Lesson Study in a blended approach to support isolated teachers in teaching with technology

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Abstract

Lesson Study (LS) is a form of professional development, with a strong foundation in mathematics education, based on teachers collaborating to design lessons. This collaboration, however, can be challenging for isolated teachers. In 2017, a course was presented at the university to train 52 teachers from all over South Africa as well as Botswana in the use of technology in teaching. These teachers represented all subject fields, including mathematics. The purpose of this course was to develop teachers' knowledge and skills in the use and integration of mobile technology in their teaching. The course was presented in a blended mode. Participants attended a three-day face-to-face session, followed by two-months online. The blended learning course had teachers working in subject specific groups in a LS format to plan, present and perfect lessons that can be taught using the technology available to them. In this study we investigate how LS can be adapted into a blended format to support isolated teachers who cannot meet face-to-face on a regular basis. We identified eleven aspects playing an important role in this process, namely technology; group; learning management system; online facilitation; technological pedagogical content knowledge (TPACK); (mobile) learning strategies; a lesson planning form; backward design; time; photos, videos and reports; and reflection questions. The eleven aspects that emerged, lead to the development of a framework consisting of three dimensions of LS namely Collaboration, Instructional Development and the Iterative Improvement Process, supported by the identified aspects.

Key words: blended learning, Lesson Study, online communities of practice, teacher professional development.

1 Introduction

The educational realm has experienced an infusion of technology in recent years (Grant 2019). Smarter, more accessible and innovative devices are making their

ways into classrooms at a rate that could never before have been anticipated. In the light of this, computer integrated education as a research field has seen growing interest in all levels of the education sector, including mathematics education. There is, as Herselman et al. (2019) state, a growing expectation for teachers to use technology as a part of their teaching practice, and to find and share resources with each other (Hooks 2015), regardless of where they are situated.

Teaching with technology creates many challenges - the most obvious being in resource constraint and remote areas. Researchers (Herselman et al. 2019) highlight that teachers' anxiety and attitudes towards the use of technology in teaching pose a challenge for educators to stay up to date with the technology and with technology integration. In an attempt to address the challenges faced in terms of teaching with technology, teacher professional development (TPD) is needed (Callaghan 2018; Herselman et al. 2019).

Lesson Study (LS) is recognised internationally as being an effective form of collaborative TPD in changing classroom practices. The cyclic process of LS typically consists of the phases *plan, teach* and *reflect* (Takahashi 2014). In a mathematics LS cycle, teachers meet to identify a problematic mathematical topic and design a lesson that will improve students' conceptual understanding. Teachers present the lesson, whilst others observe. This is followed by in depth reflection and improvement of the lesson for future presentation. The LS process requires teachers to discuss and design a number of features of teaching and learning (Takahashi 2014) through deep discussions with their colleagues around teaching mathematics. This provides rich professional development focusing on classroom practice (Xiaofeng et al. 2015).

Traditional face-to-face (f2f) TPD, however, is expensive, takes time away from teachers' work and requires from some teachers to travel great distances (Elliott 2017; Xiaofeng et al. 2015). In South Africa, many teachers are isolated from their subject-peers geographically and thus isolated from others who can support and encourage them in their practice.

This led to our interest in understanding how TPD, through sharing and collaboration of teachers that are not close together, could be supported through a blended LS approach, combining f2f and online aspects. The research question that we address in this paper, is:

> Which aspects should be incorporated into a blended Lesson Study process to support isolated teachers in teaching with technology?

The *aspects* refer to essential elements that emerged during analysis of the research data and the literature. In their absence or dysfunction, the blended LS process may not be able to function.

A course, "e-Learning for the 21st Century Facilitator", was designed and presented through the university for a company that provides educational technology to schools. The participating teachers (52 in total) were educators

from schools in all nine provinces of South Africa as well as Botswana, and represented most of the subject fields, including mathematics. The purpose of this course was to develop teachers' knowledge and skills in the integration of mobile technology whilst planning to teach in their respective subject fields. The course was presented in a blended mode consisting of a three-day f2f session, followed by two months online. Teachers were divided in thirteen subject specific LS groups, which collaborated to plan, present and perfect lessons, incorporating technology. Three of these groups focused on mathematics.

2 Literature review

The literature review focuses on lesson planning (including planning for teaching with technology); teacher collaboration in (online) communities of practice; LS as professional development; and the LS process. Key *aspects* were identified that can be incorporated into a blended LS process to support isolated teachers in teaching with technology.

Lesson planning is a fundamental part of the professional practice of teachers. Fürstenberg and Kletzenbauer (2015), propose an eight-step lesson planning process. We use this process to unpack the literature

Many authors (Estes et al. 2014; Krulatz 2014) state that planning a lesson should start with the careful selection of lesson *outcomes* that are specific (Krulatz 2014).

