation of the OLC-IM members' interactions using a Fruchterman-Reingold layout algorithm (Fruchterman & Reingold, 1991).

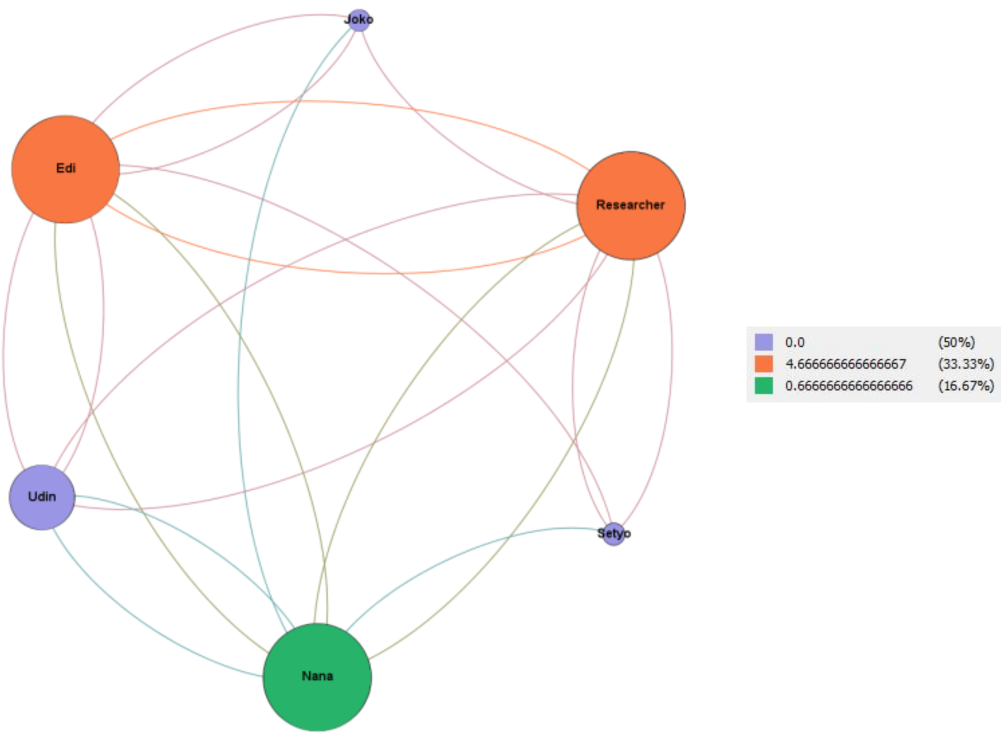


Figure 5.8 Interaction patterns of members in the FB Messenger group

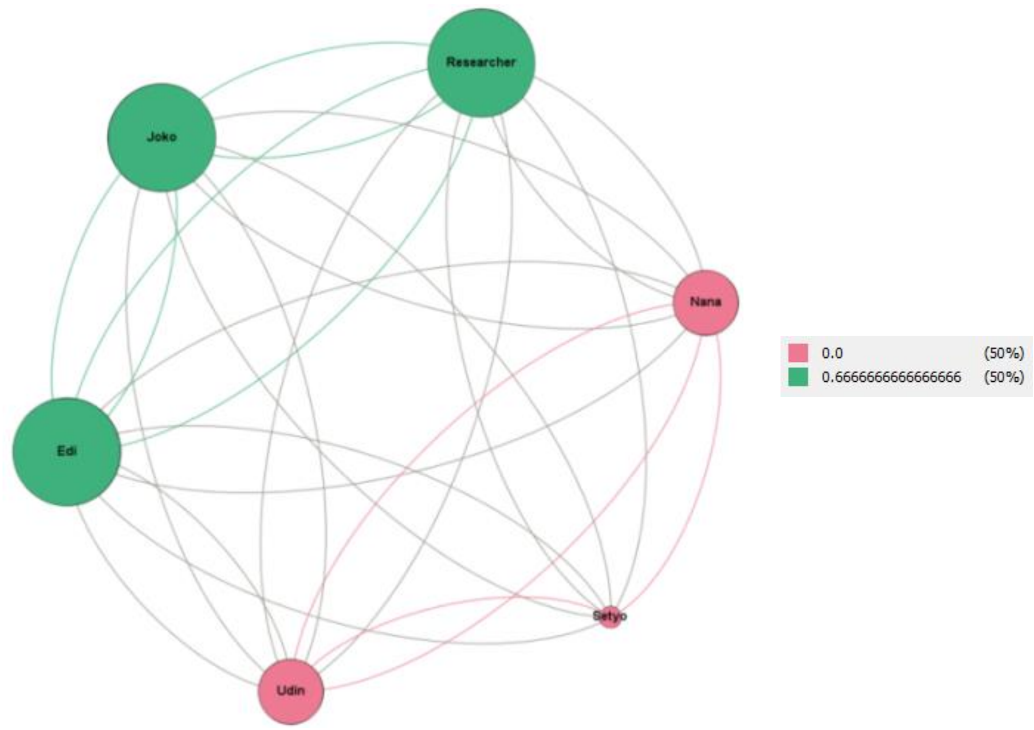


Figure 5.9 Interaction patterns of members in the WA group

The Fruchterman-Reingold algorithm is a type of force-directed algorithm based on the principles of area, gravity, and speed (Cherven, 2013). The "area" setting specifies the size of the graph. "Gravity" works to attract all nodes to the centre to avoid dispersion of disconnected nodes, and the "speed" option determines the convergence speed to trade precision for a display that is built more rapidly. The Fruchterman-Reingold algorithm emphasises placing connected nodes closer or further from each other and displays the nodes and edges in a circular area, which is useful for analysing teachers' active behaviours in the learning environment (Hernández-García, González-González, Jiménez-Zarco, & Chaparro-Peláez, 2016).

The extraction of the FB Messenger group data resulted in a network of 6 nodes and 20 edges while the WA group data yielded a network of 6 nodes and 28 edges. Similar to the adjustment on the OLC-FB visualisation setting, visualisations of interaction patterns in the FB Messenger group and WA group were adjusted. Node size represents weighted degree: the total number of times an individual interacted with another. Node colour corresponds to the betweenness of centrality, where a higher value of the betweenness of centrality indicates greater influence of an individual and thus greater power to control flow and interactions either in the FB Messenger group or the WA group (Wehbe et al., 2016).

As seen in Figures 5.8 and 5.9, over time the researcher no longer continued to dominate the interaction process, as more teachers got involved in encouraging other teachers to be active in the online learning. For example, in Figure 5.8, the researcher and Edi have the same values for betweenness of centrality (N = 4.67). This indicates that both the researcher and Edi had a high degree of influence on teachers in the FB Messenger group. Similarly, Figure 5.9 showed that the researcher, Edi, and Joko had the same influence in encouraging other teachers engaged in the WA group.

Table 5.2 Social network parameters for interactions in the OLC-IM

Label	**Type of OLC**	**Total actions**	**Weighted in-degree**	**Weighted out-degree**	**Weighted Degree**	**Closeness centrality**	**Betweenness centrality**
Researcher	FBMG	103	4	5	9	1	**4.67**
	WAG	332	5	5	10	1	**0.67**
Edi	FBMG	24	4	5	9	1	**4.67**
	WAG	94	5	5	10	1	**0.67**
Joko	FBMG	1	3	1	4	0.56	0
	WAG	162	5	5	10	1	**0.67**
Setyo	FBMG	2	3	1	4	0.56	0
	WAG	67	5	3	8	0.71	0
Udin	FBMG	48	3	3	6	0.71	0
	WAG	63	4	5	9	1	0
Nana	FBMG	30	3	5	8	1	0.67
	WAG	94	4	5	9	1	0

FBMG = Facebook Messenger group, WAG = WhatsApp group

Table 5.2 presents the parameters for social interactions in the OLC-IM. The column labelled weighted out-degree indicates that Edi and Nana interacted with all members either in the FB Messenger group or the WA group. Joko and Udin interacted with all members of the WA group but not in the FB Messenger group. In contrast, Setyo interacted less with the other four teachers in both the FB Messenger group and the WA group. Setyo said, *I rarely shared ideas on the discussion...I have less* [teaching] *experience compared to them* [the other four teachers]. Setyo's feelings occurred because of his sense of hierarchy, since the four other teachers had seniority, with more teaching experience than him. This feeling also can be categorised as what Wati (2014) termed *sungkanan* or *ewuh pakewuh*; hesitating to frankly speak about thoughts or feelings.

5.5 Views from the Five Teachers on Their Participation in the OLC

The five teachers and the researcher shared and published photos and videos in the OLC-FB. They also shared their teaching experiences, exchanged knowledge of technology tools, and identified issues and solutions either in the OLC-FB or OLC-IM. This section outlines the perceptions of the five teachers about their participation in the OLC.

5.5.1 Sustained examination of practice

Visiting each other's classrooms is an important way to share practice. Barab, MaKinster, Moore, and Cunningham (2001) contend that classroom observation is not easy to manage on a regular basis in a learning community. The use of videos posted on the OLC-FB was one way to address this limitation. Udin explained that *when watching* [teaching] *video, I felt like I am in that actual classroom. The* *video enabled me to identify the things that need to be prepared when integrating technology into the classroom*. Udin viewed teaching videos posted on the OLC-FB as beneficial because observing an actual class session was not feasible, as the teachers belonged to different educational institutions. Udin conducted online classroom observations through videos, which he said made him aware that technology preparation was essential before the technology could be integrated into the classroom.

The use of video allowed the teachers to identify areas for improvement in their teaching practice by reflecting on what had been done and what still needed to be improved. Edi's teaching videos inspired Udin. Udin stated: *I am very interested in Edi's teaching video, which was posted on Facebook* [OLC-FB]. *Edi uses the Socrative app, and his class looks so enthusiastic and gets into the learning*. Clearly, his observation had made him reflect on the increased level of student interest and their engagement with technology interventions. This observation reinforced his interest in exploring technological interventions for building and refining his own teaching styles.

Watching online teaching videos posted in the OLC-FB provided different possibilities for growth. This was dependent on whether the five teachers were able to apply an analytical lens to critical episodes. Edi analysed and noted others' videos posted on the OLC-FB:

> *As you can see here* [Nana's teaching video] *when Nana taught about "simple interest", she was supposed to teach using the technology, but apparently, it did not work as planned because there was a technical problem with the cable connection of the data projector. I also have experienced such things, and we should have a prepared backup plan when unexpected things happen.*

His statement provides evidence that Edi learned from viewing online teaching video examples of classroom situations. Edi had done what Frederiksen et al. (1998) describe as “call out” to refer to points when he saw something important in the teaching videos that he could apply to his own practices. As Seidel, Stürmer, Blomberg, Kobarg, and Schwindt (2011) explained, such examples provide opportunities for teachers to investigate points that attract their attention and they can learn from.

Joko also perceived the effect of teaching videos for his practice: *the videos* [of teaching activities using technology] *posted on the Facebook group* [OLC-FB] *are practical and can be accessed anytime when we want to revisit our practices. The videos contribute to improving teacher professional learning.* Joko’s statement provides evidence that a video of a teacher at work can be regarded as a tool for facilitating sustained examination of the practice of the teachers in the OLC.

The findings from the current study confirm that the teaching videos posted on the OLC-FB influenced teachers’ teaching practices. The teaching videos allowed the teachers to examine their own practices when technology was used to support learning. The teaching videos published on the OLC-FB became shared contents and sources of reflection for teachers to improve the quality of their technology-based teaching practices.

5.5.2 De-privatization of practice

The OLC-FB and OLC-IM enabled the five teachers to make their teaching public. The example in Section 5.3.1.1 illustrates how Edi made his lesson plan more exposed and visible on the OLC-FB. Edi's post about his lesson plan attracted other teachers in the OLC-FB to engage in the online discussion. In the OLC-FB, Edi was actively interacting with other teachers, sharing teaching experiences and exchanging knowledge about technology-based teaching practices. Evidence from this example confirms that de-privatization of practices potentially improved the teachers' instructional practices and reinforced collegial relationships.

Videos and photos shared and published on the OLC-FB were also a form of de-privatization of practice. Edi's photos of his teaching activity got reactions from members of the OLC-FB (see Figure 5.4 in Section 5.3.1.2). Some teachers were interested in the Plickers app that was used by Edi. Reactions and comments from other teachers in response to the photos indicated that Edi's teaching activities got teachers' attention. Some teachers were even motivated to look forward to Edi's teaching video and were influenced by the positive responses his photo posts received. De-privatization of practice through photos contributed to demonstrating the usefulness of the apps in supporting student learning invited curiosity from the teachers, who looked forward to the videos on how the apps were used in the classrooms.

Setyo acknowledged that de-privatization of practice in the OLC-FB helped his school: *It* [Setyo's teaching video] *was of benefit for me in my existence of being a teacher. Also, as a teacher, the video has a market value for the private school I have dedicated my teaching to.* He acknowledged that his teaching videos portrayed his school in a modernistic light. In this regard, de-privatization of practice benefited not only the teachers themselves, but also their schools, which gained benefit from it.

5.5.3 Problem solving

The discussions on the OLC-FB and OLC-IM enabled the five teachers to collaborate on finding appropriate technological tools that could be used for learning in a particular topic, and on overcoming technical issues encountered in the process of technology integration. The example in Section 5.3.2.2 illustrated how Edi, Udin, Joko and the researcher interacted in the FB Messenger group (OLC-IM) to discuss technical issues that came up during the use of the tools (the Plickers app and the Socrative app). Through the discussion, these teachers found some answers to technical issues they faced and found ways to solve the issues.

Teachers determined an appropriate time to communicate via the Facebook group or the Facebook Messenger group so that it did not violate their school policies (see Section 5.2.1 and 5.2.2). The introduction of the WA group as an alternative instant messenger was another solution that emerged based on the discussion in the OLC. Such solutions gave the five teachers and the researcher opportunities to continually engage in the OLC while remaining in compliance with existing rules.

5.6 Sustainability of Social Learning Interactions in the OLC

Wenger et al. (2002) state that enhancement of teacher professional learning in the learning community can be achieved through increased participation on an ongoing basis. To see whether social learning interactions in the OLC continued, the researcher lessened his engagement in contributing to the social learning interactions, but continued to monitor teachers' activities in the OLC. The five teachers were themselves encouraged to keep sharing their teaching experiences and they remained active in the social learning interactions either in the OLC-FB or the OLC-IM.

From September 2016 to May 2017, there were a total of three entries posted on the OLC-FB. Table 5.3 shows members of the OLC-FB who posted entries and the total comments and reactions they received.

Table 5.3 Total posts, comments, and reactions on the OLC-FB in the period from September 2016 to May 2017

Name	**Entry's description**	**Number of comments**	**Number of reactions**
Edi	*17 February 2017* Edi's story of using comics-based representations of teaching, and technology for mathematics teaching practices	5	10
Setyo	*11 February 2017* A video of Setyo's school programme on the use of the Plickers app for practices in preparation for the national exam	9	6
Setyo	*07 November 2016* A link to Setyo's video on YouTube. The video was prepared for a teacher competition on technology-based learning.	0	3

It can be seen from Table 5.3 that teacher interaction dropped compared to the interactions during the period from March to August 2016 (see Section 5.3.1). This drop in social interaction on the OLC-FB during the period September 2016 to May 2017 happened after the researcher reduced his activity on the OLC-FB. This finding indicated that the five teachers were not ready to independently engage in the social learning process in a wider community. In this regard, the role of researcher as mediator remained crucial to encourage the members of the OLC-FB to remain engaged in social interaction.

The interactions of the five teachers in the period from September 2016 to May 2017 also dropped compared to the interactions in the OLC-IM from March to August 2016 (see Section 5.3.2). Interactions only took place in the WA group, and in the FB Messenger group, there were no interactions. Figure 5.10 shows the number of actions performed by members of the WA group from September 2016 to May 2017. Actions on the WA group included sending texts, emoticons, or audio messages, and sharing files. These actions illustrate the supportive nature of the community that had been developed. The teachers were affirming each other as well as providing professional support.

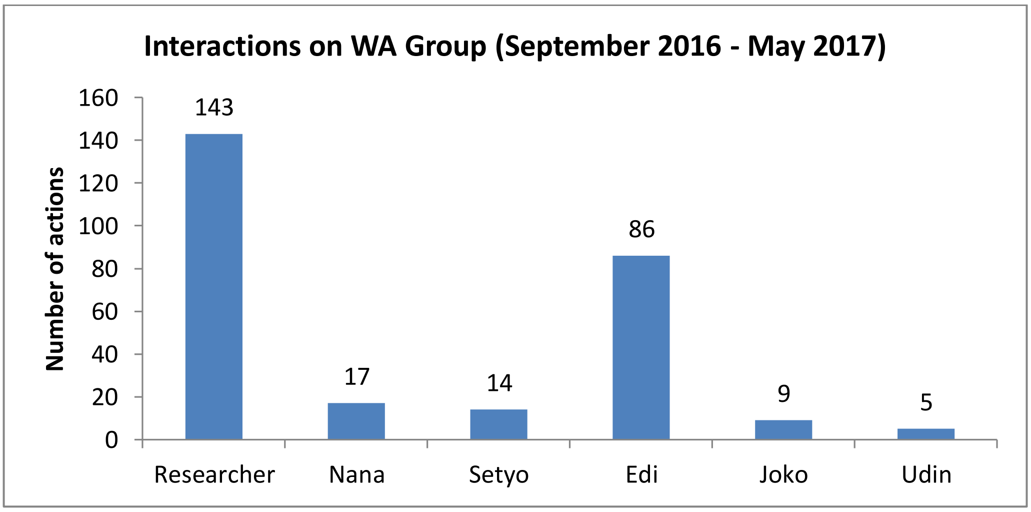


Figure 5.10 Social interactions between members of the WA group in the period from September 2016 to May 2017

Figure 5.10 shows that Udin and Joko were less engaged during this period. Meanwhile, Nana and Setyo remained active although their interactions were not significant. The researcher (as participant observer) looked dominant in the WA group discussion (see Figure 5.10), but the researcher only responded to comments from the five teachers. The responses were in the form of positive supports, such as giving appreciation, motivation, and constructive feedback as and when needed. Edi was the most interactive teacher in the WA group with 32% (N = 86) of actions being initiated by him. Edi, during this period, took the role of a mediator. He stimulated community members to be active in the online discussion. To turn the discussion on, Edi shared new information related to his experiences in working with technology. Some of Edi's new activities included assigning students' tasks to create mathematical comics by using Adobe Photoshop, conducting some new classroom action research lesson strategies based on his participation in this study, and sharing aspects of a research report he wrote for a teacher competition submission. Evidence from this data indicated that the mediator plays an important role in keeping an OLC alive.

5.7 Summary

This chapter has discussed teacher participation in the OLC-FB and OLC-IM. These online environments facilitated online teacher professional learning for five secondary school teachers through social interactions. Teachers' learning activities in the OLC consisted of sharing teaching experiences, exchanging knowledge, identifying technical issues, looking for alternative solutions, and helping each other to enhance the quality of teaching and learning in using technology.

The results suggest that teachers' participation in the OLC-IM reinforced their participation in the OLC-FB. The teachers' shared repertoires in the OLC-FB allowed the wider community to take advantage of these examples. While teachers discussed topics that had been posted in the OLC-FB, they held more open and relaxed discussions in the OLC-IM because it was more private and involved only the five teachers and the researcher.

The interaction patterns in the OLC suggested that specific roles included a mediator and a social host in the social interactions; these were crucial in both domains. These roles activated the teachers' interest and motivated them to engage in social interactions. The interaction patterns showed that moderating functions were undertaken by the researcher as a mediator, and that some teachers also took a mediator role to encourage each other to engage in the OLC. The mediator role kept the OLC alive.

The OLC made impacts on teacher professional learning, including: (1) *sustained examination of practice* for teachers to improve the quality of their teaching practices with technology; (2) *de-privatized practice* in which teachers could promote their teaching practices and their school, and reinforce collegial relationships; and (3) *problem solving* as a process to identify technical and organisational issues, and seek solutions that satisfied all parties (the five teachers and the researcher).

The next chapter will discuss the journeys of the five teachers in the use of technology to support student learning, while they remained engaged in the OLC to support their professional learning, which would lead to the better use of technology in their teaching practices. Analysis of technology was framed by four metaphors for technology-based teaching practices to explore how the five teachers leveraged the technological tools to transform their classroom practices. The sociocultural framework was used to analyse the professional learning journeys of the five teachers in using technology in their classroom practices.

CHAPTER SIX

TEACHING PRACTICES WITH TECHNOLOGY: WHAT THE FIVE TEACHERS LEARNT FROM THE OLC

6.1 Introduction

The previous chapter described how social interactions occurred in the OLC using three online learning environments: Facebook group, Facebook Messenger, and WhatsApp group. This chapter outlines the journey of the five teachers during their engagement in the OLC as they brought about changes in their teaching practices and learned to integrate technology into their instructional practices.

Section 6.2 elaborates on the five teachers' backgrounds, including their school context, availability and accessibility of technology in their schools, and their overall experiences and skills in the use of technology. Section 6.3 outlines the first phase of the current study in which the teachers' competencies in the use of technology were investigated. Section 6.4 describes five case studies of mathematics classroom teaching practice with technology. Section 6.5 provides five stories of the five teachers who engaged in the current study, after the classroom observations were done.

Section 6.6 outlines the evolution of the ZFM, ZPA, and ZPD systems of the five teachers. This section provides five case studies to illustrate how Valsiner's ZFM and ZPA were used to interpret the teachers' practices of teaching with technology and their learning within the OLC in order to gain insight into their ZPD.

6.2 Introducing the Five Teachers

The five teachers who engaged in the current study were from five junior high schools in Semarang, Indonesia. These five teachers had different levels of technology skills and the schools they taught in had different characteristics. This section introduces the five teachers in more detail, explains the school context, the ways the teachers overcame the limited technology resources, and the teachers' teaching experiences and skills in the use of technology.

6.2.1 School context

Nana, Edi, Udin, and Joko are mathematics teachers from different state junior high schools. Setyo is a mathematics teacher at a private junior high school. At the time of this study, all these teachers taught Grade 7, except Joko, who taught Grade 9.

Nana's and Setyo's schools had implemented the 2013 curriculum, in which all subject disciplines were required to be integrated with technology (Ministry of Education and Culture, 2013a). The curriculum was implemented in the schools after it was piloted for the first time in 2013. Both schools were well-resourced, and their students were allowed to bring their own mobile devices (such as mobile phones, tablets, and laptops to school).

The other three schools, at the time of the current study, were using the 2006 curriculum, which was well known as a school-based curriculum (*Kurikulum*

Tingkat Satuan Pendidikan – KTSP). However, all schools in Indonesia are obliged to implement the 2013 curriculum by 2020 as mandated by the Indonesian Government (JPNN, 2014). Each classroom in the three schools was equipped with a data projector and a screen; however, they did not have proper in-house technical support (so, in the event of a technical issue, a third party was called to resolve the problems). At these schools, the students were not allowed to bring mobile devices, except for learning purposes. Comprehensive terms and conditions were set for using these devices (for instance, students could use their mobile phones in a classroom only when their teachers requested it. Afterwards, their mobile phones were collected by their homeroom teachers).

6.2.2 Availability of and accessibility to technology facilities

For the current study, the five teachers were committed to including technology-assisted learning in their lessons. They asked their students to bring mobile devices (e.g., mobile phones, tablets, or laptops) for learning certain topics. Nana and Setyo's schools had no issue with the availability of mobile devices. Their students did not face any difficulties when asked to bring their own devices to school. However, the other three schools did not have sufficient mobile devices. Given this restriction, these teachers (Udin, Edi and Joko) had to find ways to resolve this issue. Udin, for example, asked his students to share their mobile devices with other students who did not have their own devices. Udin said:

> *I have to create teaching strategies that fit with the availability of technological resources in the school. When I implemented technology-assisted learning, I asked my students to share their mobile devices with those who did not have their own devices.*

Udin held the view that selection of appropriate teaching strategies and sharing of mobile devices could overcome the limited provision of mobile devices. Edi handled the lack of availability of mobile devices in his school and shared his solution:

> *I grouped the students into small groups based on the number of available devices. When there were eight smartphones, then I made eight student groups. When there were six laptops available, then I grouped them into six student groups.*

Joko offered the same solution:

> *At the previous meeting, I enumerated the number of students who had mobile devices. Then* [in the current meeting], *I grouped the students into* [small] *groups based on the number of available mobile devices.*

This solution of grouping students into small groups was considered a teaching strategy to match the limited availability of devices. In addition, Joko suggested that the groups could be created before the mathematics class to save time. During the second classroom observation, the students sat in their respective groups before Edi and Joko's classes started. Evidence from this classroom observation indicated that these teachers considered that grouping students before classes began could help to save time so that the students would not miss out on valuable active learning time.

Internet connection was the main problem for all five schools. It was limited and covered only certain rooms, such as the teachers' room, the principal's office, and the administration office. The five teachers used mobile tethering and mobile Wi-Fi to deal with limited the Internet access.

6.2.3 Teachers' technology experiences and skills

The five teachers had previously attended technology professional development programmes, but they reported that they had not yet applied their new knowledge in their instructional practices. Joko, for example, acknowledged his low level of technology skills, which affected his confidence in using technology. Joko said: *I had participated in some technology development programmes, but I am hesitant to implement it in my teaching practices because of my lack of technology skills.* Nana shared a similar hesitation in teaching with technology. She was afraid of having unforeseen technical issues during her classroom sessions. Nana explained: *sometimes I feel afraid if there are any technical problems or questions from my students and I cannot solve the problems. The students* [in my school] *are very critical*. Nana's low confidence level in teaching with technology appeared to create fear and anxiety, which made her reluctant to use technology.

However, Edi and Udin were eager to apply their new knowledge of technology and conducted their own research on applications. Edi said:

> *I have conducted some* [classroom action] *research to examine the affordances of technology I have learned from teachers' technology professional development programmes.*

Udin shared his experience:

> *Some teachers' technology professional development programmes have encouraged me to conduct quasi-experiments or classroom action research to investigate how technology can support student learning and whether technology is suitable in my school environment.*

Udin's and Edi's statements show their motivation to examine the potential of technology to support student learning at their schools. Their own research and the teachers' technology professional development programmes supported Udin and Edi in the implementation of technology in their classrooms.

Setyo was quite techno-savvy, having had many experiences working with technology. He had earlier taken the role of instructor in a teacher professional development programme where he introduced new technological tools for teachers. Setyo shared his experience: *at the time of becoming an instructor, my teaching experiences in using technological tools became my material*. Setyo's previous teaching experiences in using technology strengthened his pedagogical beliefs and his role as an instructor in the teacher professional development programmes added to his confidence. Ertmer and Ottenbreit-Leftwich (2010) assert that teachers are likely to have strong pedagogical beliefs built from their prior experiences in using technology in the classroom.

The next section describes how the five teachers used technology in their instructional practices. Investigation of how the five teachers used technology in their instructional practices was undertaken to examine how teachers' participation in the OLC enhanced their professional learning, which in turn will improve their ability to use technology in their instructional practices.

6.3 From a Technology Workshop to a Technological Tools Tryout in the Mathematics Classroom

The current study began with a technology workshop followed by a tryout of the use of technological tools in the mathematics classroom. For the technology workshop, the programme was set up and tailored to the teachers' needs. The teachers were introduced to three technological tools including the Socrative app, Plickers app, and Kahoot app. These tools are student response systems (SRSs), which allow teachers to gather students' responses in real time.

The technology workshop introduced teachers to new technological tools and showed them different ways to create simulations with the tools. In this session, the five teachers not only learned about the tools but also learned to identify appropriate teaching strategies using the tools. This session focused on enabling teachers to gain an understanding of these tools and acquire knowledge of how and when it is appropriate to use the tool.

The technological tools tryout was to investigate how the five teachers implemented the new knowledge obtained from the workshop in their teaching practices. Cennamo et al. (2010) suggest some aspects that need to be considered in integrating technology into teaching practice, including a selection of appropriate technological tools, identification of teaching strategies, and dealing with emerging issues during the implementation of the technology.

6.3.1 Selection of appropriate technological tools

The selection of appropriate technological tools is one of the aspects that must be considered for successful technology integration in the classroom. In the initial implementation of the technological tools, the five teachers selected one or two of the SRSs. Nana, for example, selected the Socrative app in the first trial. Nana said,

> *I actually wanted to use the Plickers app, but my mobile phone is not compatible, the mobile camera is not quite good enough for scanning the students' responses. Also, all of my students already have mobile phones and laptops.*

Device compatibility was how Nana selected the app. Setyo and Joko shared similar reasons for choosing the Socrative app. Setyo explained: *I prefer to use the Socrative in the web version instead of the mobile version because it is easy for me to manage the setting*. Meanwhile, Joko opined: *I chose the Socrative app because of its simplicity of operation.* Both Setyo and Joko suggested usability was one aspect that should be considered in the selection of appropriate apps. Usability is related to the ease with which technological tools can be used by the intended users (Preece, 2001). In addition, Nana and Setyo suggested the Socrative app was a suitable match with the school environment, where they had ease of access to technology.

Udin and Edi used the Plickers app in the first trial. Both of them had similar reasons for choosing it. Udin said: *I just need an Internet connection, a mobile phone, a laptop, and an LCD projector while each student uses a unique Plickers card and has no need for a mobile phone.* Edi explained: *I chose the Plickers app because students do not need to bring mobile phones*. *The Internet connection can be optimised*. These reasons show that Udin and Edi considered that the availability and accessibility of technology were crucial aspects in the context of technology integration. Both Udin and Edi prioritised optimisation of Internet connections for the smooth running of the implementation of technology in the classroom.

Selection of appropriate technological tools is an important aspect of the process of technology integration; however, teachers also need to take into account appropriate teaching strategies that fit with the school setting.

6.3.2 Identification of teaching strategies

The teacher plays an important role in the implementation of technology in the classroom. With appropriate teaching strategies, teachers can optimise the potential of technology to support student learning.

The five teachers employed varied strategies in their first session using the technological tools. However, the tools were mostly used for formative assessments, such as pre-tests, post-tests, and quizzes. Nana, for example, used the Socrative app for a post-test. The following fieldnote describes Nana's post-test activity with the Socrative app.

Nana's activity in using the Socrative app for post-test
At the end of Nana's lesson, she invited her students to use their own mobile devices [laptops, smartphones, and tablets] for a post-test. Nana prepared six questions about social arithmetic and asked students to complete the questions on the Socrative app. Each question was in multiple-choice form. *[Fieldnote: NA-11]*

Nana's teaching strategy was to use one-to-one learning devices. Nana applied this teaching strategy because it suited her school environment, where every student had access to their own mobile devices.

Setyo and Joko employed the Socrative app for formative assessments. They introduced the Socrative app to their students and asked the students to practise using the app before the assessment was conducted. The following fieldnote describes what occurred in Setyo's class.

Setyo used a game as an approach to attract his students to engage in technology-based learning. A number of studies have noted (e.g., Shin, Sutherland, Norris, &

Soloway, 2012; Vos, van der Meijden, & Denessen, 2011) that games encourage motivation, curiosity and attention to learning.

Joko's initial implementation of the Socrative app is described in the following fieldnote:

Joko's activity in using the Socrative app for national exam preparation
Joko introduced the Socrative app at the beginning of his lesson. He provided five contextual mathematics questions on the app. Joko used the Socrative app for national exam preparation. Because of limited availability of devices, the students were grouped into 16 groups of two students to drill and practise mathematics problems. *[Fieldnote: JO-11]*

Joko considered the sharing of devices an appropriate teaching strategy that fitted with his classroom condition. The availability of devices was the reason for choosing the teaching strategy.

Udin and Edi also chose the Plickers app as an assessment tool. The following fieldnote describes Udin's pre-test activity with the Plickers app.

Udin's activity in using the Plickers app for pre-test
Udin was teaching about triangles and rectangles. He did apperception by asking the students to answer two mathematics problems related to previous material [about the concept of angles] using the Plickers app. Udin asked the students to raise their Plickers card up to those who already found the answer. Each student had a unique card. *[Fieldnote: UD-11]*

Udin used the Plickers app to check the readiness of students to receive materials to be taught through the apperception process. Prior to learning triangles and quadrilaterals, Udin tried to figure out his students' understanding of the concept of angles.

Similar to Udin, Edi used the Plickers app to make sure his students understood the previous material on this topic. The following fieldnote describes what occurred in Edi's class.

Edi's activity in using the Plickers app for pre-test and post-test
Edi used the Plickers app to check the students' understanding of the previous material [about angles]. Two questions were in image format, and the size was too small so that students found them difficult to read. Edi then read the questions […] Edi looked at the statistical chart provided by the Plickers app to analyse which problems were likely to need further discussion, and which material was required to be clarified […] At the end of his lesson, Edi used the Plickers app for a post-test. Edi checked students' answers and discussed the solutions. When the students knew that their answers were right, they started cheering. Some of them even jumped in excitement. *[Fieldnote: ED-11]*

Edi used the Plickers app for assessment at the beginning and the end of his lesson. Edi's pre-test and post-test activities indicated that he always made sure that his students understood what he taught. Edi, in his lesson, showed that he was able to optimise the Plickers app's features to assist him in making a decision about whether the material needed to be clarified and further discussed. Students' expressions, at the end of his lesson, showed that Edi succeeded in motivating his students to engage in technology-based learning.

6.3.3 Dealing with the issues

Although technological tools such as the Socrative app and the Plickers app have the potential to change classroom teaching practices, these opportunities do not come without challenges. Some technical issues were found during the use of technological tools in the classrooms. The following fieldnote describes issues faced by Nana in the use of the Socrative app in her teaching practices.

Nana in dealing with a technical problem
In the middle of the task completion process, Nana noticed that she had forgotten to disable the students' answers preview panel [on the Plickers app]. It made the students' answers appear on the screen. Nana then immediately unplugged the VGA cable from her laptop, so that the students could not see their answers on the screen. *[Fieldnote: NA-11]*

Nana was not familiar with the Socrative app's features and faced difficulty in disabling the students' answer preview panel. However, Nana was able to respond and solve this problem quickly by disconnecting the display. Nana's action to deal with the technical issue can be considered to match what Schön (1987) describes as "reflection-in-action" as her action smoothly integrated into her ongoing teaching practices.

Setyo, in running a game with the Socrative app, also found some errors. The following fieldnote gives the details.

Setyo solved a technical error
In the middle of the game, a student noticed that there was an error [mathematics] problem that resulted in no answer that could be selected. The error problem was used as a bonus problem. It meant that each group got an additional score of one. *[Fieldnote: SE-11]*

Setyo made a mistake in inputting the correct answer option in the Socrative app. This experience indicated that a small mistake made by a teacher in inputting questions and answers in the tool could disrupt the classroom and put the teacher in an awkward situation where they may have to quickly identify some remedial action.

Joko also faced a technical issue when he used the Socrative app in his classroom. The following fieldnote gives the details.

Joko asked for assistance to solve technical problems
Joko did not seem familiar with the Socrative's features. He was having trouble adjusting the Socrative app's setting. Also, a slow Internet connection created difficulties in scanning the students' Plickers cards. I [the researcher] helped him handle these technical issues by giving guidance in using Socrative's features and by providing mobile tethering for Internet access. *[Fieldnote: JO-11]*

Joko acknowledged that he had no experience teaching with technology, so in Joko's case, the role of a mediator becomes crucial because a teacher like Joko still needs what Borko (2004) described as "guidance" as they construct new knowledge and practices. With respect to Joko's case, the researcher acted as a mediator to help Joko deal with unforeseen issues.

Udin also faced difficulty in his use of the Plickers app for the first time, in synchronising his two devices (a smartphone and a laptop). The fieldnote describes what occurred in Udin's class.

Udin asked for assistance to solve technical problems
In the first trial, Udin could not synchronise the Plickers app accounts on his smartphone and his laptop. The slow Internet connection caused the synchronising process to fail repeatedly. I [the researcher] then set up mobile tethering to solve the problem […] At the end of his lesson, Udin used the Plickers app for a post-test to check student understanding of the concept that had just been taught. No problems were found at the later stage. *[Fieldnote: UD-11]*

At the beginning of his lesson Udin needed guidance to deal with technical issues. This shows how a mediator can support a teacher who is in the process of learning a new technology. However, Udin seemed to quickly adapt and deal with technical issues as the lesson progressed.

The aspects outlined above show what was needed to enable the five teachers to design innovative instructional practices using technology. The next section describes the technology-based teaching practices of the five teachers, including the influences of the OLC on their professional learning for better use of technology in the classroom.

6.4 Classroom Teaching Practices with Technology

After participating in the technology workshop and trialling technological tools in mathematics teaching practices, the five teachers were asked to develop their mathematics classroom activities with technology independently. They were free to use any technological tools they were familiar with or introduce a new one. The five teachers were encouraged to engage with other teachers either in the OLC-FB or OLC-IM. These online learning environments (the OLC-FB and OLC-IM) were used as sources of assistance for the five teachers when they needed it. Social learning interactions of the five teachers in the OLC were investigated to understand how this participation affected teachers' professional learning. At the same time, teachers' technology-based teaching practices were observed and carefully documented.

The following subsections describe the five teachers' mathematics teaching activities with technology.

6.4.1 Nana: Using familiar technological tools to support student learning

Nana was impressed by what other teachers were doing with technology in their classrooms after watching some teaching videos posted on the OLC-FB. Her motivation levels increased, and this encouraged her to continue using technology in a more relaxed way. When Nana taught transformation (i.e., translation, rotation, dilation, and reflection), she used PowerPoint. Nana said: *I am comfortable using PowerPoint because I have many experiences working with this program*. Nana's reason for choosing to use a familiar program was previously noted by Wright and Wilson (2011), who suggested that teachers gain more confidence in their use of technology through using familiar tools.

In a previous lesson, Nana gave homework to her students about finding examples of transformation in a real-world context. She encouraged her students to use their mobile phone cameras to capture any forms of transformation phenomena that were around them, either in image or video format. The students were asked to present their homework in the form of PowerPoint slides. A fieldnote illustrates how Nana contributed to helping the students to develop what Hopson, Simms, and Knezek (2001) call higher-order thinking skills. As they presented their homework, they demonstrated skills in evaluating and analysing mathematical concepts in a real-world setting.

Presenting contextual mathematics problems
Nana reminded the students about the homework she gave at the last meeting. Nana checked each student's homework one by one. After checking their homework, Nana appointed four students [Rudi, Santi, Ana, and Danu, all names are pseudonyms] to present their homework in front of the class. One by one these students presented their homework. ▪ Rudi explained a video of a contextual example of translation. His video illustrated a board game in which a pawn was shifted from one point to another point according to the number displayed on a dice. ▪ Santi presented two images as examples of reflection. The first image depicted some paper money which was reflected in a mirror and the second image showed a cat which was sitting in front of a mirror. ▪ Ana presented a real-world example of rotation in video format. Her video showed a spinning fan. Ana explained the fan rotation movement on its axis point. ▪ Danu explained a video of a shadow of a jar as an example of dilation. The shadow could expand and shrink with a fixed proportion when a flashlight was pointed at it. After they finished the presentation, Nana showed her appreciation to her students for the hard work they had done in looking for real-world examples of transformation. Nana commented on their presentation by saying "I [Nana] am very satisfied with your homework. All examples of transformation that your friends have presented are beyond my expectations. Very good! Give applause to your friends". All students applauded them. *[Fieldnote: NA-22]*

Through her actions in this lesson, Nana demonstrated how she encouraged her students to use technology (such as mobile phone cameras, and PowerPoint) to support their learning. The contextual examples of transformation presented by the four students showed that these students were able to link the concept of transformation with the real-world problems.

In addition to PowerPoint, Nana continued to consistently use the Socrative app to perform a post-test to investigate the students' understanding of the transformation concept. The fieldnote illustrates her growing confidence in resolving technical problems while conducting a post-test.

Growing confidence to deal with technical problems
Nana checked and adjusted the Socrative setting before the post-test began. Five contextual mathematics problems related to transformation concept were prepared. At this time, all students used laptops. In the middle of the process of answering the questions, one male student asked for assistance. He needed a power source to charge his laptop. Since there were only two power sockets available, the students were asked to take turns in using the power sockets. *[Fieldnote: NA-22]*

Nana's repeated use in her lessons of the Socrative app from the technology workshop showed growth in self-efficacy. Her capability in organising the assessment and handling the technical issues was clearly evident.

With reference to the analytical framework (Goos, Galbraith, Renshaw, & Geiger, 2000) [see Section 2.3] that describes how teachers use and provide technology, it is clear that Nana used technology as a *partner*. She used it so that her students attained more support for their own learning. She facilitated her students with technology to work with mathematical tasks.

6.4.2 Setyo: An animated video and a game-based assessment

Setyo was the least active in posting and responding or even going onto the page of the OLC-FB and OLC-IM (see Section 5.4.1 and 5.4.2). However, Setyo stated that participation in the OLC had been very beneficial: *it gives me so many benefits because I learn from more experienced teachers*. *My knowledge of technology-based learning is also growing.* Setyo's participation in the OLC improved his knowledge of teaching with technology. Setyo was inspired by other teachers who were exposing their technology-based teaching practices on the OLC-FB. Setyo also saw the benefits of participation in the OLC for the wider school community:

> *The teachers* [in the OLC] *absolutely inspire me because after this activity* [the current study] *is done, our school can improve the quality of* [technology-based] *learning. Our school had applied this approach before the current study was conducted. Now, we can improve it!*

Setyo's response indicated his recognition that participation in the OLC not only benefitted him but also contributed to the uptake of technology by his school, thereby improving his school's reputation.

Setyo showed his preparedness befor the lesson in which he used technology in his instructional practice as presented in the fieldnote. He checked the learning needs at the beginning of the lesson and checked the number of available mobile devices to ensure that all required learning tools were ready.

Good preparation for a smooth teaching practice
Setyo was teaching about transformation. He checked the number of students who carried mobile devices [smartphones, or tablets]. Of the 19 attending students, there were only two students who did not have devices. The two students were given tablets. Setyo asked his students to check the Internet connection. Once all the devices had good Internet connections, Setyo started his lesson. *[Fieldnote: SE-21]*

Setyo gave an example of transformation in real-world settings. When Setyo connected the mathematical concept with reality, he created a learning environment that was meaningful and relevant to students' personal experiences. The situation when the students cheered the football player who shot the ball into the goal further indicated that the animated video motivated the students to engage in the learning process. The following fieldnote describes Setyo's teaching practice with Adobe Flash Player.

Connecting mathematical concepts with real-world problems using animations
Setyo delivered transformation material using Adobe Flash Player, which allowed him to create animations of transformation. Setyo exemplified the translation concept with a football game animated video he had made using Adobe Flash Player. In the animated video, there was a goalkeeper and a player who was asked to perform a penalty kick. When the player kicked the ball into the goal, the students cheered the player. Setyo explained that the movement of the ball from one point into the goal was an example of translation. Next, Setyo explained the concept of transformation mathematically. He said, "in Geometry, translation simply means moving". Setyo showed an animated video to explain how a triangle *ABC* was translated 3 units left and 2 units down. Triangle *ABC* had vertices *A*(4,2), *B*(5,3), and *C*(6,1). The animated video showed each vertex translated 3 units left and 2 units down and formed an image of triangle *ABC* [denoted by *A*'*B*'*C*']. Setyo guided his students to find out the coordinates of the image of triangle *ABC* by posing several questions until each image vertex was determined: *A'*(1,0), *B'*(2,1), and *C'*(3,-1). Setyo played the animated video to show how each vertex of the triangle *ABC* translated and formed the image triangle *A'B'C'*. Setyo then revealed the formula: *T'*(*x*-3,*y*-2). Next, Setyo guided his students to derive the generic formula for translation when the point *A*(*x*,*y*) was translated a units left and b units down. The formula then was displayed on the screen: $A(x,y) \xrightarrow{T(a,b)} A'(x-a, y-b)$. Setyo asked his students to write the formula in their notebook. *[Fieldnote: SE-21]*

Setyo involved his students in discovering the generic formula for translation. This learning process is part of a scientific approach, as enacted in the 2013 curriculum (Ministry of Education and Culture, 2013b), called "associating", in which students process collected information to produce new information, as illustrated in deriving the translation formula.

To assess students' understanding, Setyo conducted a post-test quiz using the Socrative app.

Assessing students' understanding with a game
Setyo created a "Unicorn Race" game using the Socrative app, with different coloured unicorns representing each student. Those who reached the finish line were the students who could correctly answer the questions. In this game, some students could not use their mobile phones because of technical problems [either not compatible with the Socrative app, or could not connect to the Internet]. From 19 students totalling 14 participants [nine single players and five players in pairs] who participated in the game, nine participants made it to the finish line. *[Fieldnote: SE-21]*

Setyo preferred to use the Socrative app for gaming and engaging students. As he did in the first trial (see Section 6.3.1.2), Setyo also made a "Space Race" game with the Socrative app. In this lesson, Setyo used the same strategies as he did in the tryout phase. He organised the students into small groups. However, in his technology-based teaching practice, the devices' connectivity and compatibility needed to be taken into account in order for the technology-based learning activities to run smoothly.

Setyo used several technological tools in his teaching practices. However, the students were less engaged with technology during the process of learning mathematics than during the game-based assessments. Drawing on the analytical framework proposed by Goos et al. (2000), in which teachers are described according to how they provide technology, Setyo used technology as what is termed a *servant*. The use of technological tools did not change the nature of his classroom activities. Setyo, when asked to review his video posted on the OLC-FB related to this lesson, evaluated his teaching practice:

> *I think my classroom activity was not creative enough. I dominated the learning process, and the students were less engaged with technology in their learning process.*

In this evaluation of the lesson, Setyo confirmed that he remained in a traditional teaching model. As a result, the students had less opportunity to construct their knowledge with technology. Setyo gave further explanation of his views on using technology-based teaching practices.

> *I need a longer time to get things prepared, such as making questions and their answers key, uploading them to the app and preparing learning media. Surely, they cannot be done not in a short time.*

He explained that preparation of technology-based teaching practices was time-consuming. Setyo revealed lack of time to be his biggest constraint, which made him less able to prepare teaching materials properly. This led Setyo to use technology as a *servant* because he only used it to deliver materials to the class, without transforming his instructional practices.