Next, a logical sequence of teaching activities is considered (Krulatz 2014) to ensure the *progression of the topic* development (Estes et al. 2014).

Teachers also need to consider *learner-centred methods* (Estes et al. 2014; Krulatz 2014) in order to assure learner achievement (Estes et al. 2014), and tailor their methods to the learners' abilities (Schraudner 2014). Further, *assessment* should be built in continuously throughout the lesson (Krulatz 2014). This implies that the teacher is applying their pedagogical content knowledge (PCK). PCK (Gudmundsdottir and Shulman 1987) refers to the integration of pedagogical knowledge (how to teach) and content knowledge (what to teach).

Next, teachers should find up-to-date and relevant teaching materials (Hooks 2015). This can be collected and negotiated *collaboratively* between teachers (Hooks 2015; Xiaofeng et al. 2015). These materials can include *technological devices and software,* which should lead to considering the *TPACK framework* (Ndongfack 2015). TPACK (Koehler and Mishra 2009) integrates the consideration of the teaching strategy and content (PCK) with supporting technology.

Typically, at this stage the teacher will *teach* the lesson, utilising clear instructions (Krulatz 2014) to encourage learner participation (Estes et al. 2014; Krulatz 2014) and using techniques like scaffolding to support high level learning (Krulatz 2014).

The last step is *reflection,* as an important part of a teacher's practice (Naresh 2013) and habits (Estes et al. 2014). The reflection can focus on learners' work and progress (Krulatz 2014) and on the identification of improvements and adaptations of the lesson plan to optimise future teaching (Souza et al. 2015).

This process reminds of the *backward design* process (Wiggins and McTighe 2005). The process starts with determining the outcomes (Estes et al. 2014; Fürstenberg and Kletzenbauer 2015; Krulatz,2014) or the goal that they want to reach during teaching (Wiggins and McTighe 2005). Next, they consider evidence of learning (Wiggins and McTighe 2005), consisting of a range of formal and informal assessment (Krulatz 2014). The last step is to design the teaching (Wiggins and McTighe 2005). This step fits in with the lesson planning processes, where methods, such as scaffolding and learner-centeredness, and materials are considered (Estes et al. 2014; Fürstenberg and Kletzenbauer 2015; Krulatz 2014).

Teacher collaboration (Hooks 2015) and *peer support* (Cakir and Yildirim 2013) is important in the development of teacher practices. By creating these communities of practice (CoP) teachers can collaboratively look at their practice as they develop their skills and knowledge (Xiaofeng et al. 2015). This strategy supports the collaborative fabrication of knowledge (Hooks 2015; Xiaofeng et al. 2015), peer instruction and support (Cakir and Yildirim 2013; Xiaofeng et al. 2015) and reduces the isolation of teachers from each other.

Many authors (Kadroon and Inprasitha 2013; Naresh 2013; Takahashi 2014; Wake et al. 2013; Xiaofeng et al. 2015) propose *Lesson Study* (LS) as a collaborative lesson planning strategy.

LS has long been used as a form of professional development (Kadroon and Inprasitha 2013) and collaborative lesson planning strategy (Ndongfack 2015). The idea originated among Japanese teachers as a collaborative process of planning and perfecting their lesson plans (Kadroon and Inprasitha 2013). LS has since been formalised and is implemented in many contexts as a professional development tool for teachers and to improve learner performance.

The following definition of LS is used for this study:

> *Lesson study* is a collaborative instructional development process (Kadroon and Inprasitha 2013; Mee and Oyao 2013; Stigler and Hiebert 2009) that follows continual processes of improvement (Chong et al. 2017) and allows teachers to consider subject matter, the reasons for their teaching as well as the content and manner in which learners learn (Chong et al. 2017).

From this definition we identified three main dimensions of LS. These are *Collaboration, Instructional Development* and the *Iterative Improvement Process.*

LS has gained significant momentum worldwide in the mathematics education community (Hart et al. 2011). Stigler and Hiebert (1999) introduced the Japanese LS model in the USA by using the TIMSS (Third International Mathematics and

Science Study) results and video evidence. The first LS group was formed at the UCLA Lab School in 1993 and this created interest in this approach for improving practice in schools in the USA. This resulted in a commercial operation for LS, funded by the educational publisher, Pearson.