6.4.3 Joko: Mathematics practices with technological tools for national exam preparation

Joko's participation in the technology workshop and the OLC positively motivated him. He stated that:

> *It* [the technology workshop] *was very beneficial for me, giving much motivation and I applied it based on my own capabilities. The videos* [posted on the OLC-FB] *gave me inspirations, improved my insight, and aroused curiosity. I think the OLC is effective for teacher professional learning as we can update everything with the community. Teachers in the OLC encouraged me to be a more professional teacher.*

Joko's words indicated his recognition of the value of participation in the workshop and in the OLC. Hew and Brush (2006) refer to this feeling as having a positive attitude. This positive attitude influenced Joko's teaching practices, as illustrated in the following fieldnote in which another of Joko's classroom activities is described:

Using several technological tools to deliver teaching material
Joko was teaching about equations of straight lines. He started his lesson by giving an example of a straight line in a real context. He played footage from the movie "Taxi". In the footage, there was a taxi running on a straight road. Joko then posed a question: "Do you see the trajectory formed by the taxi? What is the shape of the object?" the students responded, "a straight line" […] Joko responded again, "Yes, correct! From this footage, you can see that mathematics is useful in everyday lives" […] Joko then explained the equations of straight lines using PowerPoint. He also demonstrated how to draw a straight line and how to find the equation of a straight line using GeoGebra. After the demonstration session was done, Joko distributed student worksheets (*Lembar Kerja Peserta Didik* - LKPD) consisting of three mathematics problems. The students were asked to use GeoGebra to find the solutions to the questions. Joko grouped the students into 16 groups of two students. The students worked with GeoGebra using either their laptops or smartphones. They showed much enthusiasm in using GeoGebra features to draw the given straight line functions. Joko observed the student groups' activities. Joko invited two represntatives of the student groups to discuss the results in front of the class. Joko then challenged the students with other mathematics problems and students were given an opportunity to demonstrate their work in front of the class. Those students who were able to showcase use of Geogebra got additional credit for their grade. At the end of the lesson, Joko conducted mathematics exercises. He selected mathematics problems related to the straight lines equations from the archives of national mathematics exams. Joko used the Socrative app for mathematics practices for national exam preparation. *[Fieldnote: JO-22]*

At the beginning of the current study, Joko acknowledged that he had never conducted technology-based teaching practices, and in the first trial he used only the Socrative app (see Section 6.3.2). In this lesson, Joko showed his confidence using four technological tools: PowerPoint, GeoGebra, the Socrative app, and Windows Media Player. Joko also gave students opportunities to engage with technological tools to find mathematical solutions while completing student worksheets. He also transferred learning through a demonstration of links between school mathematics and real-world problems. Joko's statement, "*from this footage you can see that mathematics is useful in everyday lives*" corroborates this evidence.

Evidence from this classroom activity shows Joko had implemented what Ertmer and Ottenbreit-Leftwich (2010) call "high-level" technological use. Joko, with constructivist beliefs, could effectively use the technological tools to support his teaching practices by maintaining a dynamic student-centred focus. Based on the analytical framework developed by Goos et al. (2000), in which teachers describe how they use and provide technology, it is clear that Joko used technology as a *partner*. He used it creatively to increase the power of students' exercises in their preparation for the national exam.

6.4.4 Udin: Learning from video tutorials and creating presentation videos with technological tools

Udin designed his technology-based teaching practices based on an inspiration he got from the teachers in the OLC. He expressed his impression of Edi's technology-based teaching practices.

> *I am very impressed with Edi's video. When he used the Plickers app, the students looked so enthusiastic and got into the learning. The students became more creative and curious. Edi could relate the technological tools to solving daily problems. His students also could work together and had the opportunity to share their ideas easily while technological tools were used. Surely, I got a real example of how the Plickers app can be implemented. This is useful for me because I know how to use the tools and can plan some aspects that can be developed in my lesson.*

Udin valued Edi's technology-based teaching practices for his lesson. Udin reviewed and explored the information he got from Edi's lesson. This included the advantages of the technological tools, the students' learning processes, and Edi's teaching strategy. Edi's videos became what Borko et al. (2008, p. 419) call a "professional vision" as they gave additional impetus for Udin to reflect on, and extend his own teaching.

Udin used several technological tools in his lesson. The following fieldnote describes how Udin used the Plickers app, FX Draw, and Screencast-O-Matic. He also used YouTube as a learning medium for students at home.

Using several technological tools to deliver teaching material
Today's topic was triangles and quadrilaterals. At this point, Udin was teaching about parallelograms. Udin started the lesson by giving an overview of the previous materials and then conducted a pre-test using the Plickers app. He presented two questions about lines and angles. He scanned students' responses using his smartphone camera. All students had answered the questions correctly. Udin did not face any technical difficulties in using the app. Next, Udin grouped the students into eight groups of four students. A file of the student worksheet in document format was transferred to each student's laptop. Before asking the students to complete the student worksheet, Udin asked: "Did you watch my tutorial videos on YouTube? Who has watched the video? Raise your hand, please!" The majority of students had not watched the videos yet. Udin then played his tutorial videos about drawing a parallelogram using the FX Draw program. Each group practised constructing parallelograms with the FX Draw program following the tutorial, while discovering the properties of a parallelogram. The discovery results were reported in the student worksheet. Udin roved and observed student groups' activities. *[Fieldnote: UD-22]*

Udin showed his progress in the use of the Plickers app. No technical issues were found in using the app for the pre-test. The assignment involving viewing tutorial videos on YouTube had received less response from the students. One student explained: *I watched the videos at the Internet cafe but could not directly practise because I do not have a laptop at home, and there is no FX Draw in Internet café's computer.* Another student said: *I have no Internet access at home, and I* *believed Mr. Udin would play the videos in the class*. These students' views indicated that availability of devices was still a barrier to technology integration and was the reason he asked the students to share their laptops.

At the end of his lesson, Udin asked each student group to create a presentation video using Screencast-O-Matic.

Making presentation videos to evaluate mathematics communication skills of students
Udin instructed the student groups: "I give you 15 minutes to create a video presentation based on what you have written on the student worksheet. Each student in the group must speak up. You may find a quiet place outside the classroom. If you face any technical difficulties, please come to see me in this room." Each student group went out of the classroom to find a quiet place to record their presentation. I [the researcher] roved and observed their activity. I found the students enthusiastic to practise their presentation before recording the video. All groups finished in approximately 25 minutes, 10 minutes more than Udin had instructed, because they recorded their presentation several times until they got a good video result. All videos were transferred to Udin's laptop. As time was limited, Udin chose two videos that were played in the classroom. Other student groups were asked to review the presentation and evaluate whether the student group in the video had correctly answered all the questions on the student worksheet.   *[Fieldnote: UD-22]*

Udin encouraged all the students to engage with the technological tools. He purposefully invited the students to work in groups and communicate using technology to enhance their collaboration and communication skills. The skills that Udin embedded in his lesson are what Watanabe-Crockett (2016) lists as the "21st-century skills" needed by every student. In this regard, it can be said that Udin used technology as what Goos et al. (2000) term an *extension of self* to promote the collaboration and communication skills of the students, as well as to support them in their learning.

6.4.5 Edi: Outdoor classroom activities with technological tools

Edi was the most active teacher in the OLC. He was not only a learner in the OLC but also acted as a mediator alongside the researcher to keep social interactions in the OLC flowing. Edi acknowledged that his participation in the technology workshop and the OLC helped him to improve his knowledge of teaching with technology. Edi explained:

> *They* [the technology workshop and the OLC] *give me benefits especially in the learning process of the use of technological tools in the classroom. I can improve my knowledge about how to implement the things* [technology-based teaching practices] *that have been performed by the four teachers*.

Edi perceived that the technology workshop and the OLC added value and made him relate better to the technological materials he could use to support students' learning. This perception can be considered as what Hew and Brush (2006) call a positive attitude, as Edi perceived the benefits of his participation in the technology workshop and the OLC. Edi's participation in the technology workshop and the OLC also helped change his classroom practices and made him a more reflective practitioner.

In the following lesson, Edi built a foundation of the concept of constructing angles before the students used GeoGebra. He also considered an appropriate technological tool and teaching strategy that suited the classroom conditions.

Demonstrating how to construct angles manually and using GeoGebra then challenging the students
Edi demonstrated how to construct angles (30^o, 60^o, and 90^o) using a compass on the whiteboard to convey the basic concept of drawing angles. Edi then asked students to construct angles manually using a compass in their books. The students were also asked to check the results using a protractor. Edi continued his lesson by demonstrating how to construct angles with GeoGebra. Before he demonstrated this, he grouped the students into eight student groups because only eight laptops were available. After Edi finished demonstrating, he asked his students to practise using GeoGebra following guidance provided on the student worksheets. Edi asked the students to complete the student worksheet too. He roved and observed student group activities until all students had completed the tasks successfully. Edi then challenged the students to find ways to construct an obtuse angle of 120^o. Edi said: "Those who can demonstrate the right way to construct an angle of 120^o using GeoGebra in front of the class will get a reward point". Four students accepted the challenge, but Edi chose one student to demonstrate it. Other students were given opportunities to demonstrate if they had alternative ways to construct an angle of 120^o. *[Fieldnote: ED-22]*

In this lesson, Edi demonstrated his competence in the use of technology for mathematics teaching practices. With respect to a mathematics challenge offered to the students, Edi directed the students to use their cognitive skills, or what Hopson et al. (2001) term higher-order thinking skills, as the students analysed the underlying basic concepts of angles to construct angles that had not yet been learned. In this lesson, Edi used technology as what Goos et al. (2000) call *a partner* as he emphasised the added value of technological tools to help the students explore their cognitive skills and construct their own knowledge of the concept of constructing angles.

In the next lesson, Edi discussed angles, and perimeters and areas of 2D shapes. Edi introduced two mobile apps: Smart Protractor and GPS-Field Area Measure. Smart Protractor is a mobile app to measure the angle and slope of an object while GPS-Field Area Measure is a mobile app useful as a map measurement tool in outdoor activities to gauge the area, distance and perimeter of an object. Edi conducted outdoor classroom activities using those apps. This is illustrated in the following classroom activity:

Conducting technology-mediated outdoor classroom activities
The students worked in groups. Each group had a map [of the school area] and a student worksheet. Edi selected three places that must be visited by the students. These three places were already marked on the map. The students were also asked to read the guidance provided on the student worksheets. When the students visited the first place, they had to find a solution for the first mathematics problem. Likewise, when they visited the second and third places, the students had to solve the second and the third mathematics problems, respectively. Each mathematics problem mentioned what app should be used to find the solutions. The students left the classroom and started to complete the student worksheet. Firstly, all the student groups entered the school hall to complete the first mathematics problem. They measured the perimeter of one of the sections of the roof of the school hall using the GPS-Field Area Measure app. The instructions for finding the solution were included in the student worksheet. The second mathematics problem involved measuring the angles of one of the windows in the school hall. The students took measurements with the Smart Protractor app. The last mathematics problem was about the perimeter and area of the school football field. Representative students from each group walked around the field and made sure that the GPS-Field Area Measure app recorded their trail. The third problem was quite challenging because some groups had intermittent Internet connection issues. Consequently, the app could not record the trail properly and the students had to repeat it two or three times to get a good trail. To deal with this issue, Edi let the students use manual mode. In manual mode, the students only selected the field area on the digital map as requested on the mathematics problem, and the app displayed the perimeter and area of the field […] Edi supervised the students' outdoor classroom activity intensely as he made sure that the students used the apps properly, and they followed the instructions carefully […] The students went back to the classroom after all tasks were finished, and Edi discussed the results. *[Fieldnote: ED-23]*

Edi had never performed outdoor classroom activities using technology before. Edi's outdoor classroom activities in this lesson show evidence of his growing confidence to leverage the technological tools and integrate them into a pedagogical strategy that promoted student engagement and rich learning of mathematics. Further, Edi showed in this lesson that he was open to new ideas and able to experiment with a new strategy and that he wanted to achieve improvements in his teaching methods. Edi exhibited what Sang et al. (2010) call a high level of self-efficacy in the use of technology for teaching practices.

Edi, at the end of his lesson, confirmed his outdoor classroom activities with the students.

Hearing students' voices about technology-mediated outdoor classroom activities
Edi asked the students to give comments about their outdoor classroom activity. Edi asked: "Does anyone want to give comments about today's activities?" One student expressed his opinion: "I was happy because this is our first experience of having outdoor learning activities with technology. We have never had this kind of activity before". Another student added, "Using technological tools like GeoGebra, the Socrative app, and the last tools we used [the Smart Protractor and the GPS-Field Area Measure app] we can understand better the concept of mathematics, and we can also solve mathematics problems in everyday life". Edi responded: "Do you think it is fun or a boring activity? All the students answered simultaneously: "Fuuunnn". *[Fieldnote: ED-23]*

Students showed positive attitudes to the technological tools and the teaching strategy. Edi, in this lesson, altered his mode of working with technology from *a partner* to technology as an *extension of self* (Goos et al., 2000) in re-organising cognitive processes. Students' feedback confirmed how the technological tools (GeoGebra, the Socrative app, Smart Protractor and the GPS-Field Area Measure app) were integral to the production of students' cognitive skills in mathematics.

6.5 Post Classroom Observations

After six months of observing the five teachers' classrooms, the teachers were still participating in the OLC either in the OLC-FB or OLC-IM. The five teachers still shared their updated stories in the WA group about their teaching activities with technology. The following are some highlights of the stories from the five teachers.

6.5.1 Nana's story

In January 2017, Nana sent a message to the WA Group stating that her school had been given the responsibility of holding a computer-based national examination (*Ujian Nasional Berbasis Komputer* – UNBK). She was teaching Grade 9 students at that time and the classroom activities were mostly focused on preparation for the national exam. Nana stated that she had continued using the Socrative app. At that time, she was using the Socrative app for improving her students' skills in solving mathematics problems with computers.

> *I use the Socrative app for mathematics drill-and-practice activities so that students are accustomed to working with computers. The students use their own laptops for learning activities.*

Nana's action indicated that she recognised that the use of the Socrative app made her Grade 9 students better prepared for taking the computer-based national exam. Besides the Socrative app, Nana reported that she used Cabri, mathematics software for geometry and algebra, to help students solve 3D geometry problems. Nana stated: *the four teachers in the OLC inspired me and so I challenged myself to learn more about technology. I introduced Cabri to my students*. Clearly, Nana's participation in the OLC had encouraged her to continue exploring the use of new technology, in contrast to what she had done in the previous practices, where she had used only familiar programs such as PowerPoint and the Socrative app in her mathematics teaching practices (see Section 6.4.1). Evidence from this finding showed that participation in the OLC had encouraged Nana to progress by challenging her to learn new technological tools.

Outside of schoolwork, Nana was also appointed as a mentor teacher for the Continuous Professional Development programme (*Pengembangan Keprofesian Berkelanjutan* – PKB). The PKB programme aims to improve the competence of teachers, especially to develop instructional skills and knowledge of the content taught (Ministry of Education and Culture, 2017). Nana supervised 20 teachers from Bandung, West Java. Since the programme was conducted online, she created an online learning community using a WhatsApp group to facilitate the PKB teachers to learn. Nana said that she established her own OLC to manage the process of supervision effectively.

> *I was inspired by the OLC established by the researcher, which I now want to take forward so as to supervise and help these teachers to improve their competencies through online discussion, exchange files/documents, and collaboration learning the PKB's materials.*

The teacher learning model proposed in the current study had inspired Nana to replicate it. She supervised and assisted the PKB teachers online through sharing repertoires via a WhatsApp group.

6.5.2 Setyo's story

Setyo's school organised an in-house professional development programme and confirmed that the school was committed to enacting the 2013 curriculum by optimising the use of technology. Setyo was appointed to be a facilitator in the professional development programme. He introduced the Plickers app to his colleagues. He also invited his colleagues to simulate how the Plickers app would be used to gather student responses. After the in-house professional development programme was finished, the teacher participants were asked to implement the Plickers app in their own classroom practices. Setyo described the follow-up programme:

> *As a follow-up to the in-house professional development, I* [Setyo] *supervised the teachers in the implementation of the Plickers app in their classroom. I saw that the students showed much enthusiasm because the teachers offered different teaching strategies to the learning activities so that they would not get easily bored. The use of the Plickers app also helped the students to foster a competitive sense.*

Setyo, in playing the role of a facilitator and supervisor, confirmed that the teaching experiences he had gained from his classroom practices and his participation in the OLC were beneficial for developing the professional learning of his colleagues in his school.

Setyo also continued to use technology in his teaching practices. One of his teaching activities in the use of technology was documented and included in a teacher competition on technology-based learning organised by the Integrated Islamic Schools Network (*Jaringan Sekolah Islam Terpadu* – JSIT) at the provincial level. Setyo won first place in the competition. Setyo said:

> *To compete in the competition, I prepared my material using the Plickers app, Wondershare Quiz Creator, and Adobe Flash. I have already implemented all of these technological tools in my classroom practices when you* [the researcher] *observed my classroom. All these things gave me an extra score that let me win the competition.*

It is clear that Setyo’s teaching experiences in the use of technology were beneficial to his professional growth as a teacher. Setyo’s capabilities in combining the technological tools helped him to create innovative technology-based teaching and learning. This is also evidence of how Setyo expanded his knowledge of pedagogical practices using technological tools. This is similar to Borko and Putnam's (1995) suggestion that expanding and elaborating teachers' knowledge helps teachers in changing their practices.

6.5.3 Joko's story

Joko sent a message to the WA Group in May 2017 about his continuing use of the Plickers app for mathematics teaching and learning. Joko had not used the Plickers app during the classroom observations; he used the Socrative app all the time. Joko and his colleague collaborated to conduct classroom action research to examine the effectiveness of the technological tool (the Plickers app) for student assessment. He said that he provided peer coaching to his colleague on how to use the Plickers app before his classroom action research was conducted. Joko at that point acknowledged that his learning process in participation in the OLC helped develop his confidence to experiment with new technological tools. Joko said: *I am getting more confident to use technology, and I am no longer afraid to invite other teachers from other schools also to use technology for supporting their teaching practices*.

At the beginning of the study, he appeared to lack experience in teaching with technology. His statement reflects how, through his engagement in the OLC, he had grown in the ability to use technology for his teaching practices. Joko's statement also confirms that he needed time and space for this learning process to happen before making his practice public.

6.5.4 Udin's story

Udin sent a picture of his current activity as an invited speaker at a technology professional development programme in May 2017. His role was to educate in-service teachers in the use of the Plickers app as a formative assessment tool. Although at that time he was not using technology in the classroom frequently because of other school pressures, Udin explained that at any opportunity where he was an invited speaker in teacher professional development programmes, he always shared his experiences in using technology. Udin explained: *I am very pleased to share my teaching experiences with all the teachers* [in the technology professional development program]… *I am ready to share everything with the teachers in Semarang particularly*. Udin's statement indicated that the experiences and knowledge he had received through participation in the OLC extended his self-efficacy to give additional impetus to other teachers to learn about the use of technology in the classroom.

6.5.5 Edi's story

In January 2017, Edi confirmed that he was still using technology in his lessons. Edi, for example, used the Socrative app for mathematics practices to prepare Grade 9 students to sit the national exam. In March 2017, he conducted independent classroom action research to examine the students' communication skills and to improve student learning outcomes. Edi used Edmodo and the Plickers app as learning tools. Edi's research was selected by the Centre for the Development and Empowerment of Educators and Educational Personnel in Mathematics (*Pusat Pengembangan dan Pemberdayaan Pendidik dan Tenaga Kependidikan* – PPPPTK Matematika) to be presented in the PPPPTK national seminar. Edi explained that his research was a follow-up to his participation in the current study. Edi stated:

> *In this modern era, teachers are always asked to adjust themselves to technological progress. If we are sceptical about technology, we will be left behind. I am committed to continuing to develop innovative learning with technology that brings improved student learning.*

Edi's statement emphasises that his positive attitude towards technology had spurred him to continue using a range of different technological tools to promote mathematical learning. It also provides evidence that he knows that technology is part of the modern world needed for 21st century learners.

A number of noticeable factors that supported the process of teacher learning in the OLC for better use of technology in the classroom, and a number of factors that interfered in teacher change, were analysed using zone theory. The following section outlines the evolution of the ZFM/ZPA complexes of the five teachers to create a set of possibilities for development of their ZPDs.

6.6 Five Teachers' Evolving ZFM/ZPA/ZPD Systems

The aim of this section is to use Valsiner's ZFM and ZPA to interpret the five case studies' learning in the OLC and their practices of teaching with technology in order to gain insight into their zones of proximal development (ZPD) (Valsiner, 1987).

6.6.1 Nana's case

Analysis of data from the interview, questionnaire, online discussion, and fieldnotes of classroom observation made it possible to trace Nana's professional learning in the use of technology in her teaching practices. Nana's school implemented the 2013 curriculum in which every lesson is intended to be integrated with technology. Her school was well-resourced and had technical support. The majority of students were from upper-middle socio-economic status families. When mobile devices were needed for learning, the students had no difficulties in bringing their own mobile devices. In addition, as Nana said, her students were very critical and active (see Section 6.2.3). Each of these elements of Nana's ZFM could be interpreted as factors that might support her teaching actions.

Nana previously had participated in face-to-face technology professional development programmes (F2F-ZPA); however, her low level of technology skills (i.e., her ZPD) made her somewhat reluctant to teach using technology. In this respect, the F2F-ZPA offered by technology professional development programmes did not appear to promote Nana's beliefs about teaching with technology (ZPD). However, Nana's participation in the OLC (OLC-ZPA) promoted her interest in leveraging technology to support student learning. Teaching practice videos from other teachers posted on the OLC had motivated Nana to learn more about technology-mediated teaching delivery (ZPD). She learned how the participant teachers used technology for teaching mathematics (see Section 6.4.1). Although not all resources from the OLC suited her needs or matched her school conditions, Nana improved her beliefs (ZPD) about using technology in her teaching practices. The F2F-ZPA and OLC-ZPA to some extent offered the same goals regarding promoting the use of technological tools in the teachers' classroom practices. This is represented in Figure 6.1 by the overlap between the F2F-ZPA and OLC-ZPA. The relationship between the three conceptual zones depicted in Figure 6.1 appears to predict a trajectory of development involving the use of technology.

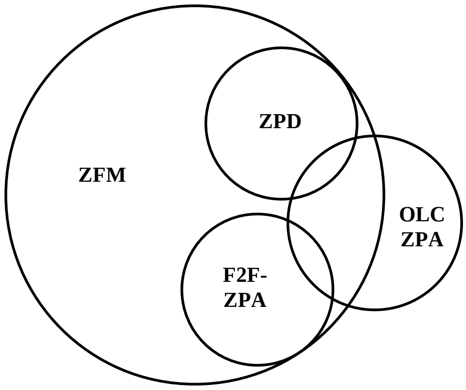


Figure 6.1 Relationships between Nana's ZFM, ZPA, and ZPD at the beginning of the current study

During the 15 months that Nana participated in the OLC, she was able to build a ZPA/ZFM complex that created a set of possibilities for development of new beliefs, knowledge, and practices (ZPD). Nana extended her teaching practices using different technology tools. She continued to use the Socrative app not only as an assessment tool but also as a tryout tool in preparation for the national exams. Nana also used software she had learned about in the technology professional development programme, named Cabri. Nana adapted the same teaching strategies she had learned from the OLC (see Section 6.5.1). In this regard, Nana's F2F-ZPA now overlapped with this ZPD, as shown in Figure 6.2.

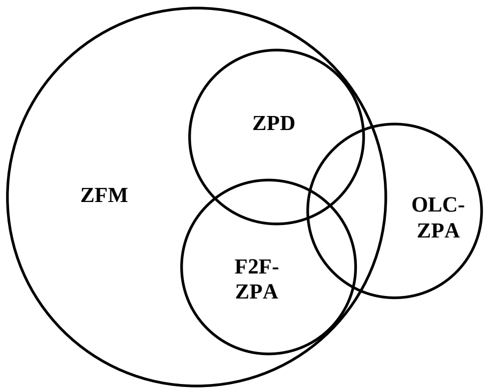


Figure 6.2 Relationships between Nana's ZFM, ZPA, and ZPD as the current study progressed

6.6.2 Setyo's case

Many elements of Setyo's ZFM were positive. For example, the school was well-resourced, with the majority of students coming from wealthy families and thus able to supply their own mobile devices. The school curriculum also emphasised the use of technology across all subject areas. Thus Setyo's ZFM appeared to afford teaching practices consistent with his beliefs (ZPD) about mathematics teaching and learning.