Although teachers in countries in Eastern Europe did not use the actual term *Lesson Study*, they have a very informed approach to TPD in which teachers will naturally observe and review lessons with colleagues (Burghes and Robinson 2010). In initial training of their teachers, small groups of students work in their first practice with their mentor (expert teacher) in a University Practice School, jointly planning, observing and reflecting on the lessons, with students taking turns to deliver lessons. These students teach fewer lessons compared to their counterparts in the UK, but they help plan lessons and have the chance to review and reflect on lessons. Fujii (2018) discusses the interplay between LS and teaching mathematics through problem solving and outlines suggestions for educators.

Tall (2008) reports about a developmental project where LS is being incorporated in different societies in Japan and Thailand, in cooperation with government-supported participants from a number of other countries. He concludes that LS in the end, supports learners towards a deeper, more meaningful and coherent understanding of mathematics, in the process developing "powerful and insightful ways of thinking" (Tall 2008, p 50).

The LS process can easily be adapted to suit the context. In some of the simplest cases LS is a three-step process of *Plan (a lesson), Do (teach the lesson)* and *See (observe and reflect on the lesson) (*Juhler and Håland 2016; Kadroon and Inprasitha 2013; Takahashi 2014). Some contexts call for more refined processes, such as in a study done by Chong et al. (2017) which refines the iterative process of LS. Other authors (Lewis and Perry 2017; Mee and Oyao 2013) adopted a less intense process. Here LS consists of Planning, Teaching, Observing, Reflecting, and Refining. The process used by Mee and Oyao (2013), is illustrated in Fig. 1.

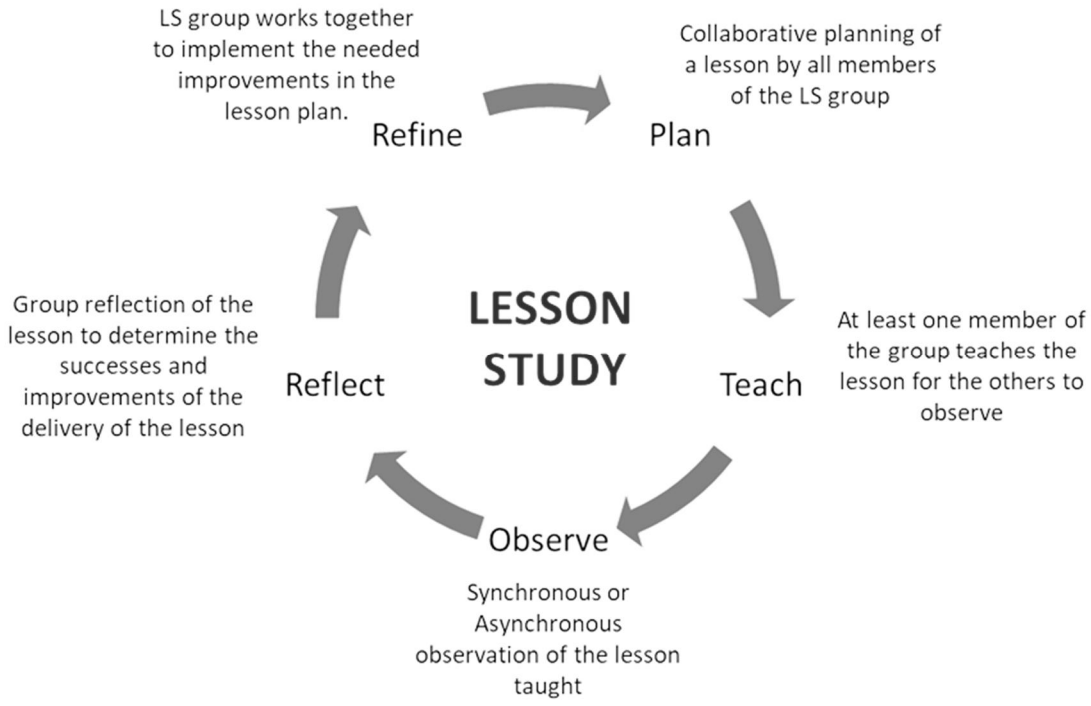


Fig. 1: The LS process

Planning is done collaboratively by the teachers (Ndongfack 2015; Xiaofeng et al. 2015) meeting in groups (Mee and Oyao 2013). Teachers scrutinise instructional materials in order to assure the quality and relevance of the material for the lesson (Juhler and Håland 2016). Planning can have a *pre-set format*, goal or strategy in mind (Mee and Oyao 2013).

After carefully considering the planning (Fürstenberg and Kletzenbauer 2015; Wiggins and McTighe 2005), teachers then *teach*. In standard LS practice, this phase would see one teacher of the group teaching the lesson and the rest of the group *observing* the lesson (Chong et al. 2017; Mee and Oyao,2013).