Setyo had many experiences working with technology. He took an elective course called Multimedia for Mathematics Learning when he was at both undergraduate and postgraduate degree levels (F2F-ZPA). Setyo said that the course taught students to design and develop technology-based learning media for mathematics, including creating videos, cartoon animations, and e-learning. Setyo commented, *I have created many animation videos* [about mathematics concepts], *and I have used some of the videos for my classroom practices*. However, he could not fully implement technology-based teaching practice because while it appeared that Setyo's F2F-ZPA promoted his beliefs about teaching mathematics with technology (ZPD), he could not consistently use the technology in his instructional practices because at the time of the current study he served as both a mathematics teacher and a vice principal. Setyo explained that he was less able to prepare the teaching material properly when teaching with technology (see Section 6.4.2). Thus, Setyo was unable to optimise his pedagogical practices with technology (ZPD).

Regarding promotion of the use of technological tools for teaching practices, Setyo's F2F-ZPA offered the same goals as OLC-ZPA. This is represented in Figure 6.3 by the overlap between the F2F-ZPA and OLC-ZPA.

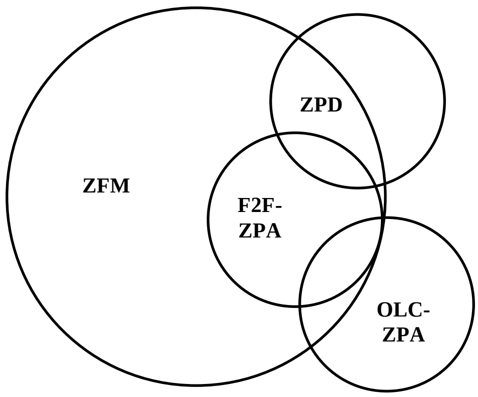


Figure 6.3 Relationships between Setyo's ZFM, ZPA, and ZPD at the beginning of the current study

Setyo was the only teacher who was less engaged in the OLC (see Section 6.4.2). Setyo explained: *At the beginning, I cannot be completely active as well, and I personally sometimes do not know what to write to comment*, *but sometimes I send some comments on the OLC.* Setyo's statement can be considered as a feeling of *ewuh pakewuh*, a feeling that made him hesitate to express himself openly to the other teachers. Setyo feelings occurred because of his sense of courtesy based on the seniority of the other four teachers, who had more teaching experience than he did (see Section 5.4.2). However, his lack of participation in the OLC at the beginning of the study contributed to the lack of improvement in his professional development (ZPD), hence there is no overlap between ZPD and the OLC-ZPA as shown in Figure 6.3.

Nevertheless, after ongoing participation in the OLC, Setyo was able to set up possibilities for the development of new beliefs, knowledge and practices (ZPD) with the current configuration of his ZFM/ZPA complexes. Setyo remained active in the OLC-FB. He sent two entries about his technology-based teaching practices. He also appeared to be active in the WA Group (see Section 5.6)

Setyo also changed his early perception of the OLC. He was able to overcome his reluctance to express his views. He had no hesitation about sharing ideas on the OLC-FB and was also active in the online discussion on the OLC-IM (see Section 5.6). He confirmed that his participation in the OLC was beneficial for the development of professional learning (ZPD), not only for himself but also for his colleagues in his school (see Section 6.5.2). Setyo's double workloads led to a contraction of his ZFM in ways that tended to exclude some of the pedagogical practices promoted by his OLC-ZPA (see Figure 6.4).

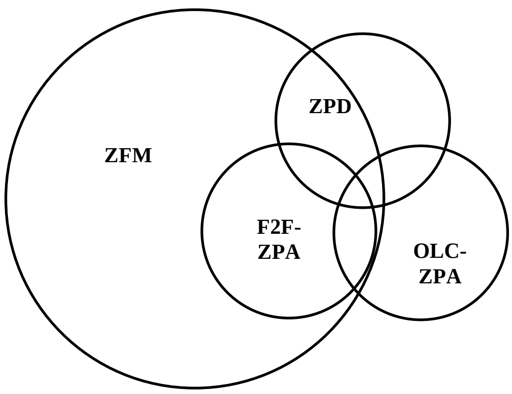


Figure 6.4 Relationships between Setyo's ZFM, ZPA, and ZPD as the current study progressed

6.6.3 Joko's case

Joko described a professional environment (ZFM) characterised by slow Internet access, limited technology resources, and a school curriculum that did not emphasise technology use across all subject areas. All these elements of Joko's ZFM could be interpreted as constraints that limited his teaching actions.

Joko had previously attended several technology professional development programmes (F2F-ZPA) organised by educational agencies who were either government or teacher professional organisations, but it appeared that the programmes had not promoted his technology skills and self-efficacy (ZPD). Joko described himself as an inexperienced technology user. He confirmed that he had no experience teaching with technology (see Section 6.3.3).

Joko's participation in the OLC had positive impacts (OLC-ZPA). He perceived that his participation was beneficial to the development of his professional skills (ZPD) in the use of technology for mathematics teaching and learning (see Section 6.4.3). Although not all the OLC's resources suited his school conditions and needs, Joko promoted his pedagogical beliefs (ZPD) by pushing himself to use technology in his teaching practices. Further, Joko's F2F-ZPA and OLC-ZPA offered the same goals in terms of promoting the use of technological tools for mathematics teaching practices. This is depicted in Figure 6.5 by the overlap between the F2F-ZPA and OLC-ZPA.

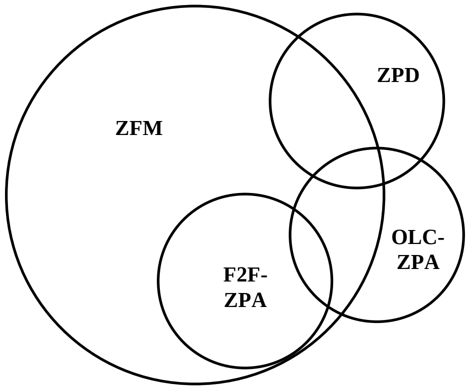


Figure 6.5 Relationships between Joko's ZFM, ZPA, and ZPD at the beginning of the current study

Joko's journey in participating in the OLC developed and reinforced his beliefs about the use of technology for teaching practices. Joko kept on using technology in his teaching practices. He challenged himself to learn a new technological tool, as shown in Section 6.5.3; he used the Plickers app for student assessment, which he had not used during the classroom observations. Further, Joko also conducted two projects, demonstrating his commitment to using technology in the classroom. Joko said,

> *I did two agendas after the project* [the current study] *done. Firstly, I applied the CONINCON (connection, integration and contextual) learning model by using the Socrative app and mathematics songs, and secondly, I invited Ms. Wati* (pseudonym) *to use the Plickers app in her teaching practices during the junior teacher supervision session on my on-the-job learning programme. I became her supervisor.*

Joko's statement indicates that he was able to apply a learning model he had learned from another professional development programme (F2F-ZPA) and integrate the technology he had learned from the OLC (OLC-ZPA) into it. Joko extended his role not only as a teacher but also as a teacher supervisor in promoting the use of technology in the classroom. Besides serving as a mathematics teacher, Joko was also a vice principal of the school at the time of this study. These double responsibilities involving both school administration and teaching therefore tended to undermine his goal of using technology in his teaching and learning activities. It led to a contraction of Joko's ZFM in ways that tended to exclude some of the pedagogical practices promoted by his OLC-ZPA (see Figure 6.6). However, the configuration of Joko's knowledge and beliefs, professional contexts, and sources of support came together to shape opportunities for his professional learning using the technology.

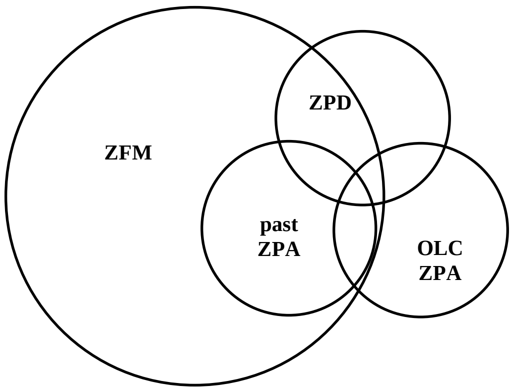


Figure 6.6 Relationships between Joko's ZFM, ZPA, and ZPD as the current study progressed

6.6.4 Udin's case

Udin's school lacked facilities, with no technical support, limited technology devices and slow Internet access. The majority of the students came from the lower-middle socio-economic class, so only a few students were able to bring mobile devices for learning. The school's curriculum also did not emphasise the use of technology in the teaching practices. These elements of Udin's ZFM appeared to constrain his teaching actions.

Udin had participated in many technology professional development programmes (F2F-ZPA). He also had some experience as an instructor and facilitator in such programmes. However, the knowledge he had gained from the professional development programmes was not fully implemented in his class because sometimes it was not suitable for his school conditions. Udin's participation in the OLC (OLC-ZPA) improved his self-efficacy (ZPD) (see Section 6.5.4). Udin's F2F-ZPA and his OLC-ZPA offered the same goals to some extent, in promoting the use of technology for teaching and learning. Therefore, the F2F-ZPA overlapped with OLC-ZPA, and these two ZPAs overlapped with Udin's ZPD as illustrated in Figure 6.7.

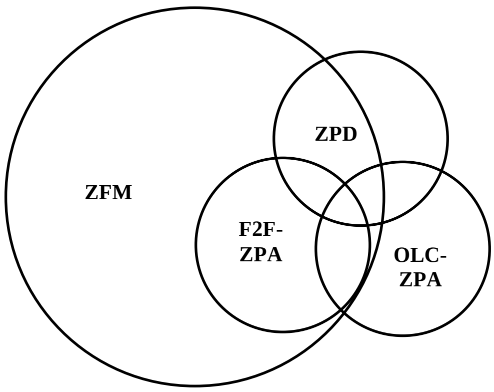


Figure 6.7 Relationships between Udin's ZFM, ZPA, and ZPD at the beginning of the current study

Udin, during his participation in the OLC, was impressed with some of the videos posted on the OLC-FB. He noticed that some schools had the same conditions in terms of limited technology devices and poor Internet connection, but those constraints did not impede the teachers' drive to use technology in their instructional practices. Udin said,

> *The limited sources are not a big deal. For me, whatever the conditions of existing infrastructure are, the technology remains important to support teaching and learning. I do believe that the technology can improve the learning to be more exciting and create better conditions inside the classroom*.

Udin's statement indicates that with limited ZFM, the advantages of technology still can be optimised to support teaching practices. Udin believed that technology use had an impact on the development of his professional learning (ZPD). Therefore, Udin's ZPD was now contained within the ZFM because he could still realise elements of his ZPD despite his limited ZFM (see Figure 6.8).

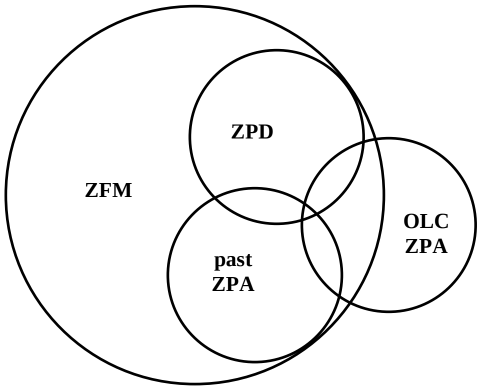


Figure 6.8 Relationships between Udin's ZFM, ZPA, and ZPD as the current study progressed

6.6.5 Edi's case

Edi's professional environment (ZFM) was characterised by slow Internet access, limited technology resources, and a school curriculum that did not emphasise technology use across all subject areas. These components of Edi's ZFM tended to constrain his teaching actions.

Edi had many experiences involving teaching with technology. Edi also had some prior experience as an instructor and facilitator in technology professional development and teacher professional development programmes conducted by educational agencies. In addition, Edi often participated in various professional development programmes (F2F-ZPA).

In terms of participation in the OLC, Edi was the most active teacher in the OLC (see Section 6.4.5). In social interactions with other OLC members, Edi not only shared his experiences, and exchanged his ideas about teaching mathematics with technology, but also actively energised and nurtured the community (see Section 5.3.1). Edi considered that the OLC was a medium for him to learn and improve himself to become a better teacher. Edi stated, *through this group* [the OLC] *I can share my teaching practices with other colleagues so that I can evaluate and improve myself related to the quality of my teaching*. So, the OLC was an element of Edi's ZPA (OLC-ZPA). Furthermore, Edi's F2F-ZPA and OLC-ZPA offered the same goals in terms of promoting the use of technological tools for mathematics teaching practices. The overlap between the F2F-ZPA and OLC-ZPA is represented in Figure 6.9.

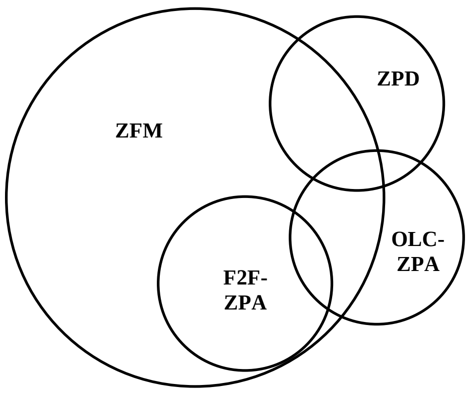


Figure 6.9 Relationships between Edi's ZFM, ZPA, and ZPD at the beginning of the current study

The journey that Edi experienced while participating in the OLC helped him to develop his professional learning (ZPD). Edi committed to continuing to use technology in his lessons despite the components of his ZFM, which appeared not to constrain his teaching actions. Edi said,

> *The existing infrastructure does not disrupt me at all from applying innovative learning methods. I can keep being innovative by preparing appropriate teaching strategies for the students to optimise the learning process. For instance, when the Internet access goes down during the quiz, the Plickers app helps me to continue the works, and when there is only a limited number of laptops and smartphones, the provided laptops and smartphones can be used for group learning.*

Edi's statement indicates that his limited ZFM did not prevent him from continuing to grow professionally. Therefore, Edi's ZPD was now contained within the ZFM because he could still realise elements of his ZPD despite the conditions that limited his teaching actions (see Figure 6.10).

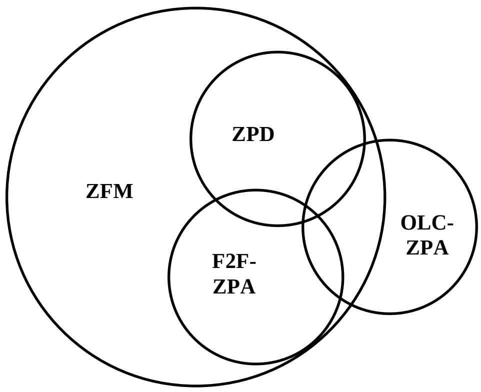


Figure 6.10 Relationships between Udin's ZFM, ZPA, and ZPD as the current study progressed

6.7 Summary

This chapter has discussed five case studies of teachers engaged in the use of technology in their mathematics teaching and learning. Three phases were designed for the current study: technology workshop, classroom observation and post classroom observation. These helped in investigating how the five teachers used technology in their instructional practices and in examining how teachers' participation in the OLC enhanced their professional learning, which in turn supported them to use technology for instructional practices.

The technology workshop and tryout of the use of technological tools in the mathematics classroom helped the participant teachers to identify what aspects need to be taken into account in using technology in the classroom. The aspects were the selection of appropriate teaching strategies, identification of appropriate teaching strategies, and problem solving as applied to issues that come up during the implementation of technology in the classroom.

Findings from the classroom observations suggest that the OLC had influenced the five teachers to develop their professional learning. The diversity of the teachers' teaching practices in the use of technology is evidence of the development of their professional learning. Social interactions in the OLC motivated the five teachers to learn from each other about how to optimise the advantages of technology to support student learning. With reference to the analytical framework describing how teachers provide technology, Nana and Joko used technology as a *partner* to help students gain more support for their own learning. Setyo still used technology as a *servant* because the use of technological tools did not change the nature of his classroom activities. Udin and Edi used technology as an *extension of self*. It was used as a way to re-organise the cognitive process and promote students' collaboration and communication skills as well as to support their learning.

The results from the case studies suggest that the face-to-face meetings were beneficial to the members of the OLC. The five teachers suggested that face-to-face meetings could be additional activities for social interactions in the OLC-FB. However, the post classroom observations revealed that the five teachers continued to use technology not only for their classroom activities but also to help other teachers who wanted to learn and to use technology in their teaching practices.

A number of factors that supported the process of teacher learning within the OLC for better use of technology in the classroom, along with a number of factors that interfered in teacher change, were analysed based on zone theory (Valsiner, 1987). The findings revealed that the five teachers were able to fashion ZFM/ZPA complexes so that they could create a set of possibilities for developing their new beliefs, knowledge, and practices (ZPD). The components of the ZFM were either constraints or encouragements to their teaching actions. However, previous technology professional development (F2F-ZPA) and the social learning interactions in the OLC (OLC-ZPA) together promoted new knowledge, self-efficacy, beliefs, and technology skills in the five teachers (ZPD).

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CHAPTER SEVEN

DISCUSSION

7.1 Introduction

Chapters Five and Six described the interactions that occurred through the OLC and provided a narrative of the five teachers' journeys during their engagement in the OLC. The changes to classroom instructional practices by the teachers in their use of technology for mathematics teaching were described, with examples illustrating the teaching methods they have adopted since the start of this study. This chapter gives a wider picture of how the three zones – the zone of proximal development (ZPD), zone of free movement (ZFM), and zone of promoted action (ZPA) – influenced the development of teachers' professional learning.

Section 7.2 describes the facilitations and barriers that were observed as teachers participated in the OLC. Section 7.3 brings together the activities in the OLC that promoted teachers' professional learning. The sources of assistance available within the OLC and the role of the researcher (as a mediator and social host) in supporting teachers during their professional learning journey are also discussed.

The ZFM and ZPA are intertwined and dynamically shape the ZFM/ZPA complex. Section 7.4 describes how the ZFM/ZPA complex generates an environment in which teachers can develop their professional learning. Elements of the ZPD are described as a set of possibilities for developing the professional learning of teachers in using technology for teaching mathematics through their participation in the OLC. This section elaborates on the elements and provides more detail.

7.2 Facilitators and Barriers Related to Participating in the OLC

Participation in the OLC created opportunities for the five teachers to learn in a collegial environment. The findings show that social participation in the OLC affected teachers' learning as they used technology to advance their classroom teaching practices. Factors that encourage and impede teacher participation in the OLC are investigated to answer the first subsidiary research question: *What were the facilitators and barriers to the teachers' participation in the OLC?*

The five teachers constructed knowledge on the use of appropriate tools for explaining mathematical concepts during their interactions with other members of the community. As Hoadley and Kilner (2005) state, within communities' knowledge is generated and shared when there is an objective-oriented conversation around content in some specific context. In the current study, *social knowledge construction* took place through conversations between members of the online learning environments. In this respect, conversation refers to the to-and-fro exchanges in the online discussions among the community members on enhancing technology-related teaching practices. Hoadley and Kilner consider discussion as meaningful when the content is relevant to the community. This was evident in the findings, where the content of discussions ranged across pedagogical teaching strategies, identification of technical issues and problem solving of these, identification of technological tools, and instructions on how to use the tools properly. These were all relevant to the context, and the promotion of the use of technology in mathematics classroom teaching. The wide range of topics being discussed among the members to develop each other's learning was evidence of the dynamics of conversations that occurred in the OLC where the five teachers constructed their new understandings.

Teachers posting their teaching experiences, lesson plans, images and videos of their teaching activities with technology on the OLC-FB were a form of *de-privatization of practice*. Campbell et al. (2013) promote de-privatization of practice as a means to potentially encourage collaboration between and among teachers in the sharing of ideas, skills and practices. De-privatization as described by Campbell and colleagues occurred through collaboration among the teachers. This was evident in the way teachers exchanged knowledge, shared individual experiences, resolved technical issues and provided solutions to help each other improve the quality of teaching and learning in different school settings. Moreover, teachers viewed each other's teaching activities through videos posted on the OLC. These can also be regarded as de-privatization of practice. This style of providing visual leads brought clarity to the use of technology in the classrooms (see Section 5.5.1). This finding parallels those described by other researchers who studied teachers' professional communities (e.g., Louis & Marks, 1998; Tam, 2015). Of particular importance is that when teachers observed other teachers in the professional learning community, they reflectively changed their own practices. This study has illustrated how teachers changed their own mathematics teaching practices after observing other teachers' technology adoption strategies in the virtual community.

In the virtual community (OLC) the five participant teachers mutually engaged in collective activities and shared perspectives. For example, in the OLC-FB, the public community could send comments and reactions in regard to the teaching practices of the five teachers. In the OLC-IM, with just the core members (i.e., the five teachers and the researcher), the five teachers openly gave suggestions and provided constructive feedback within a closed discussion setting. This resulted in relevant topics receiving more meaningful and in-depth discussion. The five teachers also became more receptive to others' inputs (see Section 5.2.2). Being receptive can be seen as what Dewey (1933) calls an attitude of open-mindedness, which is necessary for the process of reflection. All inputs from the community were used to perform *reflection-on-action* (Schön, 1987) by the teachers. This provided teachers with opportunities to think back critically and reflect on their teaching practices. In the process of reflecting on their actions, they recognised factors of their practices that could be improved. The findings showed that participation in the OLC contributed to reflective practice. The process of reflection transformed teachers' pedagogical strategies in teaching mathematics with technology.

During the transformation process to instructional practices with technology, the teachers faced some technical difficulties, which included issues related to slow Internet connections, unfamiliarity with tools and difficulty in finding suitable tools that would work in limited infrastructural settings. Through online discussions within the OLC, teachers shared these issues, and together they devised solutions to resolve the problems. For example, the teachers used mobile Wi-Fi and mobile tethering to deal with limited Internet connections (see Section 6.2.2), and other teachers provided alternative tools that could be used to teach about transformation (see Sections 5.3.1.1 and 5.3.2.1). The availability of devices was another issue that emerged in the implementation of technology for teaching.

Teachers handled this issue by organising the students into small groups (see Sections 5.3.1.1 and 5.3.1.2). The teachers acknowledged that putting students into small groups was an appropriate teaching strategy in conditions where limited infrastructural support was available (see Section 6.2.2). All this provides evidence of how participation in the OLC helped the teachers to overcome some of the problems they faced.

The OLC also facilitated teacher collegiality and collaboration. Teacher participants engaged in social interactions in the OLC frequently and supported each other with encouraging comments. For instance, they gave compliments for tasks that were well done, made positive remarks to motivate each other, offered helpful suggestions and provided constructive feedback to support others to streamline their teaching practices with technology use. Such positive supports *reinforced collegial relationships* among the teachers, which in turn potentially improved teacher professional learning. This finding is consistent with what a number of other researchers have noted (e.g., Harris & Anthony, 2001; Shah, 2012); that a collegial relationship results in significant professional development among teachers. In such instances, teacher collegiality becomes a key aspect of teacher professional learning and a vehicle to increase teacher knowledge. The current study indicates that in addition to teacher participation in traditional settings, virtual forums such as OLCs contribute to building collegial relationships among teachers.

The OLC played a significant role in motivating collegial participation to support individual teachers in making changes in the use of technology for teaching practice. Scott and Scott (2010) who investigated school-based teacher professional development, note that collegial reciprocity can be a positive element that motivates teachers to bring changes to classroom teaching behaviours. The results of the current study add new knowledge about the way in which online professional development also contributes to both strengthening collegial relationships among teachers and stimulating contributions from teachers in social learning. For example, the teacher participants who observed videos posted on the OLC of other teachers conducting lessons later shared videos of their own teaching practices. These individuals may have done so because they felt a sense of obligation to contribute to forum posts on the OLC themselves. Moreover, these teacher participants received collegial support not only from other teachers in their school but also from educators in other institutions (see Section 5.3.1.2).