Some studies show that *observation* is done by teachers physically sitting in each other's classroom viewing the lesson (Mee and Oyao 2013). Lewis and Perry (2017), however, suggest that teachers can also *video record* their lessons. This brings about the advantage that the observers can be anywhere and does not have to meet at the same place and time (Xiaofeng et al. 2015). These observations should focus on elements that need to be discussed during reflection.

Good teacher practice is to *reflect* after teaching (Naresh 2013). During LS, teachers have a detailed discussion of the lesson (Wake et al. 2013). This is a collaborative reflection and critical exchange of ideas (Ndongfack 2015) in terms of classroom practice (Kadroon and Inprasitha 2013; Wake et al. 2013), lesson content (Ndongfack 2015) and learner interaction (Wake et al. 2013).

Refining, or revising, is a process of improving the lesson (Chong et al. 2017). Reflection is an inevitable part of the refining process as it serves as an

instrument of improvement (Kadroon and Inprasitha 2013). By questioning each other's practices, teachers can make the necessary refinements for future teaching (Mee and Oyao 2013).

3 Conceptual framework

The Technology Integration Planning (TIP) model of Roblyer and Doering (2014) provides an effortless connection to the LS process. The model proposes three phases needs-analysis; planning; post-instruction-analysis and refining, incorporating seven steps to assure successful technology integration into teaching.

Fig. 2 depicts a combination of the TIP model and the LS process. The first two phases in the TIP model aligns with problem identification and planning in the LS process. The teach phase in the LS is depicted between the second and the third phase in the TIP. The third phase in the TIP model can be aligned to observe, reflect and refine in the LS process.

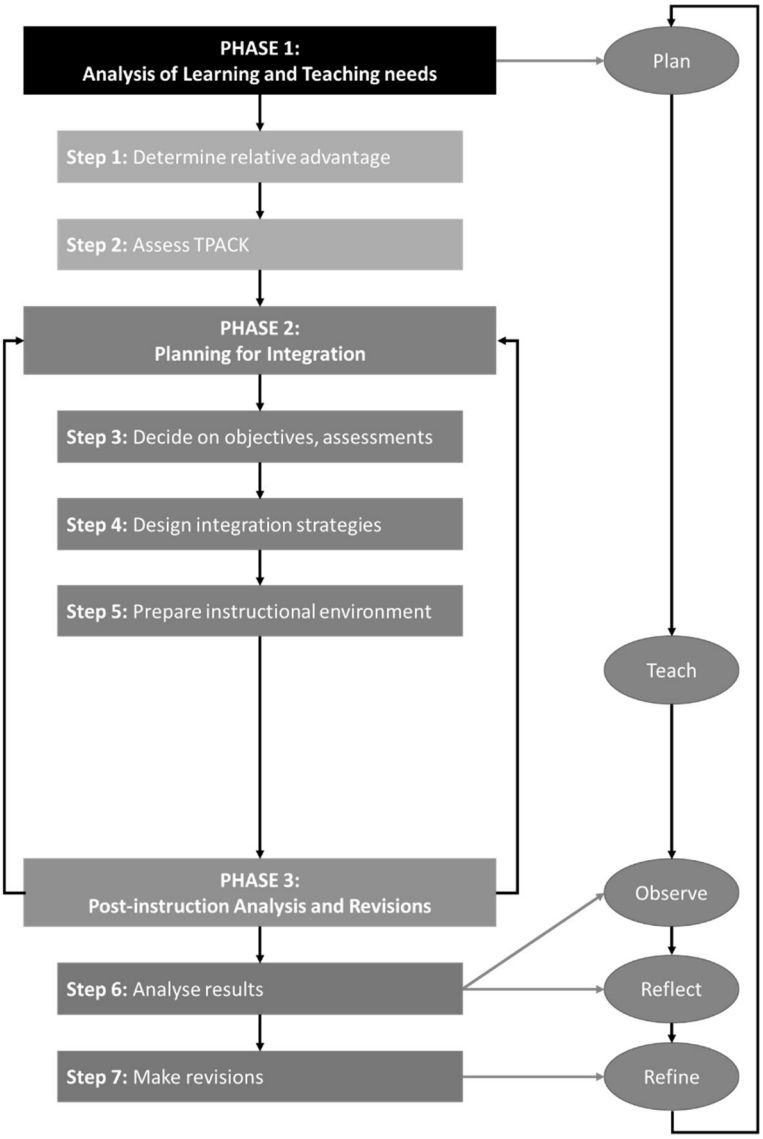


Fig. 2: Conceptual framework based on the TIP model

Phase one of the TIP model consists of two steps that develop the teacher's understanding of the teaching and learning needs associated with the technology-based teaching. *Step 1* considers which challenging topic to focus on, and the implicit benefits of the inclusion of technology (Sweeney-Burt 2014). *Step 2* deals with the assessment of the TPACK integration (Koehler and Mishra 2009). TPACK within the TIP gives planning purpose, efficacy and meaning and engages teachers meaningfully in the integration process (Roblyer and Doering 2014).