The OLC empowered the five participant teachers to change their teaching practices as they learnt to integrate technology with instructional practices (see Section 6.4). These five teachers felt confident in sharing their teaching methods with technology. This further reveals how their knowledge, pedagogical beliefs, technology confidence, and technological skills were improved. Evidence is also provided of how teachers were themselves empowered and also how they inspired their colleagues and other teachers to leverage technology for teaching and learning purposes (see Section 6.5). The results showed that teachers who are highly efficacious tend to feel empowered. Empowered teachers can change their instructional practices and work more effectively to use technology in the mathematics classrooms.

Although participation in the OLC offered opportunities for teachers to promote their professional learning, there were some barriers, which hindered teacher engagement in the OLC. The results found that *school facilities and policies* had some influence on the level of participation of the teachers in the OLC. The schools that participated in the current study had different technology resources. While the schools provided many facilities to enable teachers to improve their professional teaching and learning, they had some limitations. The two well-resourced schools allowed their teachers and students to bring mobile devices to school (see Section 6.2.1). The teachers and students could use their mobile devices during class hours, but only if they were being used for teaching and learning activities. The other three schools had earlier restricted the use of mobile devices, especially mobile phones or tablets. However, the schools allowed students to use their mobile devices for the purposes of teaching and learning, but only after they obtained permission from the school principal or an authorised teacher, such as their homeroom teacher.

Internet connection was one of the facilities provided by the schools. At the time of the current study, the schools' Wi-Fi did not reach classrooms. It generally only covered the staff room, the principal's office and the administration office (see Section 6.2.2). Overall, the wireless connectivity across all five schools was poor. This hindered teacher participation in the OLC, since the teachers needed to switch to their own data package to access the Internet to engage in the OLC.

The five schools also had different policies. For example, some schools prohibited the use of Facebook, but some others had no rules about this (see Section 5.2.2). Teachers who worked in the schools that prohibited the use of Facebook only engaged in the OLC-FB after school hours. Clearly, the different school policies caused some teachers to be reticent and less actively engaged in the OLC during school hours. Despite the school policy, the teachers found some ways to engage with each other in the OLC. They had different solutions to address this problem (see Section 5.5.3).

Another barrier to teacher participation in the OLC was related to teachers' readiness to engage in ongoing social interactions. The teachers who participated in the OLC hesitated and were not inclined to independently engage in the social learning process without some form of positive encouragement from the researcher (see Section 6.5.2). The researcher (as a participant) had taken the role of mediator and motivator to ensure that the teachers felt supported in interacting with each other in the OLC setting. The researcher also took on the role of social host, and provided guidance and facilitated online discussions to keep the OLC alive (see Section 5.3). When there was no assistance from a mediator or social host, the OLC was like *a class without a teacher*. In this manner, the teachers in the OLC were brought together through the researcher's role of mediator and social host. The researcher undertook duties such as giving relevant guidance and facilitating ongoing discussions to keep the OLC more active. However, after a period of time the researcher stepped back from the role of mediator in the OLC. This happened seamlessly as some teachers took over the researcher's role by taking the initiative and inviting other members of the OLC to contribute to the online discussions. It can therefore be concluded that reaching readiness to engage in some social interaction forums independently can be a long process. This is because each teacher has their own journey, which determines the pace at which they become involved in the OLC.

Cultural context is another significant aspect that affected teacher participation in the OLC. In the current study, the five teachers were Javanese. An aspect of Javanese culture plays an important role in what Hofstede et al. (2010) say forms individuals' ways of feeling, thinking and acting towards technology. This aspect can explain how individuals or social groups perceive their interactions with technology. One of the personal characteristics of Javanese people is *ewuh pakewuh,* a feeling of shyness in expressing thoughts. Some researchers (Artiawati, 2017; Wati, 2014) contend that the feeling of *ewuh pakewuh* affects the performance of individuals in work environments. The culture of *ewuh pakewuh* makes individuals feel *sungkanan*, which means 'a hesitation to refuse' (Artiawati, 2017). They become less assertive in refusing requests from someone who is in a higher position or displays higher competency.

In the context of the current study, the feeling of *ewuh pakewuh* affected the social interactions of teachers in online environments. It caused the teachers to be reticent about expressing their thoughts in the OLC-FB. They felt that since they were *gurus* (an Indonesian term for teachers), they could not openly raise their doubts to other teachers. *Guru iku digugu omongane lan ditiru kelakoane*, in the Javanese language, means that the speech of teachers is always copied, and their behaviour is always an example (model) for everybody (Artiawati, 2017). This philosophy could explain why the teachers were more cautious in providing feedback or posting comments on the public OLC. The teachers tried to foster harmonious relationships. Their overly cautious nature made the teachers less engaged in the OLC. Based on the findings, the feeling of *ewuh pakewuh* came up for one teacher as a result of his lack of teaching experience (see Section 5.4.2), and contributed to the cautious approach of the teachers in expressing their opinions (see Section 5.2.1).

Length of overall experience in teaching with technology also contributed to the level of participation in the OLC. Although all the teachers had participated in technology professional development programmes, not all of them had previously implemented these technologies in their instructional practices. This meant that they had different lengths of experience in teaching with technology. The current study suggests that teachers with little experience in using technology for instructional practices tended to be passive participants in the OLC. In contrast, the teachers with higher levels of technology usage in teaching exhibited more confidence and active participation in the OLC. In other words, it appeared that more experiences in teaching with technology made the technology adoption process easier and resulted in more benefits from participation in the OLC.

The level of technology skills was another aspect that appeared to impede participation in the OLC. The five teachers in the current study had different levels of technology skills (see Table 3.4). The capability of teachers in using social media (OLC-FB) and instant messenger applications (OLC-IM), as well as some technological tools, influenced their level of social interactions in the OLC. Having these skillsets enabled the teachers to confidently use the online learning environments and other features of the tools. Teachers with a higher level of technology skills were more innovative in creating technology-based teaching practices than teachers with lower levels (see Section 6.4). The former were more enthusiastic when their experiences with teaching with technology were publicly shared on the OLC. This attitude affected their participation in the OLC. The teachers with lower skill levels with technology mostly just posted comments in the form of compliments and motivations; while teachers with better technology skills immersed themselves actively in discussions (see Section 5.3.1 and 5.3.2).

These facilitators and barriers to participating in the OLC affected how teachers took actions to promote their professional learning. The next section describes a number of activities in the online learning environments that supported teachers in promoting their professional learning.

7.3 Activities in the OLC that Promoted Teachers' Professional Learning

The teachers did some collective activities through social interactions with community members in the OLC. Teachers' activities in their participation in the OLC were examined to answer the second subsidiary research question: *How did participation in the OLC promote professional learning in using technology in the mathematics classroom?*

The teachers exchanged various learning materials in the form of teaching experience stories, professional learning reflections, lesson plans, tutorial videos, teaching and learning videos and photos of classroom activities via the OLC-FB and the OLC-IM. They did all this on a voluntary basis. There are many reasons that explain why the teachers shared their learning materials. For instance, they shared their teaching experience stories, and teaching and learning videos on the OLC-FB to get constructive feedback from the wider teaching community (see Section 5.2.1). Within the OLC, the teachers could observe other teachers' classes via videos. Scott (2009) explains that classroom observation is a form of peer coaching where teachers inform and are informed by each other's classroom methods. Scott believes that peer coaching is significant in facilitating the transfer of knowledge. From the findings it was revealed that knowledge transfer occurred in social interactions among teachers in the OLC. Also evident is the new process of *online peer coaching* through videos, which led to significant changes to teaching practices with technology. The teaching and learning videos were used to give additional impetus for teachers to reflect on and extend their instructional practices. The videos provided opportunities for the teachers to identify specific tools and teaching strategies that could be applied to their own practices. In such instances, the teachers became familiar with the tools. This enabled them to identify technological tools that were relevant to the contents being discussed. This de-privatization of practice also provided the teachers with information about pedagogical strategies for technology-mediated teaching delivery. They were then enabled to replicate or create appropriate teaching strategies that matched their school conditions (see Section 6.3.2) and plan teaching material to help students meet specific learning goals (see Section 6.3.1 and 6.4).

Some tutorial videos about the use of technological tools, which were posted on the OLC-FB, also proved to be beneficial to the teachers who used the same tools. The teachers learned how the tools could be potentially used to solve certain mathematics problems. They also used the video tutorials to give audio-visual experiences to help students become familiar with the technological tools used (see Section 6.4.4).

Teaching and learning activities documented in the form of photos posted on the OLC-FB were a motivating factor, which added value to the contributing teacher.

The photos attracted other teachers' involvement in online discussions (see Section 5.3.1.2). The teachers used emoji reactions and posted comments on the photos and on each other's entries in OLC-FB. These social interaction activities in which teachers expressed their ideas, thoughts and feelings online were also a form of conversation. In the conversation, the teachers updated existing content and created new ones. Therefore, the topics being discussed varied from conversation to conversation. Therefore, conversation is a significant element for constructing knowledge effectively in OLCs.

Teacher collaboration was another essential activity to promote professional learning. Collaborative learning cultures in the OLC grew naturally as the teachers constructed their knowledge. Teacher collaboration is way to build a strong professional community. The OLC provided opportunities for teachers to interact with other teachers in the online learning environments. Teacher collaboration in the current study was in the form of reciprocal interactions among the teachers in which they shared values and knowledge through the OLC. Collaboration in the OLC led the teachers to improve the quality of their teaching practices with technology. This finding extends Pang and Wang's (2016) claim that teacher collaboration leads teachers to improve their teaching practices to support students' learning. Pang and Wang conducted their study in school-based professional learning communities, while the current study was conducted in virtual communities and adds new knowledge about how teacher collaboration can occur and how effective it can be in this new domain.

The teachers who participated in the current study did not merely focus on the quality of teaching with technology but also discussed how students can best take advantage of the benefits of technology in the classroom. Pang and Wang (2016) argue that a collective focus on student learning is central to a professional learning community. In the current study, the teachers focused on how the students embraced the technology to support all phases of the student learning process including observation, questioning, exploration, analysis, and communication (see Section 6.4). This finding aligns with Niess's (2005) suggestion that the infusion of technology in the classroom should be able to enhance student learning. The current study results revealed that students held positive attitudes towards learning mathematics with technology. Investigation of students' perceptions on the use of technology for learning mathematics was not included in this thesis; however, the way students perceived the benefits of technology for learning mathematics in the current study has been described elsewhere (Abidin, Mathrani, & Hunter, 2018).

Problem solving to deal with technical issues was one topic that was frequently discussed in the OLC. The teachers raised awareness of any technical issues that came up during the infusion of technology. The results of the current study showed that the ability of teachers to handle technical issues gradually increased. The teachers also gained more confidence in their use of technology and more confidence in introducing new technological tools to their students.

The role of the researcher in the current study contributed to the promotion of teacher professional learning within the OLC. The researcher established the OLC with three online learning environments: a closed Facebook group (OLC-FB), a Facebook Messenger group and a WhatsApp group (OLC-IM). The first group was for the wider community, which consisted of mathematics teachers and mathematics teacher educators. The other two groups were specifically for the five research participants. To promote teachers' professional learning, the researcher took the role of mediator and social host to nurture the OLC. The researcher invited the teachers to participate in the OLC and ensured that the teachers interactively engaged in the online discussions. Evidence from the current study showed that the teachers demonstrated that they were able to take over the role of mediator. The teachers took part in nurturing the community by facilitating and supporting the community in the adoption of technology. These findings indicated that the teachers' sense of ownership of their online learning community grew over time. Thus, this model of an online learning community potentially helps to increase teachers' professional learning. Table 7.1 presents the tasks of the mediator and social host in nurturing the OLC in the context of the promotion of the use of technology in the classrooms.

Table 7.1 The tasks of a mediator and social host in the OLC

Mediator*	**Social host****
▪ Identify members' interests in the online discussions by creating relevant topics for discussion. ▪ Narrow the content of the online discussions and bring the members to a mutual engagement in collective activities in the online learning environment. ▪ Encourage each member to engage in the online discussions to keep the conversation flowing. ▪ Facilitate and support the members in the adoption of technology ▪ Offer options for considerations, stimulate new perspectives and offer reference points for considerations in using technological tools. ▪ Give recognition to the members by valuing any contributions they make to the online discussions.	▪ Set the norms by posting clear guidelines for contributing on the OLC. ▪ Issue warm invitations to the members to participate in social interactions by sending encouraging private messages to the members. ▪ Give suggestions about what the members of the OLC may be qualified to contribute in promoting technology use in the classroom

* Performed by the researcher and the teachers, ** Performed by the researcher.

The researcher took the role of social host to establish a community and initially construct social interactions in the online learning environment. An online discussion model was chosen as a form of communication for the groups. With a social host, social interaction within the online learning environment can be achieved. Both the researcher and the teachers took the role of mediator in the OLC. This kind of active mediator role is significant to ensure that the members of the OLC are actively engaged in the social interactions. Both these roles are crucial to support teachers' professional learning in online learning environment settings. Without sufficient support from those who take these roles, teacher professional learning in the online learning environment cannot be sustained (Sari, 2012).

While the members of the OLC benefitted from knowledge dissemination, there were still some teachers who chose to take a passive role in social learning. The model of the virtual community used in the current study effectively contributed to these teachers' learning because they were able to see how to use technology in the classroom. These teachers became active participants in the OLC. They were interactively immersed in the social learning process. These teachers were able to apply the new knowledge obtained from the OLC into their technology-based mathematics teaching practices. They were also able to create innovative teaching strategies and give opportunities for their students to engage with technology. This finding confirms that having a strong shared vision and a sense of purpose enables teachers to optimise their potential in learning within a virtual community.

In face-to-face professional learning programmes, many participants tend to sit silently during discussion sections (Feenberg et al., 2002). The Training of Trainers (ToT) model is the most common strategy chosen by the Indonesian government for face-to-face teacher professional development (TPD) (Widodo &

Riandi, 2013). Widodo and Riandi argue that the ToT model is not effective in contributing to teachers' learning because the contents sometimes do not match school conditions. The model of virtual teacher professional learning outlined in the current study overcomes this problem. The results of this study have added new knowledge with regard to the way members participated in the virtual settings, in contrast to how teachers often participate in face-to-face TPD. The discussions were driven by the needs of the members of the OLC. They participated in the discussions any time when it was relevant to their needs. They were able to connect with other "expert" teachers, share experiences, and learn together. This kind of virtual professional learning facilitated the teachers' exploration of how to integrate technology into their classrooms effectively. This included exploring the mathematics learning areas, pedagogies, and assessment methods within a technology usage context.

7.4 Development of Teacher Professional Learning Through Participation in the OLC

An important line of inquiry within mathematics teacher professional learning is concerned with promoting changes in classroom practice. Zone theory, used in the current study, offers a useful framework to enable understanding of teachers' learning and development in virtual communities. Goos (2013) contends that zone theory provides guidelines for interpreting teachers' learning and identifying factors that assist or impede the integration of technology in the classroom. Zone theory was therefore used as an analytical tool to analyse the extent to which teachers learnt from the online learning community to adopt technology for instructional practices. This analysis was conducted to answer the main research question: *How do teachers develop their professional learning in using technology in mathematics classroom through their participation in online learning communities?*

A teacher's state in relation to developing knowledge and skills for the transition to using technology in the classroom constitutes the form of a zone of proximal development (ZPD). Goos (2013) proposed the zone theoretical model of teacher learning and development. Goos defined the ZPD as a set of possibilities for the development of new knowledge, beliefs, goals and practices through the interactions between teachers and their environments, the people in the environment, and the resources it offers. Two additional zones, the zone of free movement (ZFM) and the zone of promoted action (ZPA), create the ZPD. These two zones are interrelated and form ZFM/ZPA complexes. The ZPD concept is usually related to an individual's development. The examples provided by Goos (2013) illustrate the complexities of teacher learning in changing mathematical practices and show that it makes sense to take into account how the ZFM/ZPA complexes set up ZPD possibilities for groups of learners within the same professional learning setting. The findings of the current study add new knowledge regarding analyses of the ZFM/ZPA/ZPD systems negotiated by a group of teachers who engaged in the OLC to learn the use of technology for teaching mathematics. The study results are also significant for development of learning trajectories on how teachers gain new knowledge and experience that can be used to support other teachers in their learning journeys. The study has provided evidence on how teachers actually transform their mathematics classrooms with technology over time and how they articulate the acquired knowledge and skills. Having some form of activity instead of merely giving them a description of ideas will help teachers gain better experiences to build new knowledge.

The teachers experienced the social learning process during participation in the OLC. The results illustrate that the OLC brought change to teachers-as-learners negotiating the ZFM/ZPA complexes that structure opportunities for teacher change, as shown by teachers' desires to use technology for teaching mathematics, even though there were some obstacles that hindered the integration of technology in the classroom. Overall, the teachers' capabilities, showcasing their knowledge and skills, increased as a result of their participation in the OLC. The diversity of technology-mediated teaching delivery showed that the teachers tried to implement new knowledge and new technology into their instructional practices.

The zone of free movement (ZFM) comprises "constraints and affordances within the professional context" (Goos et al., 2007, p. 26). Thus, teachers' ZFMs are shaped by the barriers and affordances in their context (see Section 7.2). In the current study, the teachers' professional contexts or ZFMs were characterised by differences in school facilities and infrastructure, school policies and cultural context. School facilities and infrastructure matters are concerned with the availability of mobile devices and ease of access to the Internet. School policies embody restrictions on the use of Facebook (OLC-FB) during school hours and in the use of mobile devices (mobile phones and tablets) during class hours. Cultural context implies personal characteristics that affect teachers' participation in the OLC. Thus teachers' ZFMs defined narrow boundaries for action. Re-negotiation towards the boundaries sometimes was taken to avoid tensions. Goos (2013) notes that the notion of *productive tensions* is “central to an understanding of teacher change from a zone theory perspective” (p. 523). The tension is productive when it brings about change. It can be done by modifying the environment (ZFM) or looking for professional learning opportunities (ZPA). For example, in the current study, introducing the WhatsApp group (OLC-IM) as an online learning environment was done to re-negotiate the boundaries. WhatsApp was selected because it was commonly used for communication while the teachers were at school (see Section 5.2.2). In this way, teachers were still able to be in touch with members of the OLC and kept engaged in the social learning interactions. The establishment of OLC-IM was also done to re-negotiate the cultural context. The teachers, who were basically from Java, mostly had the personal characteristic of *ewuh pakewuh*, a feeling of shyness in expressing their thoughts and feelings. The OLC-IM, with just a few members, made the teachers more open to expressing ideas and thoughts, and they became more receptive to giving and receiving feedback. It is clear that modifying some factors of the environment gave possibilities for teachers to change, which supported their development.

While the ZFM represents the professional context, which suggests the actions are allowed, Goos, Stillman, and Vale (2007) propose that the ZPA represents “sources of assistance available to teachers in promoting specific teaching actions” (p. 417). In the current study, the notion of the ZPA was extended to sources of assistance offered by members of the OLC to promote teachers' professional learning. Some activities in the OLC in respect of which the teachers' actions were promoted were social learning interaction, online peer coaching, and teacher collaboration (see Section 7.3). Inviting and encouraging teachers to immerse themselves in the social learning interactions were also part of the ZPA offered by the researcher and the teachers in the OLC. The researcher, in the role of mediator and social host, initiated online discussions to promote the use of technology in the classroom. With the teachers' growing sense of ownership of the online learning community, some teachers also took the role of mediator (see Section 7.3). Clearly the role of mediator and social host were significant in providing the ZPA.

Face-to-face professional development programmes (such as technology workshops and one-day face-to-face meetings) with the teachers who participated in the OLC contributed to the increased level of teacher participation in the social learning interactions. The face-to-face professional development programmes strengthened the shared vision of the teachers. This, in turn, empowered them to get involved in the OLC to promote the use of technology for teaching mathematics (see Section 6.5.1).

The teachers who participated in the current study showed that they were able to fashion ZFM/ZPA complexes that created a set of possibilities for development of new knowledge, beliefs, and practices (ZPD). Through participation in the online learning community, the teachers were able to take advantage of the benefits of technology for teaching mathematics. At the beginning of the current study (in trialling the implementation of technological tools) the teachers used and provided technology as *a master* (Goos et al., 2003) because their knowledge and competence in using technological tools were limited. Their participation in the OLC altered their mode of working with technology. Some teachers were able to add the value of technology to help students to attain more support for their own learning. In this regard, the teachers were able to use technology as *a partner*.

Some teachers were also capable of shifting their mode of working with technology as *a partner* to technology as an *extension of self*. These teachers were able to combine some technological tools with the production of students' cognitive and communication skills in mathematics (see Section 6.4.4 and 6.4.5).

Each teacher in the OLC motivated other teachers to look for ways to effectively teach mathematics with technology. It increased teachers' beliefs (ZPD) in the usefulness of technology for teaching mathematics. The results of the current study extend the findings of Windschitl and Sahl (2002), who found that teacher beliefs on the classroom use of technology are shaped by the context of the school culture. The current study showed that teacher beliefs were also fashioned by the level of participation of the teachers in the OLC. The more the teachers participated in the OLC, the stronger their beliefs about the benefits of technology for teaching mathematics became. Further, active participation in the OLC also improved teachers' technology skills (ZPD). The teachers showed that they could use some technological tools and at the same time gain more power to help students meet curricular goals. With such increasing technology skills, the teachers were increasingly able to deal with technical issues that emerged during the implementation of technology. The online topic of problem solving, often discussed in the OLC, offered solutions for technical issues.

Participation in the OLC helped the teachers to increase their confidence levels (ZPD). Confidence in performing specific tasks with technology can be considered what Albion (1999a) calls self-efficacy. The results revealed that teachers' self-efficacies improved after participating in the OLC. The teachers were open to experimenting with new technological tools and more willing to seek improved teaching methods to use technology for teaching mathematics effectively. As Ertmer and Ottenbreit-Leftwich (2010) state, technology is always in a state of flux; therefore teachers should continually learn the latest technology in an attempt to hit a moving target.

Table 7.2 Factors affecting teacher participation in the OLC

Zone	Factors affecting participating in the OLC
ZPD	▪ Mathematical knowledge ▪ Technology knowledge ▪ Self-efficacy ▪ Beliefs about technology, mathematics, teaching and learning ▪ Technology skills
ZFM	▪ School facilities and infrastructure ▪ School policy ▪ Cultural Context (e.g., ewuh pakewuh)
ZPA	▪ Social learning interaction ▪ Online peer coaching ▪ Teacher-researcher collaboration ▪ The role of mediator and social host ▪ Face-to-face technology professional development programme

Participation in the OLC offered opportunities for the teachers to improve their knowledge (ZPD). The teachers obtained rich knowledge from shared repertoires posted on the OLC and from the online discussions. The current study showed that with increasing knowledge (mathematical content knowledge and technology knowledge), the teachers were able to create technology-rich learning environments for their students. For example, the teachers were able to create interactive formative assessments using student response systems (Socrative and Plickers). They also delivered mathematics material by linking the concepts with real-world problems using footage from movies, animated cartoons, videos, and animated photos. The teachers also demonstrated their capabilities to create indoor and outdoor classroom activities while using technology and maintaining a dynamic student-centred focus. This confirmed that the participation of teachers in the OLC contributed to transforming their instructional practices. The aforementioned factors, representing elements of teachers' ZPD, ZFM, and ZPA, are summarised in Table 7.2.

The teachers who experienced the social learning process through participation in the OLC showed similar patterns regarding their relationships between the ZFM, ZPA, and ZPD in their practices, except those who had double positions of responsibility. For example, Setyo and Joko, at the time of the current study, had double workloads. They served as mathematics teachers and vice principals at the same time (see Sections 6.6.2 and 6.6.3). Teachers with double workloads could not optimise their potential in the development of professional learning. They could not consistently use the technology in their instructional practices due to lack of time, which made them less able to prepare the teaching material properly. This also affected their level of participation in the OLC. The rest of the teachers (Nana, Edi, and Udin) could realise elements of their ZPD despite the conditions that limited their teaching actions (see Section 6.6.1, 6.6.4, and 6.6.5). Teachers' experiences from previous technology professional development programmes (ZPA) and their participation in the online teacher professional learning appeared to develop their ZPDs. The technology professional development programmes and the online teacher professional learning to some extent offered the same goals regarding promoting the use of technological tools in mathematics teaching practices. However, the results of the current study revealed that the teachers continually engaged in defining new ZPDs throughout their participation in the OLC. Even after post data collection, the teachers continued to engage in social learning interactions, which continued to foster the development of their ZPDs (see Section 6.5.2). This finding indicates that participation in the OLC helped teachers get closer to their professional ideals.

7.5 Summary

This chapter has elaborated some factors that enhance or impede teacher participation in an OLC. The affordances of participation in the OLC included social knowledge constructions, de-privatization of practices, reflective practices, problem solving, reinforcement of collegial relationships, and empowerment. These factors positively affected how teachers advanced their professional learning within the OLC. Some of the barriers identified were school facilities and policies, self-readiness, cultural context, length of experience in teaching with technology, and level of technology skills. Although the teachers faced some barriers to participation in the OLC, they were able to find ways to alleviate their problems.

Activities were identified that promoted teacher professional learning within the OLC. The activities included social learning interactions, online peer coaching, collaboration, a collective focus on student learning, and sources of assistance, either from other teachers or the researcher (as a mediator and social host), to support teachers during their professional learning journey.

The development of teacher professional learning was analysed using zone theory to examine how teachers learned from the OLC to adopt technology for teaching mathematics. The elements of teachers' zones of free movement (ZFM), promoted action (ZPA), and proximal development (ZPD), which affected teacher participation in the OLC, were investigated. The ZFM/ZPA complex, which was formed by two zones (ZFM and ZPA), generated an environment in which teachers could develop their professional learning (ZPD). Teachers' ZFM/ZPA complexes were continually evolving and gradually helped to move the teachers up to meet their professional learning goals. Using the analytical framework of master, servant, partner, and extension of self, the current study was able to describe how teachers used and provided technology in their mathematics lessons. The findings of the current study showed that the teachers were able to alter their modes of working with technology. Some teachers were capable of using technology as a partner, and others had the ability to change their mode of working from using technology as a partner to using technology as an extension of self.

CHAPTER EIGHT

CONCLUSIONS AND IMPLICATIONS

8.1 Introduction

The intent of this thesis was to conduct an exploratory study to determine how teachers developed professional learning in the use of technology for teaching mathematics through social participation in an online learning community (OLC). An ethnographic case study methodology was used in this investigation. An online learning community, which used three online learning environments and one face-to-face meeting, was established. The five participant case teachers participated in the OLC from March 2016 – May 2017. At the early stages of OLC formation (from March – August 2016), the researcher facilitated many discussions to encourage participants to participate in the social learning interactions. By September 2016, the researcher's role as facilitator and social host had slowly phased out as participants got more involved with their own learning exchanges.

Data gathered from this research were both qualitative and quantitative. Quantitative data were gathered from the quantification of the number of posts, comments, and reactions made by the participant teachers on the OLC-FB and OLC-IM. The data were analysed to investigate the social presence of teachers in the OLC. Further qualitative data relating to the five participant teacher cases were generated from classroom observations, interviews, documents, videos and online posts, and an open-ended survey. In this manner, rich data gathered from multiple sources were analysed to investigate the affordances and barriers related to teacher participation in the OLC. The goal was also to identify and investigate activities in the OLC that promoted teachers' professional learning in the use of technology in mathematics lessons. Zone theory grounded the analytical approach that was employed to gain understanding of the process of professional learning within the OLC in promoting the use of technology in mathematics classrooms.

This thesis has presented rich descriptions of the social learning interactions that occurred through the online learning environments and the professional learning journeys of the five case study teachers. The findings show that the impact of teachers' participation in the OLC on their professional learning was significant. Important changes were revealed in all classrooms as the teachers shifted their mode of working to using technology either as *a partner* or as an *extension of self* to help students to attain more support for their own learning (Goos, Galbraith, Renshaw, & Geiger, 2000). The study shows that through participation in the OLC the teachers gradually transformed their participation from peripheral (novice) to full (expert) participation in promoting the use of technology for teaching mathematics. This finding supports Lave and Wenger's (1991) concept of teacher learning from sociocultural perspectives.

Section 8.2 summarises the key findings, which include aspects that facilitated and impeded teacher participation in the OLC, the activities that promoted teachers' professional learning, and the sociocultural perspectives in the development of teacher professional learning through participation in the OLC.

Section 8.3 presents the contributions this study has made to the academic research field. In Sections 8.4 and 8.5, the limitations and implications of this study are examined. Section 8.6 proposes recommendations for further research. Section 8.7 presents the conclusions drawn from this research.

8.2 Key Findings

Analysis from the theoretical and empirical perspectives led to the formation of a conceptual framework to answer the research questions posed. Teachers' professional learning with regard to using technology in the classroom through social participation in the OLC was examined using Tu and Corry's (2002) model of an OLC and Valsiner's (1997) zone theory. A sociocultural approach was used, positioning teacher professional learning as a sociocultural process. Three online learning environments were established to facilitate social learning interactions among teachers. Technology-based classroom teaching practices of teachers were observed, to understand how they used technology to support student learning and how their participation in the OLC affected their use of technology in their mathematics teaching practices.

The first subsidiary research question asked: *What were the facilitators and barriers to the teachers' participation in the OLC?*

Participating in the OLC offered opportunities for teachers to improve their professional learning. Factors that supported teachers' participation in the OLC are as follows:

Social knowledge construction. The construction of knowledge occurred through the to-and-fro conversations among teachers in their online discussion posts. This study provided evidence of the dynamics of conversations where a wide range of topics were discussed. Topics included pedagogical teaching strategies that were being used; identification and resolution of technical issues; identification of technological tools related to subject delivery; and clarifications on instructions on how to use these tools properly. These topics were all relevant to the context of the use of technology for teaching mathematics. This finding supports the work of Hoadley and Kilner (2005), who noted that conversations in an OLC are considered meaningful when the content is relevant to the community. The meaningful conversations allowed teachers to construct new understandings.

De-privatization of practice. Teachers de-privatized their practices through collaboration in a virtual space. They exchanged knowledge, shared teaching experiences, resolved problems and gave assistance to other teachers to improve their quality of teaching with the available technology infrastructure in different school settings. Posts, stories, photos and videos about teaching practices using technology shared on the OLC were artefacts for teacher learning. These artefacts exemplified the de-privatization of practice.

Reflection practice. Teachers performed *reflection-on-action* (Schön, 1987) of their teaching practices, based on self-evaluation or external inputs from community members. The findings of the current study showed that teachers used positive supports and constructive feedback from members of the OLC as evaluation material to improve the quality of their teaching practices.

Strengthened collegial relationships. In the online learning environment, teachers engaged in social interactions and mutually supported each other. Such activities built collegial relationships among various community members. This finding extends the results of other researchers (Harris & Anthony, 2001; Shah, 2012) and adds new knowledge related to the nurturing of collegial relationships not just through physical contact but also through interactive and critically reflective communication in virtual spaces.

Empowerment. Teachers were empowered by participating in the OLC, and they also encouraged others to use technology in their mathematics teaching. This study provided evidence that through the scaffolding and motivation teachers received in virtual spaces, they were empowered to create change in their instructional practices and work more effectively in using technology in their mathematics classrooms.

However, participation in the OLC for teacher professional learning did not come without challenges. Teachers faced some challenges that impeded them from participating in the OLC, as follows:

School facilities and school policies. Each school had a different policy in terms of the use of technology. Teachers whose schools restricted the use of Facebook proposed a WhatsApp group as an alternative online learning environment. The findings of the current study revealed that the use of an appropriate and permissible app made teachers more comfortable about engaging with other teachers in the OLC as they were not violating school policy.

The differences in technological resources in the schools also affected the participation of teachers in the OLC. The main technology issue faced by the schools was limited access to the Internet because schools' Wi-Fi did not reach classrooms. It generally only covered the staff room, the principal's office and the administration office. The findings of the current study showed that despite limited Internet access, teachers were able to deal with such situations by accessing apps only when they were in the area that was covered by Wi-Fi or by switching to their own personal data package to access the Internet and engage with online community members in the OLC.

A sense of independence for engaging in the OLC. Each teacher had different reasons to participate in the OLC. Although the five participant teachers knew the aim of their participation in the OLC, they were not inclined to independently engage in the social learning process without some form of positive encouragement from the researcher. Developing a sense of independence to engage actively in social learning interactions in the OLC was a long process. Each teacher had their own journey, which determined their work pace in getting involved in the OLC and ultimately how they used technology in their mathematics classes.

Cultural context. Indonesia consists of more than 600 ethnic groups, and at the national level Javanese make up the largest ethnic group, accounting for 40.2% of 236.7 million Indonesians (Arifin, Ananta, Utami, Handayani, & Pramono, 2015). Each ethnic group has its own characteristics. The participant teachers in the current study were Javanese. One of the personal characteristics of Javanese people is *ewuh pakewuh,* a shyness about expressing thoughts (Artiawati, 2017; Wati, 2014). The findings of the current study revealed that lack of experience and the cautious approach to expressing opinions were the most prominent factors that made the teachers feel *ewuh pakewuh*. Such feelings affected teachers' social learning interactions in the OLC.

Length of experience in teaching with technology and *technology skills levels* contributed to teachers' participation level in the OLC. Teachers who were less experienced in teaching with technology or who had a low level of technology skills tended to be passive in the OLC. However, the results of the current study showed that as their teaching experiences with technology increased and their technology skills gradually improved, the teachers became progressively more active in the social learning interactions.

Although these factors impeded the participation of teachers in the OLC, the teachers made efforts to overcome such barriers to enable ongoing engagement with community members in the OLC.

The second subsidiary research question was: *How did participation in the OLC promote professional learning in using technology in the mathematics classroom?*

Social learning interactions, online peer coaching and teacher collaboration were significant in promoting professional learning and facilitating the transfer of knowledge. This research showed that knowledge transfer led to significant changes in teachers' teaching practices with technology. The teachers were able to replicate or create appropriate teaching strategies and were able to select appropriate technological tools that matched their school conditions to help students meet specific learning goals. Student learning also received attention from the teachers. Also, there was visible improvement in the quality of teaching with technology.

The continuity of social learning interactions in the OLC was dependent on facilitating and hosting. The findings of the current study showed that support from people who took the role of facilitator and social host resulted in increased sustainment of teachers' online professional learning. The results of this study add new knowledge about ways for professional learning to occur. The teachers in this study predominantly participated in on-line learning within a virtual space, in contrast to participation in face-to-face TPD programmes. In Indonesia, the largest archipelago in the world, many teachers' work in dispersed and remote locations, which can cause mobility issues with regard to professional development (Sari, 2012). Schools usually send only one or a small number of representatives to attend face-to-face TPD because these programmes are frequently conducted in distant towns or cities. Also, the content delivery of the face-to-face TPD sometimes does not match actual school conditions. Teacher professional development within the OLC did not need personal attendance by teachers because the process of concept development and the acquisition of knowledge took place in a virtual space using technology as a communication tool. Teachers were able to access learning appropriate to their immediate and future needs in a way that improved their professionalism. Clearly, accessibility to the online discussions at any time ensured that the learning was relevant to their needs.

An important line of inquiry within mathematics teacher professional learning is concerned with promoting change in classroom practice. The main research question was: *How do teachers develop their professional learning in using technology in mathematics classrooms through their participation in an OLC?* Clearly, in the findings it can be seen that the teachers' participation in the OLC developed their professional learning, which brought about a change of practice in the classroom. This study provided evidence of the teachers' movement from peripheral to full participation. Some teachers became mediators in the online discussions by creating relevant topics related to their teaching experiences with technology. These teachers supported community members to interactively engage in the discussion and they built a sense of responsibility to jointly nurture the OLC.

The case-study teachers used the OLC-FB and the OLC-IM interchangeably. They shared artefacts such as videos, photos, stories, lesson plans, and other documents mostly on the OLC-FB. However, for discussion, teachers mostly used the OLC-IM because it was more private than the OLC-FB. Teachers used artefacts posted on the OLC-FB as learning resources. These artefacts gave additional impetus to teachers to improve their quality of teaching with technology. Using such learning resources enabled the teachers to reflect on and extend their own teaching.

Teachers preferred to discuss certain topics in the private learning community (OLC-IM). Within the private learning community, teachers had fewer feelings of *ewuh pakewuh* as they were able to openly express their thoughts in the discussions. The teachers in the private learning community had a shared vision to enhance the quality of their teaching of mathematics with technology. This shared vision tied the teachers together in a joint enterprise.

Although teachers had gone through the same experiences in integrating technology into their mathematics classrooms, their learning journeys were all different with regard to the ways they used and provided technology to their students. Some teachers used technology as a *partner* to facilitate their students with technology to work with mathematical tasks, while others shifted their mode of using technology as a *partner* to technology as *an extension of self*. In the latter, teachers themselves demonstrated how their use of multiple technological tools was integral to the production of students' cognitive skills in mathematics. Teachers showed a variety of teaching practices with technology. It can be said that participation in the OLC expanded teachers' knowledge of pedagogical practices in using technological tools. Further, participation in the OLC helped to increase teachers' confidence levels. Teachers became more confident to show their abilities in employing new technological tools for teaching purposes. They were also more confident to deal with technical problems faced during the implementation of technology in their classrooms.

Teachers' participation in the OLC encouraged them to continue exploring new ideas in using technological tools to support their mathematics teaching practices. This research showed that teachers continued to post stories about their teaching activities in using technology even after classroom observations had finished. Teachers have remained interested in creating learning innovations with technology for the purpose of improving their professional competencies. This evidence indicates that the OLC provided ongoing informal professional development for teachers.

Understanding of teacher professional learning in the use of technology has been examined using zone theory. In this study, the zone theory was extended. In this regard, the zone theory provided a useful framework for understanding teachers' learning and development in virtual learning communities. Teachers who participated in the OLC were able to negotiate the zone of free movement (ZFM) and the zone of promoted action (ZPA), which structures opportunities for teacher change in their practices with technology. Teachers' ZFMs were shaped by the affordances and barriers in their professional context, while teachers' ZPAs were sources of assistance offered by members of the OLC to promote professional learning. The barriers to participating in the OLC affected the teachers' professional learning, which caused tensions. Tensions were considered productive when they brought about change (Goos, 2013). Modifying the environment (ZFM) and looking for professional learning opportunities (ZPA) were effective in generating productive tensions, which created possibilities for teachers to change and promoted the desired development. Models of online teacher professional learning offered opportunities for teachers-as-learners to fashion ZFM/ZPA complexes that created a set of possibilities to extend teachers' zones of proximal development (ZPD). Teachers' ZPD elements, in this regard, included the development of new knowledge, beliefs, and practices as well as the improvement of self-efficacy and skills in working with technology. The findings of this study provided evidence that online teacher professional learning in a virtual space has the potential to stimulate teachers to continually transform their ZPD and gradually transform their professional practices.

8.3 Contributions

Teacher professional learning is "an internal process through which individuals create professional knowledge" (Timperley, Wilson, Barrar, & Fung, 2007, p. 3) and which has an impact on teachers' professional development. This is part of the continual process of teachers becoming better educators. In the 21st century, the presence of technology has changed the possibilities for how teacher professional development can be designed. An online teacher professional learning model can become an alternative way for teachers to improve their professionalism. Tu and Corry (2002) go so far as to argue that an OLC is becoming an essential concept in the current technology-based learning. However, there appear to be limited studies that have explored how teachers develop their professional learning through participation in OLCs. Nor do there appear to be many studies that explore how teachers implement the new knowledge learned in the OLC in the mathematics classroom.

Particularly in Indonesia, teacher professional development is mostly conducted in conventional ways. In more recent times, Widodo and Riandi (2013) report that some online teacher professional development programmes are being gradually introduced. However, the impact of online teacher professional development has not been investigated, nor have its outcomes in classrooms been explored. This study, while promoting the use of technology in mathematics classroom to support student learning, also sought to understand and explain how mathematics teachers' professional learning in Indonesia is enabled through participation in an OLC.

This study makes the following contributions:

1. Empirical evidence revealed that factors that impeded teachers' participation in the OLC were school facilities and school policies; a sense of dependence preventing them from openly engaging in the OLC; the cultural context (for example, hesitation in making adverse comments); length of teaching experience with technology; and levels of technology skills. These factors made teachers find alternate ways to increase their level of participation in the OLC. Further, facilitating participation in the OLC enabled teachers to construct knowledge, de-privatize practice,

reinforce collegial relationships, be empowered and empower others to use technology for teaching mathematics. These factors positively affected how teachers promoted their professional learning within the OLC. The community members also built a strong shared vision and a sense of purpose, which enabled them to optimise their potential in learning within the virtual learning environment.

2. This study illustrated the impact of teacher participation in an OLC that promoted technology use for teaching mathematics. It is significant in the way it provides knowledge to support others to understand and explain how participation in the OLC affected teachers' learning in terms of transforming mathematics classroom practices with technology. This study was conducted in a developing world context and may inform government and policy makers on future education growth and expansion plans.
3. The research study provided network patterns to portray the social learning interactions of the participant teachers in the OLC. The network patterns helped to investigate community members who had central positions. This study provided evidence that as teachers gradually improved their teaching experiences with technology and with technology skills, they progressively moved towards the centre. Some teachers attained central positions that enabled them to eventually replace the researcher as mediator in the OLC. A sense of ownership towards the OLC grew as they took the role of mediator. Taking the role of mediator, the teachers not only learned; they also facilitated and supported others to become more active in social learning interactions. The findings of the current study showed teachers themselves contributed to nurturing the OLC.

4. The OLC provided ongoing informal professional development. An OLC helps meet teachers' professional development needs because their engagement is driven by "real-world" issues that are relevant to their personal development. This research study provided evidence that teachers kept renewing themselves in using technology for teaching mathematics even though the researcher was no longer observing their classes. Technology as the main medium of the OLC enabled teachers to maintain engagement with other community members virtually at any time. This finding indicates that learning in an OLC is promising because learning can be conducted anytime and anywhere and it does not require a personal presence. Teachers can continue to explore and discover relevant information in the OLC to construct their knowledge and meet their professional needs.
5. This study has provided sociocultural perspectives in research on mathematics teachers using Valsiner's (1997) zone theory approach. Although some researchers extended the use of Valsiner's zone theory for several purposes (Blanton et al., 2005; Geiger et al., 2017; Goos, 2013; Patahuddin, 2013), it appears that zone theory was generally used to understand the process of teacher professional learning in face-to-face professional development. In this study, zone theory was applied to professional learning in an OLC. This study also adapted Tu and Corry's (2002) model of an OLC, which provided insight on how the four elements of the OLC (i.e., community, learning, network, and technology) have an impact on the social learning process. Tu and Corry's OLC model provided understanding of how social learning interactions occurred

within the OLC, while Valsiner's zone theory guided the examination of how the participation of teachers in the OLC helped them to develop their professional learning in the integration of technology into their mathematics classrooms.

8.4 Limitations

This study provided strong evidence of teachers' professional learning in the OLC improving the quality of mathematics teaching with technology. However, there were some limitations to this research that should be considered. The results of this research are based on empirical analysis of a small sample of five teachers and five schools in three rural and two urban areas of a city. The study participants belonged to one ethnic group, native to the Indonesian island of Java. Given the study constraints, the generalisability of the findings for educators in other social contexts, different schools and different cultural settings may be limited. However, the findings showed that teachers with different levels of skills and different lengths of experience working with technology had benefited from this model of an OLC. It therefore allows others to trial a similar study. Notwithstanding the limitations, this study can be a stepping-stone for further research on teacher professional learning through OLCs in the same context in Indonesia and in other countries.

Online learning environments and classrooms are complex environments in which many things happen simultaneously. Interpretation of the results in this study, therefore, can only provide an emerging understanding of social learning interactions relevant to the promotion of the use of technology for teaching mathematics as well as the technology-based pedagogical practices in the mathematics classroom. Further, the multiple roles taken by the researcher as a participant observer and a facilitator may have caused biased assumptions that affected data collection and data analysis processes. Although triangulation methods were used, the possibility of bias in the results of this research also needs to be considered. The findings are based on one researcher's interpretation of empirical data gathered from a wide range of data sources including field notes, interviews, teacher stories, surveys, documents, and online posts. A deductive content analysis approach was used to make robust interpretations of how teachers enhanced their classroom practices and collaborated with each other in the OLC.

Technology, as the backbone of an OLC, was necessary to facilitate flexible and ongoing professional learning activities. However, not all schools had easy access to technology, and some teachers had less experience with technology than others. Therefore, teachers had different levels of participation in the OLC. Also, teachers were more comfortable participating in the small (private) community than in a big (public) community. Participation in the private online community made teachers more open and receptive to receiving feedback compared to participation in the public online community. This kind of OLC affected teacher's professional learning. Technology access and technology competency became prerequisites for teachers to participate in the OLC to optimise the potential of the OLC for the development of teachers' professional learning. This research used Facebook and WhatsApp apps to establish the OLC. Consideration needs to be given to schools that have policies on restrictions on the use of Facebook in the schools. Therefore, teachers were asked to use multiple apps to engage with the community.

8.5 Implications and Further Research

Teacher professional learning is an ongoing process in which teachers stimulate their cognitive thinking and professional knowledge to make sure that their practice is critically informed and up-to-date. Professional development likely has little impact without professional learning. Therefore, teacher professional development should be designed to encourage personal learning experiences. Evidence from this study suggests that it is the teachers themselves who are responsible for improving their professionalism on an ongoing basis. An OLC-based model becomes an alternative for teacher professional learning to develop the professionalism of teachers. It was evident in this study that the OLC-based model enabled secondary school mathematics teachers to develop their professional competencies, increase self-efficacy and reinforce collegial relationships, and gave equal opportunities for teachers from rural and urban areas to develop. It is important to extend this knowledge base beyond secondary schools located in urban and rural areas.

Evidence from this study demonstrated that cultural context has a significant impact on teacher professional learning within an OLC. When the OLC is set up, everybody can participate in it. The case studies in this research were all from the Javanese ethnic group, and the majority of the participant teachers were male. Additional research needs to incorporate understandings developed in this study regarding the development of online professional learning to constitute broader understandings with different ethnic groups and based on gender differences.

The significance of de-privatized practice is one of the profound findings in this research on teacher professional learning within an OLC. De-privatization of practice makes teachers' practices more exposed and visible. This exposure enables teachers to work with other teachers in sharing ideas, skills, and practices (Campbell, Saltmarsh, Chapman, & Drew, 2013). This notion of de-privatization of practice is significant for the learning process as it potentially improves teaching practice; therefore it is significant for pre-service/student teachers too. It is important to extend this base of knowledge beyond the in-service teacher learning context, to seek understanding of the impact of de-privatization of practice for teacher education.

The success of teacher professional development programmes in Indonesia is often measured on the basis of teacher understanding and competence, without giving sufficient attention to whether or not these teachers are motivated to keep on learning. An OLC-based model can be an alternative way to empower teachers to promote their professional learning continually. It can also be used to complement other forms of TPD programmes managed by the Government and educational agencies. It must be noted though that when OLC model is used, the participation of teachers becomes a key factor for the success in the development of teachers-as-learners. Evidence from this study has also showed that the role of a mediator and social host in the OLC is crucial for the success of teacher professional learning. This role of the mediator is significant to ensure that the ongoing social learning interactions are maintained to keep the OLC alive. Therefore, understanding needs to be extended to examine how teachers will mediate social learning interactions and to what extent their role affects the growth and sustainability of the OLC.