Phase two is focussed on planning. This is done in three steps that correspond to the backward design process. *Step 3* determines the outcome and assessment. In *Step 4* teachers interrogate fitting strategies and activities for teaching, incorporating technology. During *Step 5* teachers need to design conditions within the classroom to support the use of technology.

Phase three commences after teaching, in two steps to review the success of the technology integration (Roblyer and Doering 2014). In *Step 6* (analysis of results) the first important consideration is whether the desired outcome has been achieved through validation of the assessment – as set out in Step 3 (Wiggins and McTighe 2005). Learner feedback also supports the revision of instructional strategies. In *Step 7* relevant improvements are made, based on the analysis in Step 6 (Roblyer and Doering 2014).

4 Research design

The study followed an explorative qualitative case study strategy (Creswell 2007). The case focused in the blended learning course "e-Learning for 21st Century Facilitators", as introduced in section 2. This course was designed to include the aspects identified in the literature review, such as a blended approach (a f2f session followed by two months online collaboration); the implementation of the LS process; inclusion of the TPACK and backward design to introduce planning for teaching with technology; a structured lesson planning form to facilitate the planning process; a subject-specific group-focused approach to online collaboration in the LS process; and the use of a Learning Management System (LMS) to facilitate online processes. Two LS cycles were completed during the course. This implies that the groups planned, taught and refined two different lessons. During the online phase of the course, participants took part in discussion forums on the LMS. Some of the more general forums were open to all participants, but each subject specific group participated in the LS process in a closed forum accessible to the group members and the facilitators.

4.1 Participants

The participants in the research were teachers from across Southern Africa who attended the course and consented to participation in the research. These 52 teachers were *isolated* in the sense that they were separated from their peers in terms of geographic location or field of expertise. This means that a teacher

could, for example be the only mathematics teacher who uses technology as part of their instruction in a particular school, district or province. Further, the schools where the company implemented their technology were far from each other, isolating the teachers geographically.

Our interest in these participants came from the fact that they represent a diverse set of attributes. The teachers were at different levels of their teaching careers, taught learners from different backgrounds and had all been introduced to teaching with technology in some way due to the technology provided to them by the software company.

Four university facilitators, experienced in teaching with technology, online facilitation and different subject areas, also were participants in the research. The first and second author of this article designed the course. Fig. 3 illustrates how the sample was framed (Shapiro 2008). Participants grouped themselves into 13 subject specific groups. The three groups that chose to work with mathematics is indicated with the * in Fig. 3. The ratio of facilitators to participants was one facilitator to six groups (24 people).

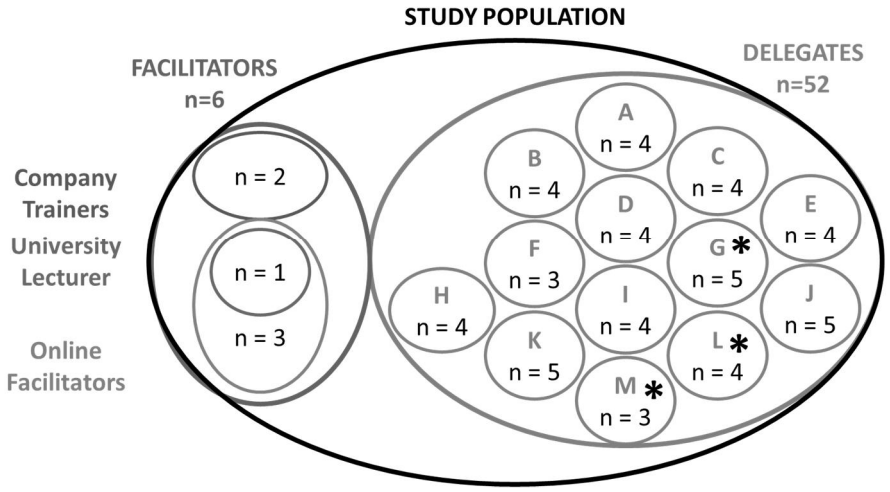


Fig. 3: Study population

The research project received ethical clearance from the university, as well as permission from the company to use the data, and adhered to the prescribed principles of voluntary participation, anonymity and confidentiality. During the face-to face session of the course the research was discussed, and consent letters provided to participating teachers. All teachers consented to participate in the research.

4.2 Data collection instruments

Three data sets were utilised for data analysis, a *final survey*, completed by all participants, the *lesson plans*, developed by participants and an *observation schedule.* The LMS was used to capture and access the data in electronic format.

Final survey

At the end of the course participants could complete an anonymous open-ended survey on the LMS, completed by 33 of the 52 participants. The questions used for this research are presented in the results section.

Lesson plans

A lesson plan template (Fig. 4) was designed to support teachers in the planning process for teaching with technology. The template incorporated the aspects identified in the literature review, such as alignment in the backward design (1-3); and unpacking of various teaching activities (5-9). Each activity was described as the integration (TPACK) of teaching strategy (5 - PK), content (7 - CK) and the relevant technology (4, 8, 9 - TK). Participants utilised symbols to indicate different decisions, such as teaching strategy and technology. Participating teachers were advised to assure that their teaching strategies are learner-centred, modular (as indicated in the time column – 6) to promote variety in teaching and learning activities and incorporate mobile technologies available to them in their classrooms.

Fig. 4: Lesson plan template

The teachers used a hard copy during the f2f session to plan for their first LS cycle lesson. These forms were photographed and shared on the LMS for all groups to see. – an example in Fig. 5. Participating teachers could provide advice and comments through post-it notes on each other's work during the f2f session. This emulated the process to be followed online.

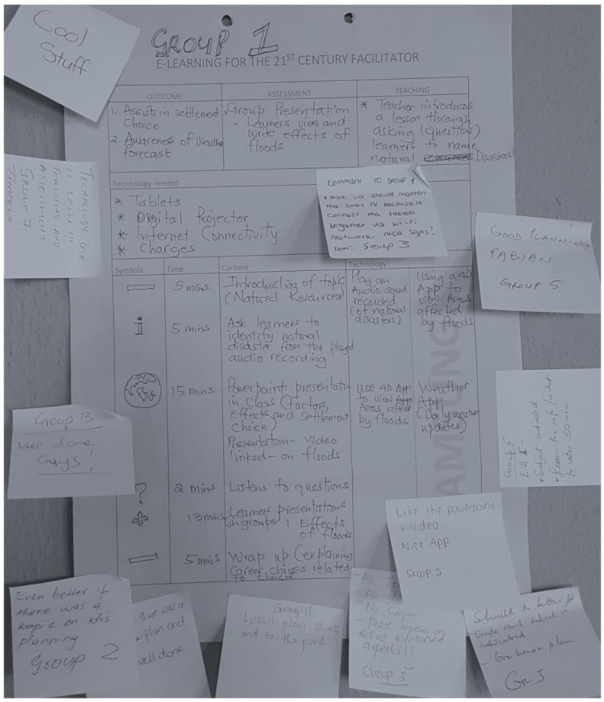
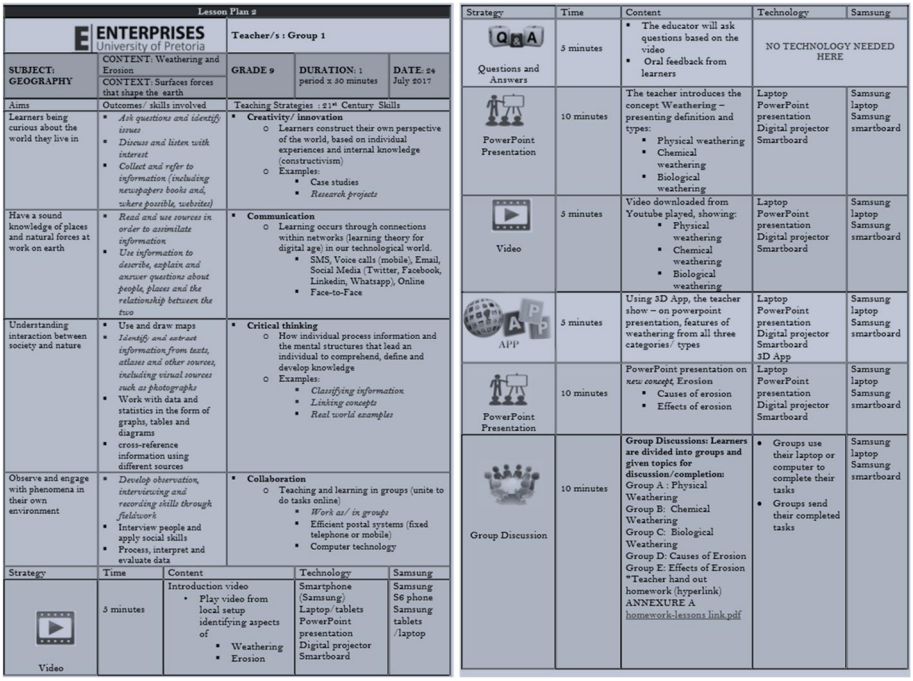


Fig. 5: Example of a hard copy lesson plan

Participating teachers submitted two versions of the lesson plan for each or the two LS cycles. The first cycle commenced with the hard copy form, and after teaching and reflection, a revised digital lesson plan was submitted online. A similar process was followed for the second LS cycle.