Teachers identified various teaching strategies to overcome their differences in school facilities and school policies during their professional learning journeys. Evidence from the study has shown that despite the lack of facilities (like poor connectivity and availability of few devices), teachers improvised and made prior plans to address these limitations for using technology in mathematics classroom teaching. Therefore, it is important to extend this knowledge base to seek understanding of how teacher's professional learning can be improved despite them having limited school resources.

8.6 Concluding Words

The intention of this research was to examine the development of teacher professional learning through social participation in an OLC for the promotion of the use of technology for teaching mathematics. The affordances and barriers factors that affected teacher participation in an OLC in Indonesia were presented. Some collective activities in social learning interactions that promote the professional learning of teachers were also investigated.

The alteration of teachers' mode of working from using technology as a partner to using technology as an extension of self was evidence of teacher change in the use of technology for instructional practices. This process of teacher change was directly linked to the social participation activities in teacher professional learning in the OLC. Teachers were able to independently continue to improve themselves in teaching with technology while participating in the OLC is also evidence of the evolutionary process of teachers developing their professional learning. Teachers gradually moved from peripheral to full participation in the OLC. This changing participation was part of the teachers' learning outcomes from a sociocultural perspective. This research study has provided evidence that teacher professional learning within the OLC contributed to ongoing teacher professional development in Indonesia.

Of particular importance for Indonesian teachers is that the findings of this research provide an OLC-based model that could be implemented in other contexts that share similar technology landscapes and sociocultural heritages. This type of teacher professional learning model can complement the existing face-to-face teacher professional development practices. It is in that sense that the findings can be applied for re-envisioning future teacher professional development.

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APPENDICES

APPENDIX A: Full Ethics Approval Letter

MASSEY UNIVERSITY
ALBANY

12 January 2016

Zaenal Abidin
[redacted]

Dear Zaenal

HUMAN ETHICS APPROVAL APPLICATION – NOR 15/060

Online community of practice: Leveraging information and communication technology for reflective practice in promoting mathematical literacy

Thank you for your application. It has been fully considered, and approved by the Massey University Human Ethics Committee: Northern.

Approval is for three years. If this project has not been completed within three years from the date of this letter, a re-approval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Andrew Chrystall
Chair
Human Ethics Committee: Northern

cc Dr Anuradha Mathrani, Dr Suriadi Suriadi
School of Engineering & Advanced Technology
Albany Campus

Professor Don Cleland
Head of School of Engineering & Advanced Technology
Palmerston North

Te Kunenga ki Pūrehuroa

Research Ethics Office
Private Bag 102 904, Auckland, 0745, New Zealand Telephone +64 9 414 0800 ex 43276 humanethicsnorth@massey.ac.nz

APPENDIX B: Low Risk Notification of Preliminary study

MASSEY UNIVERSITY
ALBANY

18 March 2015

Zaenal Abidin
c/: School of Engineering and Advanced Technology
ALBANY CAMPUS

Dear Zaenal

Re: Mobile-Assisted Mathematical Literacy: Analysing the use of Mobile Learning in Mathematics

Thank you for your Low Risk Notification which was received on 18 March 2015.

Your project has been recorded on the Low Risk Database which is reported in the Annual Report of the Massey University Human Ethics Committees.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

> *"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.*
>
> *If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director (Research Ethics), telephone 06 356 9099, extn 86015, e-mail humanethics@massey.ac.nz".*

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to provide a full application to one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

B T Finch.

Brian T Finch (Dr)
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

cc Professor Don Cleland
School of Engineering and Advanced Technology,
PALMERSTON NORTH

Massey University Human Ethics Committee
Accredited by the Health Research Council

APPENDIX C: Teacher Information Sheet and Consent Form

TEACHER INFORMATION SHEET

Researcher Introduction

I am Zaenal Abidin, a PhD candidate in Massey University, Albany, New Zealand. The following research is conducted in partial fulfilment of the requirements for completing a Doctorate degree.

Project Description and Invitation

The advent of information and communication technology (ICT) has brought significant changes in education domain, especially in the field of mathematics education. The presence of ICT offers new directions for teachers to revisit and evaluate mathematics lessons to align them closer to real-world contexts. The national curriculum of Indonesia mandates that teachers should be able to integrate ICT within instruction. However, the implementation of technology integration in Indonesia school faces challenges such as lack of schools' facilities and low-level technology skills of teachers (UNESCO-UIS, 2014). Therefore, it is important to make some breakthrough such as making initiatives to improve teacher capabilities with technology through teacher professional learning to meet the desired expectations.

This research set out to examine teachers' professional learning journeys within the online community of practice (CoP) in which teachers shared their practices related to the integration of technology in the mathematics classroom. The research will investigate aspects that facilitate and impede teachers' participation in the online CoP in promoting their professional learning. Also, the study will examine of how participation in the OLC impacted on promoting teacher professional learning in their use of technology in the mathematics classrooms.

I cordially invite you to be a research participant in this research. The research is intended to examine teacher professional learning through participation in the online CoP for the promotion of technology usage in the mathematics classroom.

Participant Identification and Recruitment

Research participants in this study are mathematics teachers' Junior High School in Semarang, Central Java Indonesia. The teachers participate voluntarily in this study by providing some personal information such as prior technical skills and knowledge, management skills and knowledge related to ICT, and skills of using ICT in practice. The number of participants is five teachers. The number of participants is determined based on Daniel (2012: p.243) method. He suggests that participants for case study research are about 3 to 5 participants.

Project Procedures

Information will be collected from the fieldnotes of classroom observations and also series of interviews with the teachers. The classroom observation takes approximately 120 minutes and the interviews will be performed after some classes and each interview will take at most 20 minutes.

Research participants will be encouraged to actively participate in the online CoP (closed-Facebook group) where they reflect on their mathematics teaching practices with technology applications. Reflection will be done through discussion with other members of the online CoP.

Data Management

The obtained data will be stored in locked drawer. It will be disposed of completely following Massey University procedure for disposal of confidential documents when the thesis has been published. Insights obtained from analysis of the data will be published in conference proceedings and journals; however, all research participants will remain anonymous and their identity will be kept confidential.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study until two weeks after the end of data collection;
- ask any questions about the study at any time during participation;

Regarding the interview process, you may ask for recorder to be turned off at any time during the interview. If you would like to obtain a summary of the findings of the research please contact the researcher at the following email address, Z.Abidin@massey.ac.nz.

Project Contacts

Please contact the researcher, Zaenal Abidin or my supervisors, if you have any questions about this study.

Researcher:

- Zaenal Abidin (Z.Abidin@massey.ac.nz)

Supervisors:

- Dr. Anuradha Mathrani, Senior Lecturer, School of Engineering & Advanced Technology Email: A.S.Mathrani@massey.ac.nz
- Dr. David Parsons, National Postgraduate Director, The Mind Lab by Unitec
  Email: david@themindlab.com
- Dr. Suriadi, Lecturer in Information Technology, School of Engineering & Advanced Technology
  Email: S.Suriadi@massey.ac.nz

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 15/060. If you have any concerns about the conduct of this research, please contact Dr Andrew Chrystall, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x 43317, email humanethicsnorth@massey.ac.nz.

CONSENT FORM FOR PARTICIPANT TEACHERS

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction.

I also acknowledge that:

- My participation in this study is voluntary.
- I may ask further questions at any time.
- I understand that the participation in the research project will involve classroom observations, interviews, and questionnaire surveys.
- I understand that the information provided will be kept confidential, and that my identity will not be disclosed without consent.
- I understand that the information provided will only be used for the purposes of this research project, and understand how the information is to be used.
- I understand that I am free to withdraw from the study until two weeks after the end of data collection.

Please check (✓) that apply.

- The classroom activities being videotaped during mathematics lesson.
  ☐ I agree ☐ I do not agree
- The interview being sound recorded
  ☐ I agree ☐ I do not agree

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature : ____________________ **Date**: ____________________

Full Name – printed : ____

Any further questions please contact:

Zaenal Abidin
School of Engineering and Advanced Technology
Massey University, Albany, New Zealand 0632
Building 106, Room 106.20C, Albany (Oteha Rohe)
Ph: +64 22 389 5810 Email: Z.Abidin@massey.ac.nz

APPENDIX D: Information Sheet for Parents/Guardians, and Consent Form for Parents/Guardians and Assent Form for Students

INFORMATION SHEET FOR PARENTS/GUARDIANS

Researcher Introduction

I am Zaenal Abidin, a PhD candidate in Massey University, Albany, New Zealand. The following research is conducted in partial fulfilment of the requirements for completing a Doctorate degree.

Project Description and Invitation

This research set out to examine teachers' professional learning journeys within the online community of practice (CoP) in which teachers shared their practices related to the integration of technology in the mathematics classroom. The research will investigate aspects that facilitate and impede teachers' participation in the online CoP in promoting their professional learning. Also, the study will examine of how participation in the OLC impacted on promoting teacher professional learning in their use of technology in the mathematics classrooms.

In teaching and learning process, teacher's classroom activities may be recorded as part of their teacher's record of practice. Your child's involvement will be no more that which occurs in normal daily mathematics. The video recording would occur during mathematics teaching involving the use of technology only. You will get parental consent form to be filled whether or not the teacher's classroom activities can be recorded. If you do not give consent to the teachers then the teachers will not record their classroom activities. The teachers will also conduct formative assessments and the results of the assessments will be shared to the researcher. In the same parental consent form, you will also be asked to give or not give permission to the teachers to share the results of formative assessments of your child to the researcher. The teachers can share students' formative assessment results to the researcher only for those parents who give consents.

Your child will get student consent form asking whether or not he/she wants to take part in the study. If your child does not give assent to be involved in the study, then he/she will still need to participate in the learning process because it is not possible to pull them out from the class. However, for those students, their study details will not be included in the analysis process of the study.

Participant Identification and Recruitment

Student participants in this study are students from five Junior High Schools in Semarang, Central Java, Indonesia.
Your school **<name of school>** has agreed to participate in this research study to understand how technology-enabled teaching delivery can be made more effective for student learning.

I would like to advise you that there is no expectation of any discomfort to any student.

Project Procedures

Information will be collected from formative assessments which are given by the teachers to the researcher. Formative assessment will be conducted during the school time-frame and duration for completing formative assessments will follow the school defined curriculum standard. Researcher may record teacher's classroom activities for the purpose of this research. Students would not disadvantage their learning process.

Data Management

The obtained data will be stored in locked drawer. It will be disposed of completely following Massey University procedure for disposal of confidential documents when the thesis has been published. Insights obtained from analysis of the data will be published in conference proceedings and journals; however, all research participants will remain anonymous and their identity will be kept confidential.

Participant's Rights

You are under no obligation to accept this invitation. If you decide to give consent to your child, they have the right to:

- decline to answer any particular question;
- withdraw from the study until two weeks after the end of data collection;
- ask any questions about the study at any time during participation;

If you would like to obtain a summary of the findings of the research please contact the researcher at the following email address, Z.Abidin@massey.ac.nz.

Project Contacts

Please contact the researcher, Zaenal Abidin or my supervisors, if you have any questions about this study.

Researcher:

- Zaenal Abidin (Z.Abidin@massey.ac.nz)

Supervisors:

- Dr. Anuradha Mathrani, Senior Lecturer, School of Engineering & Advanced Technology Email: A.S.Mathrani@massey.ac.nz
- Dr. David Parsons, National Postgraduate Director, The Mind Lab by Unitec
  Email: david@themindlab.com
- Dr. Suriadi, Lecturer in information technology, School of Engineering & Advanced Technology
  Email: S.Suriadi@massey.ac.nz

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 15/060. If you have any concerns about the conduct of this research, please contact Dr Andrew Chrystall, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x 43317, email humanethicsnorth@massey.ac.nz.

CONSENT FORM FOR PARENTS/GUARDIANS OF STUDENTS

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction.

I also acknowledge that:

- I understand that my child's formative assessments grades will be shared with the researcher for the purpose of his research in promoting mathematical literacy in schools.
- I understand that the teacher may record their teaching and learning activities.
- I understand that the information provided will be kept confidential, and that my child's identity will not be disclosed without consent.
- I understand that the information provided will only be used for the purposes of this research project, and understand how the information is to be used.
- I understand that my child has optional not take part in the study but he/she still be able to participate in the learning process as normal.

I (give / do not give) permission to the teacher to make recordings of my child's learning activities in the classroom.

I CERTIFY THAT I AM 18 YEARS OF AGE OR OLDER AND THAT I HAVE READ, FULLY UNDERSTAND AND AGREE TO THE TERMS OF THIS AGREEMENT, AND I SIGN IT VOLUNTARILY WITH FULL KNOWLEDGE OF ITS SIGNIFICANCE.

Name of child : ____

School : ____________________ **Class** : ________________________

Signature : ____________________ **Date** : ________________________

Full Name : ____

Any further questions please contact:

Zaenal Abidin
School of Engineering and Advanced Technology
Massey University, Albany, New Zealand 0632
Building 106, Room 106.20C, Albany (Oteha Rohe)
Ph: +64 22 389 5810 Email: Z.Abidin@massey.ac.nz

ASSENT FORM FOR STUDENTS

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction.

Regarding the involvement of this study, please check (✓) that apply.

☐ I agree ☐ I do not agree

Signature : ____________________ **Date** : ______________________

Full Name : ____

Any further questions please contact:

Zaenal Abidin
School of Engineering and Advanced Technology
Massey University, Albany, New Zealand 0632
Building 106, Room 106.20C, Albany (Oteha Rohe)
Ph: +64 22 389 5810 Email: Z.Abidin@massey.ac.nz

APPENDIX E: Survey Questions of the Preliminary Study

Respondent No :	
Date Completed	: / / 2015

TEACHER QUESTIONNAIRE

Please fill out this survey to the best of your ability by crossing (✕) a box. For some questions, you will need to write a brief answer.

For the purpose of this study, "mobile device" include any handheld device capable of multiple functions, including but not limited to accessing the internet, running applications, listening to music, etc. examples include smartphone, tablet or similar devices.

RESPONDENT INFORMATION

1. School Name : ______________________________
2. Gender : ☐ Male ☐ Female
3. Age : ☐ Under 20 ☐ 20 – 29 ☐ 30 – 39 ☐ 40 – 49 ☐ 50 or Over
4. Qualification : ☐ Bachelor's degree ☐ Doctoral degree ☐ Master's degree ☐ Other
5. Year of Service : ☐ Less than 5 years ☐ 11 – 20 years ☐ 5 – 10 years ☐ more than 20 years
6. School locations : ☐ Rural ☐ Urban
7. Do you have a teacher's certificate from the teacher certification program?
   ☐ Yes ☐ No (go to question no. 9)
8. Is the subject you teach similar to the subject on your certification?
   ☐ Yes ☐ No, please specify: ____________________

Section 1: MOBILE DEVICE USAGE & CHALLENGE

9. How often do you carry a mobile device around?
   ☐ I don't own one (skip all your questions below) ☐ Occasionally
   ☐ Never ☐ Always
   ☐ Seldom
10. Which of the following mobile devices do you currently use? (*check all that apply*)
    ☐ Tablet (e.g., iPad, Galaxy Tab, Kindle Fire, Nexus, Blackberry PlayBook)

☐ Smartphone (e.g., iPhone, Android Phone, BlackBerry, Windows Phone)

☐ Internet-enabled basic phone (e.g., Symbian phone)

☐ I don't have a mobile phone with internet capabilities (go to question no. 12)

11. To what degree do you use your mobile device for the following activities?

Activities	**Never**	**Seldom**	**Occasionally**	**Always**
Social networking	☐	☐	☐	☐
Reading content (e.g., e-book, articles, etc.)	☐	☐	☐	☐
Accessing email	☐	☐	☐	☐
Text messaging	☐	☐	☐	☐
Searching for information	☐	☐	☐	☐
Getting directions	☐	☐	☐	☐
Uploading content	☐	☐	☐	☐
Playing games	☐	☐	☐	☐
Listening to music or watching videos	☐	☐	☐	☐

12. When and where do you find yourself using your mobile device? (please briefly describe the situations/environments in which you use it)

13. Have you ever used mobile device for your mathematics teaching and learning activities?

☐ Yes ☐ No

If yes, could you explain your experiences in using mobile device in mathematics teaching and learning activities?

a. What was the specific material?

____

____

b. What grade of your students? (*check all that apply*)

☐ VII ☐ VIII ☐ IX

c. What type of mobile device did you use? (*check all that apply*)

☐ Tablet (e.g., iPad, Galaxy Tab, Kindle Fire, Nexus, Blackberry Playbook)

☐ Smartphone (e.g., iPhone, Android Phone, BlackBerry, Windows Phone)

☐ Internet-enabled basic phone (e.g., Symbian phone)

d. What sort of activities? (*check all that apply*)

☐ Indoor ☐ Outdoor ☐ Formal ☐ Informal

e. What pedagogy strategies did you use? Please explain.

14. What challenges do you face when you employ/could employ mobile devices for teaching and learning in your mathematics class? (*check all that apply*)

☐ School prohibits the use of mobile devices in classroom because it will distract from learning

(e.g., phones ring during class, texting and checking incoming phone messages in the classroom).

☐ Concerns about cyberbullying or sexting using mobile devices.

☐ Concerns about the use of mobile devices for cheating.

☐ Lack of technology (students do not have mobile device, school have insufficient / do not have mobile device).

☐ Lack of access to available mobile technology in which teachers/students can access mathematics learning resources.

☐ I have no enough time to engage with mobile technology for preparing mathematics materials.

☐ Lack of technical support to assist teachers in using mobile devices for teaching and learning of mathematics.

☐ I am not familiar with the pedagogy of using mobile technology.

☐ I have not enough knowledge and skill to utilise technology to accomplish mathematics tasks.

☐ I cannot organize the mathematics class effectively when using mobile technology in the classroom.

☐ Principal does not understand mobile technology so that the use of mobile technology in the classroom is restricted.

☐ I dislike mobile technologies.

☐ I do not believe the use of mobile technology is of value.

☐ I am not enthusiastic towards using mobile devices in mathematics classes since mathematics exams prohibit students from using technology.

☐ School does not have enough wireless bandwidth for accessing resources using mobile devices.

☐ Others, please specify

Please provide your contact number or email in a box below if you are willing to be interviewed. I may contact you for a short interview.

*** Thank you for participating in this survey ***

APPENDIX F: Open-Ended Survey Questions of the Main Study

1. What do you think about this online learning community for the development of your professional learning?

2. What kinds of challenges do you face in participating in the online learning community and how do you overcome the challenges?

3. What kinds of actions/activities do you think significant for the development of the online learning community for enhancing teacher professional learning?

4. How have you used technology in supporting your mathematics teaching practice while participating in the online learning community?

5. How much is the impact of participation in the online learning community towards the improvement of the quality of your technology-based teaching and learning?

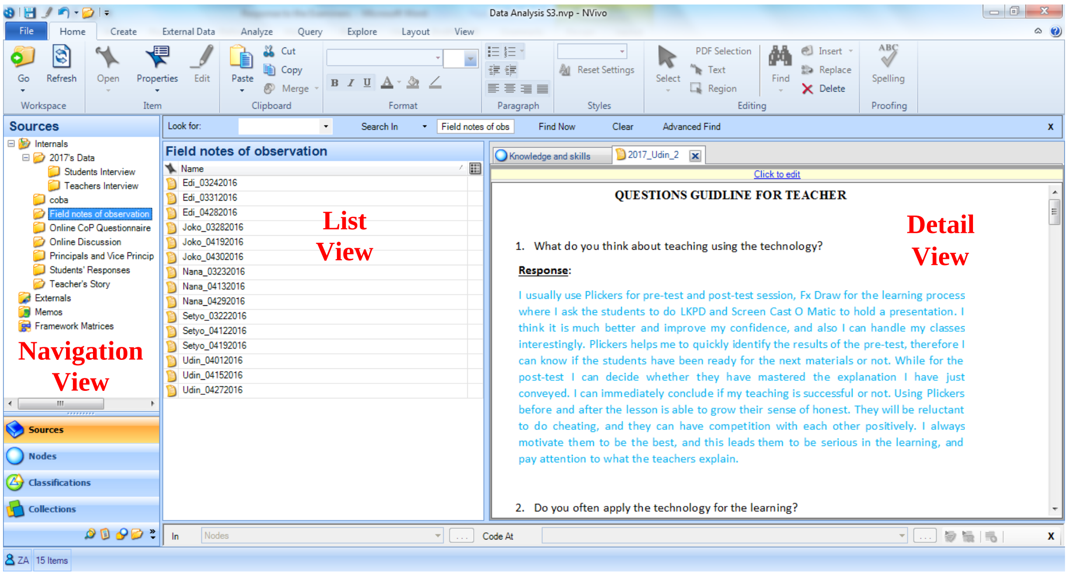
APPENDIX G: List of Categories of Data

No	Category	Subcategory	Sample reference
1.	Knowledge and skills	▪ Teachers enable to identify which technologies are needed to support specific curricular goals.	*I have used GeoGebra application in learning about central angle and circumference; I also used media of Screencast-o-Matic to record lesson material that I used on Group Facebook for giving online material.*
		▪ Teachers use certain software they familiar with.	*I am comfortable using PowerPoint because I have many experiences working with this program.*
		▪ Teachers enable students to use appropriate technologies in all phases of the learning process including exploration, analysis, and production.	*I usually use Plickers for pre-test and post-test session, FX Draw for the learning process where I ask the students to do LKPD* [student worksheet] *and Screencast-o-Matic to hold a presentation. My students practise to use these technological tools in their learning in the classroom.*
2.	Self-efficacy	▪ Teachers less fearful and more comfortable in using technology.	*I am comfortable using PowerPoint because I have many experiences working with this program.*
		▪ Teachers feel more confident to try new ideas in using technology in their classrooms.	*I am getting more confident to use technology, and I am no longer afraid to invite the teachers from other schools also to use technology for their learning.*
3.	Pedagogical belief	▪ Teachers perceive technology can help them achieve the instructional goals.	*I use the Socrative app for mathematics drill-and-practice activities so that students are accustomed to working with computers. The students use their own laptops for learning activities.*
		▪ Teachers make value judgments about whether that approach or tool is relevant to their goals.	*I chose the Plickers app because students do not need to bring mobile phones. The internet connection can be optimised. It is suitable for my school conditions.*
		▪ Teachers more implement more student-centred or high-level technology uses.	*I let my students to use GPS-Field Area and Smart Protractor App in a small group in outdoor classroom activities. They could find mathematics solutions of given real-world mathematics problems by using those tools.*

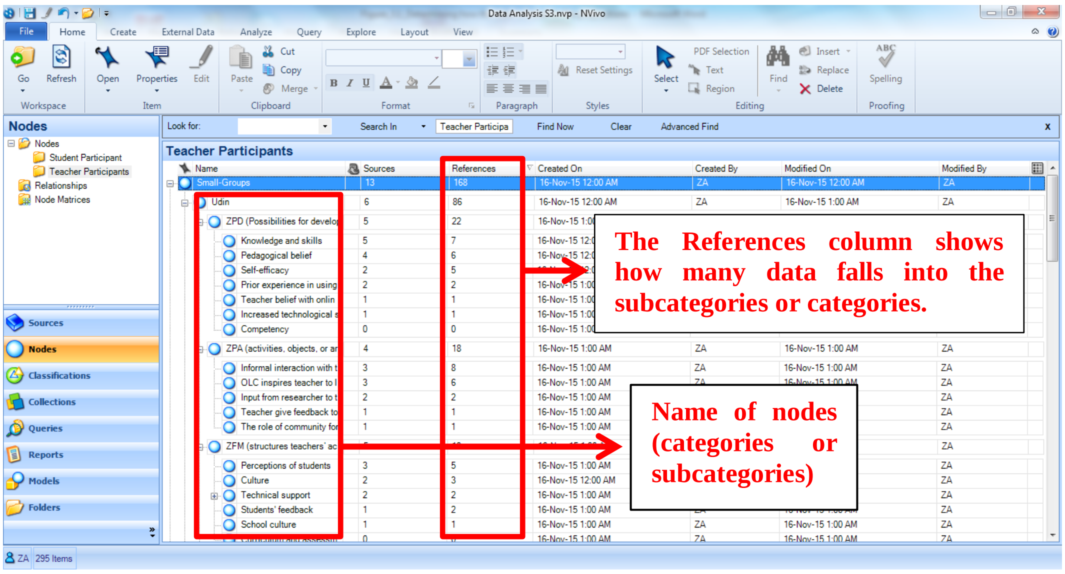
No	Category	Subcategory	Sample reference
4.	Culture	▪ Teachers adopt a technology that seems compatible with the norms of the subject culture.	*I was afraid to access FB Messenger at school because my friends will notice that I am online. They will admonish me if I get caught.*
		▪ Teachers use of technology depends on interlocking culture, social and organisational contexts	*I am not accustomed to giving comments directly on Facebook Group. I feel "pakewuh"* [feeling uncomfortable] *to give feedback in public* [a group with the wider community] ... *I am more comfortable to discuss it in person or a private group such as in WhatsApp Group or Facebook Messenger.*
5.	Problem solving	▪ Teachers identify problem during the implementation of technology	*Internet access in my school is very limited, and Wi-Fi could only be accessed in the teachers' office, while the class used for this observation was quite far from it, and was not reachable by Wi-Fi connection at all*
		▪ Teachers provide solution towards the technical problems on the OLC	*Yesterday, I used the Plickers app. Preparation that must be done: (1) Make sure that the internet is fine; (2) The connection between the Plickers app on the smartphone and laptop is good; (3) The Plickers card must be distributed before the lesson is started; (4) when scanning students' responses make sure that the students hold the card correctly as instructed.*
6.	Sustained examination of practice	▪ Teachers point out something important that could be apply to their own practices	*When watching* [teaching] *video, I felt like I am in that actual classroom. The video enabled me to identify the things that need to be prepared when integrating technology into the classroom.*
		▪ Teachers reflect on their teaching after watching other's teaching video	*I am very interested in Edi's teaching video, which was posted on Facebook* [OLC-FB]. *Edi uses the Socrative app, and his class looks so enthusiastic and gets into the learning.*
7.	De-privatization of practice	▪ Teachers expose his teaching aid in public and made it more visible	*The students will learn about constructing angles. The tools to be used in this learning are as follows:* *1. GeoGebra software version 5 as a means for learning this process* *2. A student worksheet* *3. A compass, a ruler, and a protractor* *4. A Plickers app, Plickers*

No	Category	Subcategory	Sample reference
			cards, and a tablet. These tools will be used for assessment, including apperception and post-test.
		▪ Teaching video posted on the OLC give a market value for school	*It* [Setyo's teaching video] *was of benefit for me in my existence of being a teacher. Also, as a teacher, the video has a market value for the private school I have dedicated my teaching to*

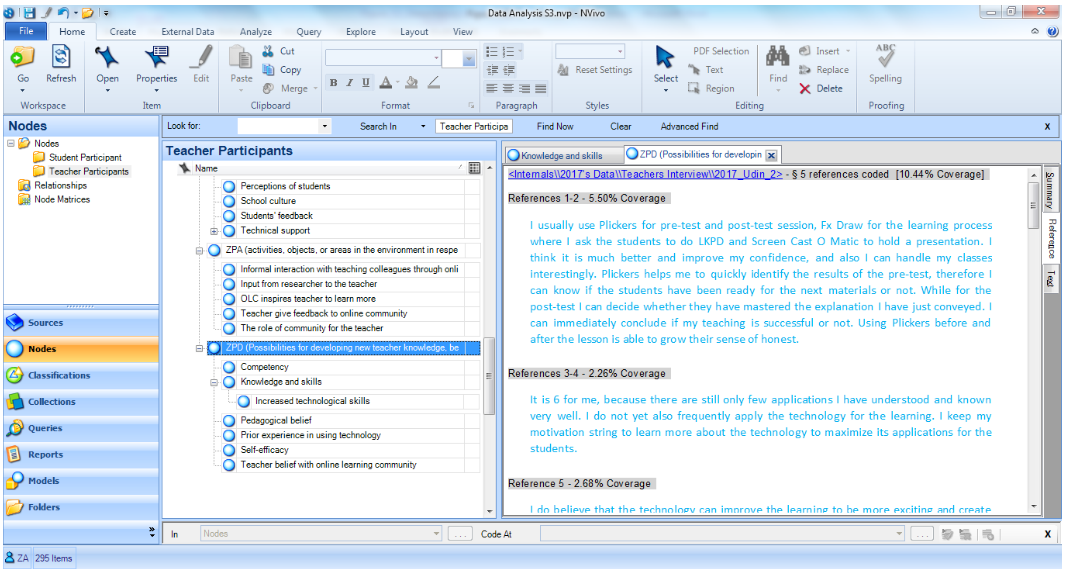
APPENDIX H: Data Management and Analysis with NVivo



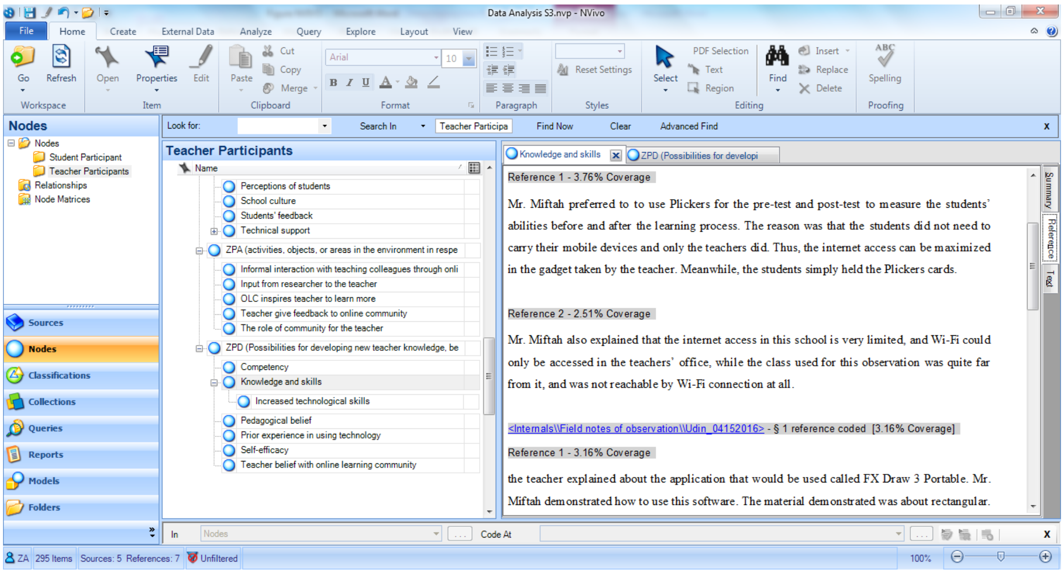
The NVivo workspace showing the ribbon, and Navigation, List and Detail Views where research data are managed



Codes emerge from the data stored in Nodes in the NVivo

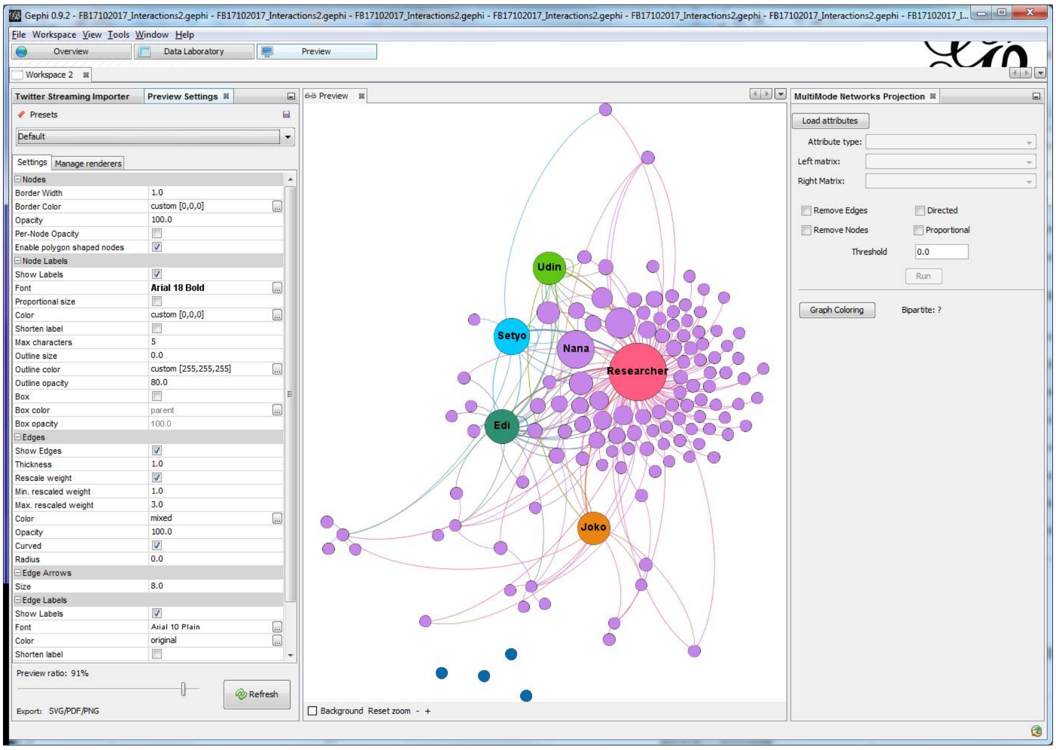


The categories "ZPD" involved some subcategories and covered both single lines of words and chunks of text



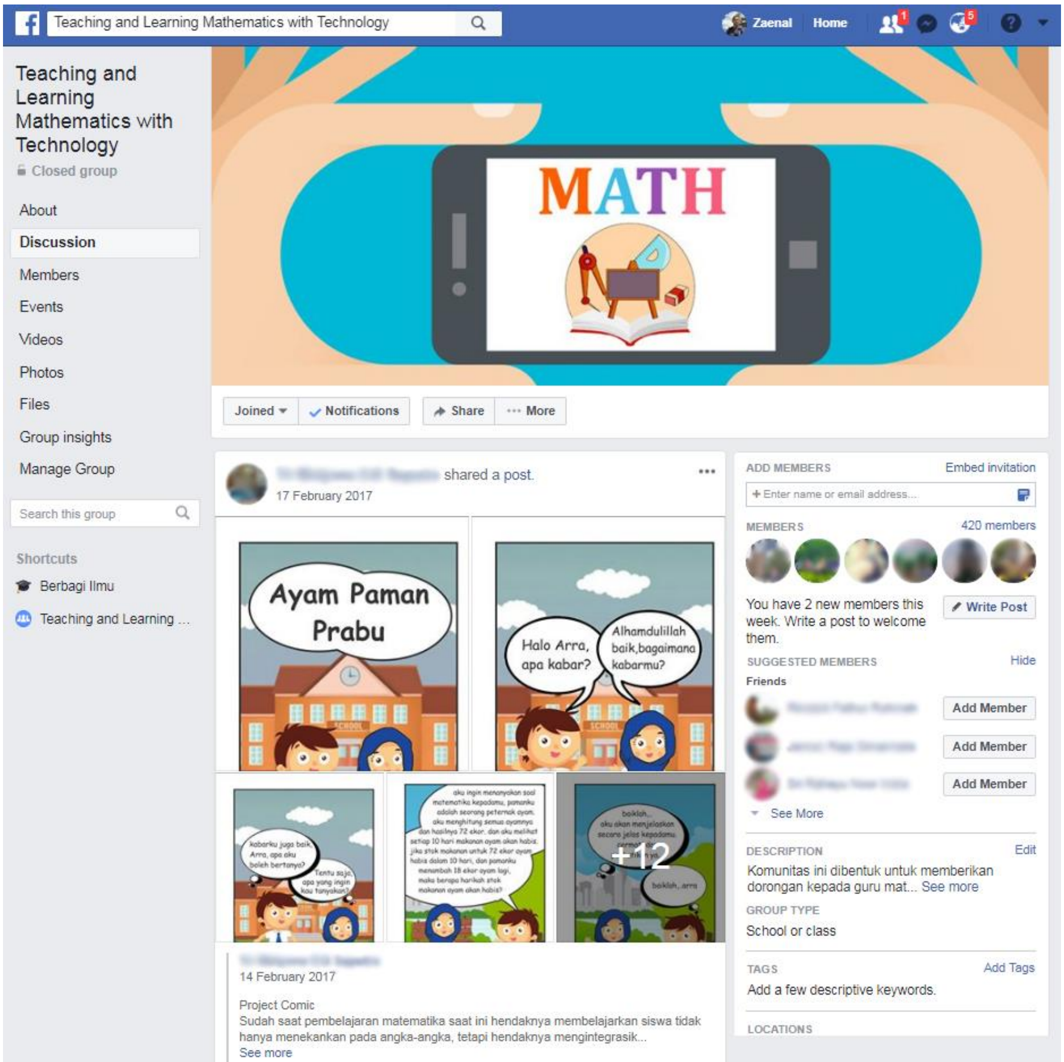
Examples of texts that had been coded under the subcategory "Knowledge and Skills"

APPENDIX I: Gephi Graph Visualization and Manipulation Software

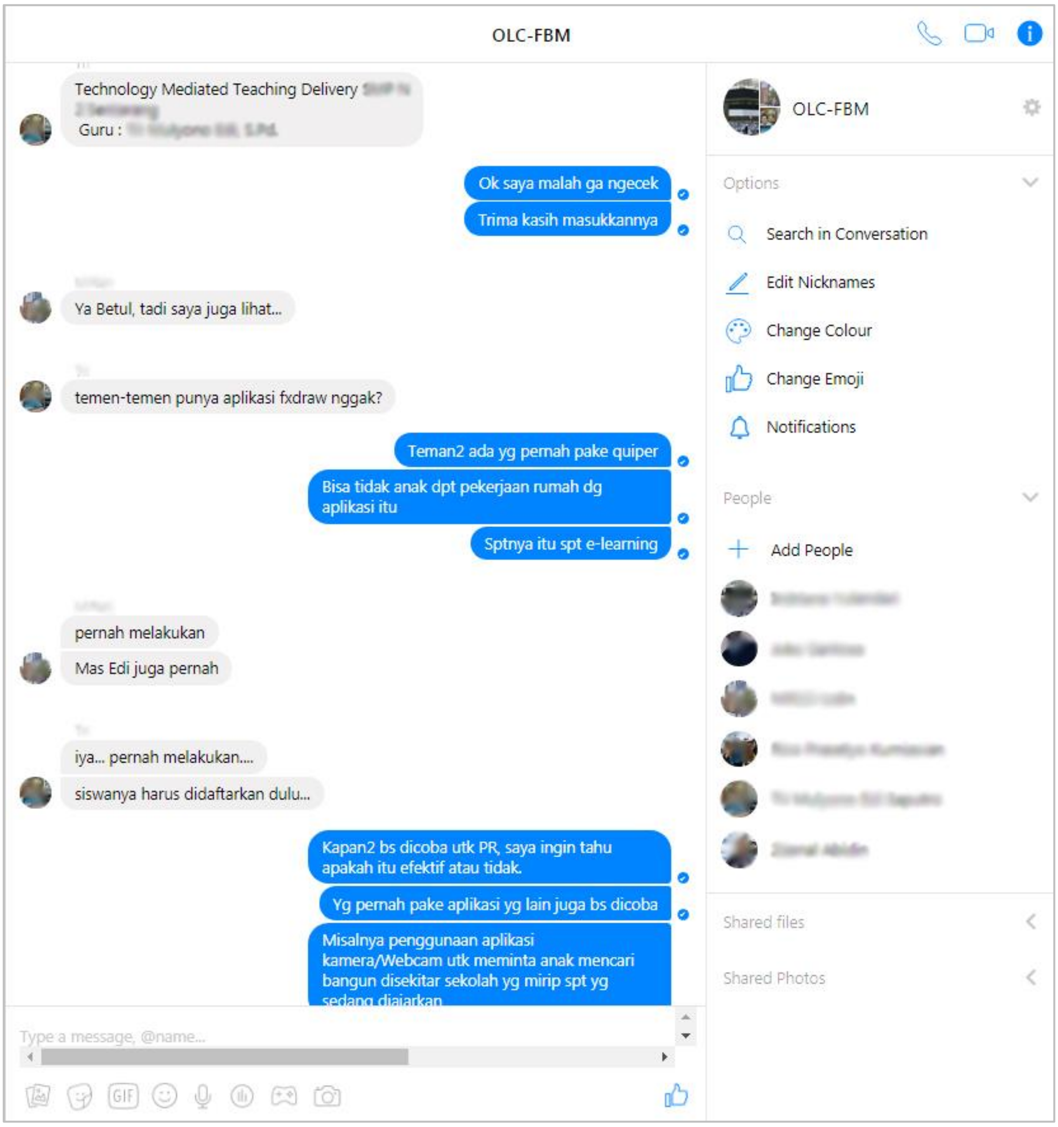


APPENDIX J: The Closed-Facebook Group, the Facebook Messenger Group, and the WhatsApp Group

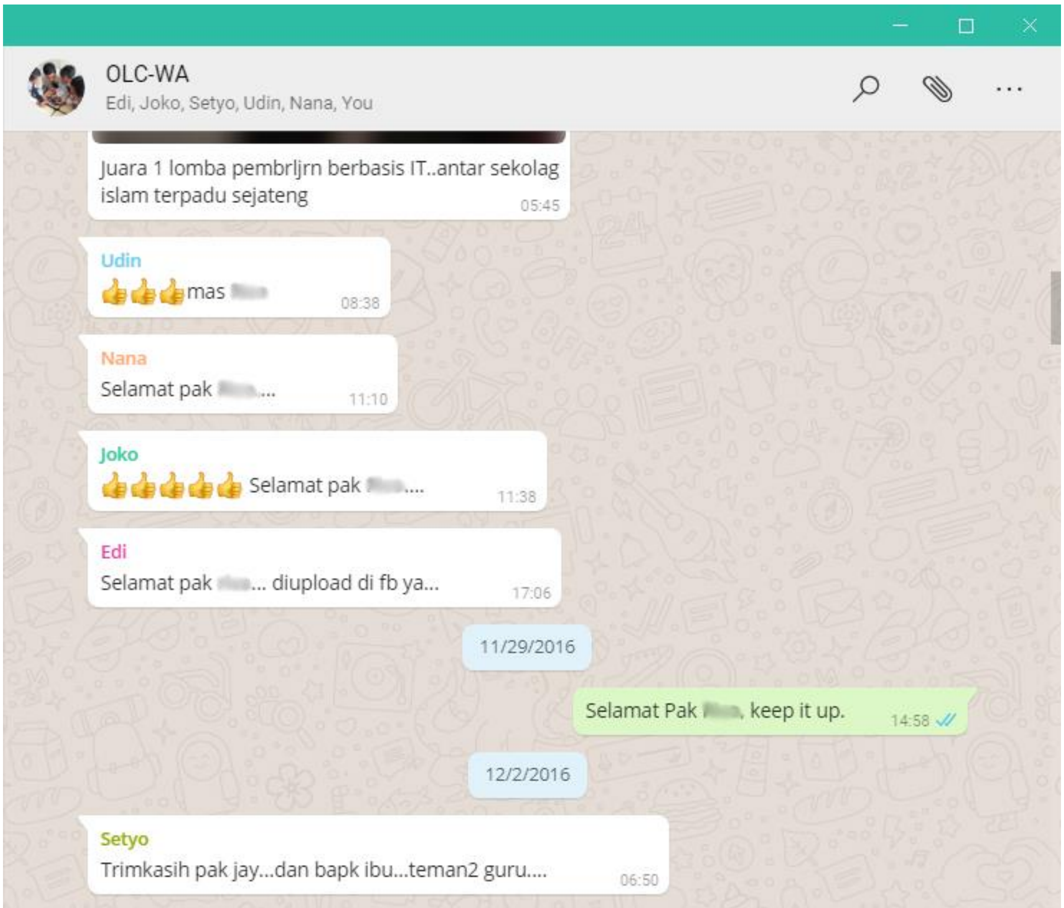
THE CLOSED-FACEBOOK GROUP



THE FACEBOOK MESSENGER GROUP



THE WHATSAPP GROUP



APPENDIX K: Photographs from One-Day Technology Workshop from the Preliminary study, Technology Workshop and Mathematics Classroom Teaching Practices with Technology from the Main Study

ONE-DAY TECHNOLOGY WORKSHOP FROM THE PRELIMINARY STUDY

TECHNOLOGY WORKSHOP FROM THE MAIN STUDY

MATHEMATICS TEACHING PRACTICES WITH TECHNOLOGY

Nana's class

Setyo's class

Udin's class

Edi's class

Joko's class

APPENDIX L: List of Publications and Presentations

1. Abidin, Z., Mathrani, A., Hunter, R. (2018). Teaching with technology: A lesson from social participation in an online learning community. *Technology, Pedagogy, and Education* [under review].
2. Abidin, Z., Mathrani, A., Hunter, R. (2018). Gender-related differences in the use of technology in mathematics classrooms: Student participation, learning strategies and attitudes. *International Journal of Information and Learning Technology*, 35(4), 266-284. doi:10.1108/IJILT-11-2017-0109
3. Abidin, Z., Hunter, R., Mathrani, A., (2018, 1 – 5 July). *Teacher Learning in the Use of Technology for Teaching Mathematics in an Online Learning Community: A Sociocultural Perspective*. Presented at the 41st Mathematics Education Research Group of Australasia. Auckland, New Zealand.
4. Abidin, Z., Mathrani, A., Hunter, R., & Parsons, D. (2017). Challenges of Integrating Mobile Technology into Mathematics Instruction in Secondary Schools: An Indonesian Context. *Computers in the Schools*, 34(3), 207-222. doi: 10.1080/07380569.2017.1344056
5. Abidin, Z., Mathrani, A., Hunter, R. (2017, 16 – 20 July). *Student Engagement with Technology Use in Mathematics Education: An Indonesian Secondary School Context*. Proceeding of the 21st Pacific Asia Conference on Information Systems (PACIS). Langkawi, Malaysia.
6. Abidin, Z. (2016, 26 October). *Integrating Information Technology into Mathematics Instructions*. Presented at INMS Postgraduate Students' Conference. Auckland, New Zealand.
7. Abidin, Z., Mathrani, A., Parsons, D., & Suriadi, S. (2015, 30 November – 4 December). *Opportunities and challenges of mobile learning for promoting mathematical literacy*. Proceedings of the 26th Australasian Conference on Information Systems (ACIS). Adelaide, South Australia.
8. Abidin, Z. (2015, 30 November – 1 December). *Online Community of Practice: Leveraging Information Technology for Reflective Practice in Promoting Mathematical Literac*y. Presented at the 2015 Australasian Conference on Information Systems (ACIS) Doctoral Consortium. Adelaide, South Australia.

9. Abidin, Z. (2015, 24 – 25 July). *Opportunities and challenges of mobile learning for promoting mathematical literacy in Indonesia*. Presented at the 6th New Zealand Information Systems (NZIS) Doctoral Consortium. Auckland, New Zealand.
10. Abidin, Z. (2015, 3 July) *Mobile-assisted mathematical literacy: Challenges of mobile technology for promoting mathematical competencies in Indonesia*. Presented at SEAT Postgraduate Students' Seminar. Palmerstone North, New Zealand.