In the first cycle, 10 refined lesson plans were submitted and 11 in the second cycle.

Lesson planning was negotiated and designed through the online discussion forums and file exchanges on the LMS, and submitted as online assignments. Fig. 6 is an example of a revised electronic Geography plan and Fig. 7 is an excerpt from a mathematics lesson plan.



Lesson Plan 2

E ENTERPRISES University of Pretoria — **Teacher/s : Group 1**

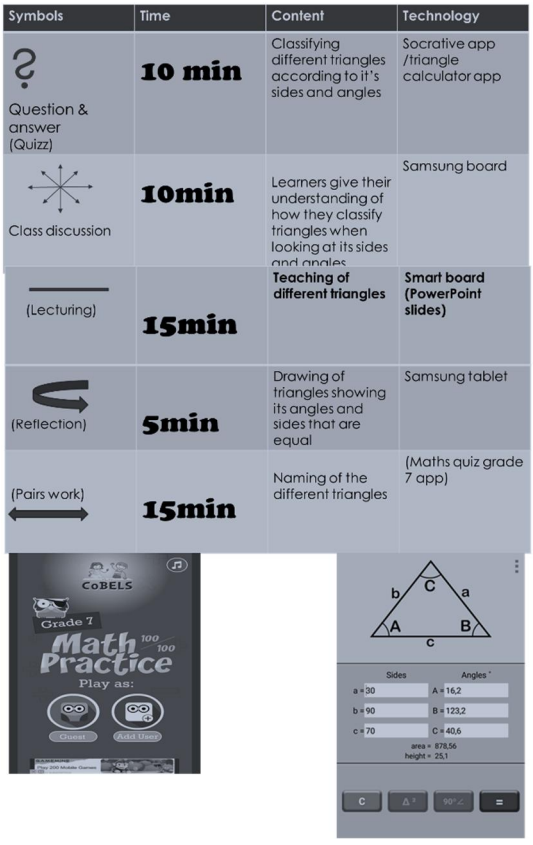
SUBJECT: GEOGRAPHY	CONTENT: Weathering and Erosion CONTEXT: Surfaces forces that shape the earth	GRADE 9	DURATION: 1 period x 30 minutes	DATE: 24 July 2017

Aims	Outcomes/ skills involved	Teaching Strategies : 21st Century Skills
Learners being curious about the world they live in	▪ *Ask questions and identify issues* ▪ *Discuss and listen with interest* ▪ *Collect and refer to information (including newspapers books and, where possible, websites)*	▪ **Creativity/ innovation** ○ Learners construct their own perspective of the world, based on individual experiences and internal knowledge (constructivism) ○ Examples: ▪ Case studies ▪ *Research projects*
Have a sound knowledge of places and natural forces at work on earth	▪ *Read and use sources in order to assimilate information* ▪ *Use information to describe, explain and answer questions about people, places and the relationship between the two*	▪ **Communication** ○ Learning occurs through connections within networks (learning theory for digital age) in our technological world. ▪ SMS, Voice calls (mobile), Email, Social Media (Twitter, Facebook, Linkedin, Whatsapp), Online ▪ Face-to-Face
Understanding interaction between society and nature	▪ Use and draw maps ▪ *Identify and extract information from texts, atlases and other sources, including virtual sources such as photographs* ▪ Work with data and statistics in the form of graphs, tables and diagrams ▪ cross-reference information using different sources	▪ **Critical thinking** ○ How individual process information and the mental structures that lead an individual to comprehend, define and develop knowledge ○ Examples: ▪ *Classifying information* ▪ *Linking concepts* ▪ *Real world examples*
Observe and engage with phenomena in their own environment	▪ *Develop observation, interviewing and recording skills through fieldwork* ▪ Interview people and apply social skills ▪ Process, interpret and evaluate data	▪ **Collaboration** ○ Teaching and learning in groups (unite to do tasks online) ▪ *Work as/ in groups* ▪ Efficient postal systems (fixed telephone or mobile) ▪ Computer technology

Strategy	Time	Content	Technology	Samsung
Video	5 minutes	Introduction video ▪ Play video from local setup identifying aspects of ▪ Weathering ▪ Erosion	Smartphone (Samsung) Laptop/ tablets PowerPoint presentation Digital projector Smartboard	Samsung S6 phone Samsung tablets /laptop

Strategy	Time	Content	Technology	Samsung
Questions and Answers	5 minutes	▪ The educator will ask questions based on the video ▪ Oral feedback from learners	NO TECHNOLOGY NEEDED HERE	
PowerPoint Presentation	10 minutes	The teacher introduces the concept Weathering – presenting definition and types: ▪ Physical weathering ▪ Chemical weathering ▪ Biological weathering	Laptop PowerPoint presentation Digital projector Smartboard	Samsung laptop Samsung smartboard
Video	5 minutes	Video downloaded from Youtube played, showing: ▪ Physical weathering ▪ Chemical weathering ▪ Biological weathering	Laptop PowerPoint presentation Digital projector Smartboard	Samsung laptop Samsung smartboard
APP	5 minutes	Using 3D App, the teacher show – on powerpoint presentation, features of weathering from all three categories/ types	Laptop PowerPoint presentation Digital projector Smartboard 3D App	Samsung laptop Samsung smartboard
PowerPoint Presentation	10 minutes	PowerPoint presentation on *new concept*, Erosion ▪ Causes of erosion ▪ Effects of erosion	Laptop PowerPoint presentation Digital projector Smartboard	Samsung laptop Samsung smartboard
Group Discussion	10 minutes	**Group Discussions: Learners are divided into groups and given topics for discussion/completion:** Group A : Physical Weathering Group B: Chemical Weathering Group C: Biological Weathering Group D: Causes of Erosion Group E: Effects of Erosion "Teacher hand out homework (hyperlink) ANNEXURE A homework-lessons link.pdf	▪ Groups use their laptop or computer to complete their tasks ▪ Groups send their completed tasks	Samsung laptop Samsung smartboard

Fig. 6: Geography example lesson plan



Symbols	Time	Content	Technology
Question & answer (Quizz)	**10 min**	Classifying different triangles according to it's sides and angles	Socrative app /triangle calculator app
Class discussion	**10min**	Learners give their understanding of how they classify triangles when looking at its sides and angles	Samsung board
(Lecturing)	**15min**	**Teaching of different triangles**	**Smart board (PowerPoint slides)**
(Reflection)	**5min**	Drawing of triangles showing its angles and sides that are equal	Samsung tablet
(Pairs work)	**15min**	Naming of the different triangles	(Maths quiz grade 7 app)

Fig. 7: Mathematics grade 7 triangles - lesson plan excerpt

Observation schedule

To support the analysis of the lesson plans, an observation schedule was designed. This schedule was structured to observe "predefined" aspects of the lesson plans (McKechnie 2008). Three items were observed by the researchers, namely the backward design process (1.1-1.4); the TPACK framework (2); and mobile learning strategies (3). The schedule is illustrated in Fig. 8.

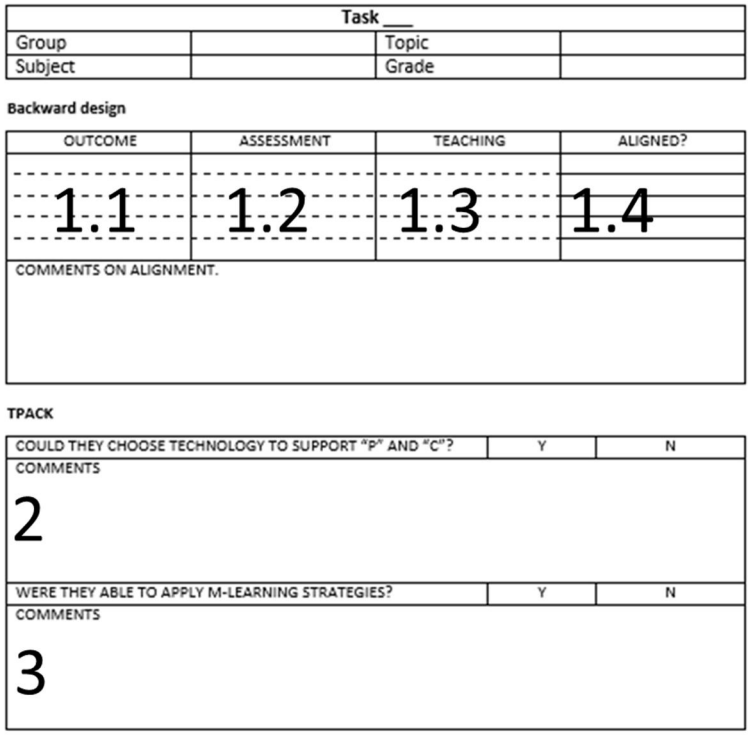


Fig. 8: Structured lesson plan observation schedule

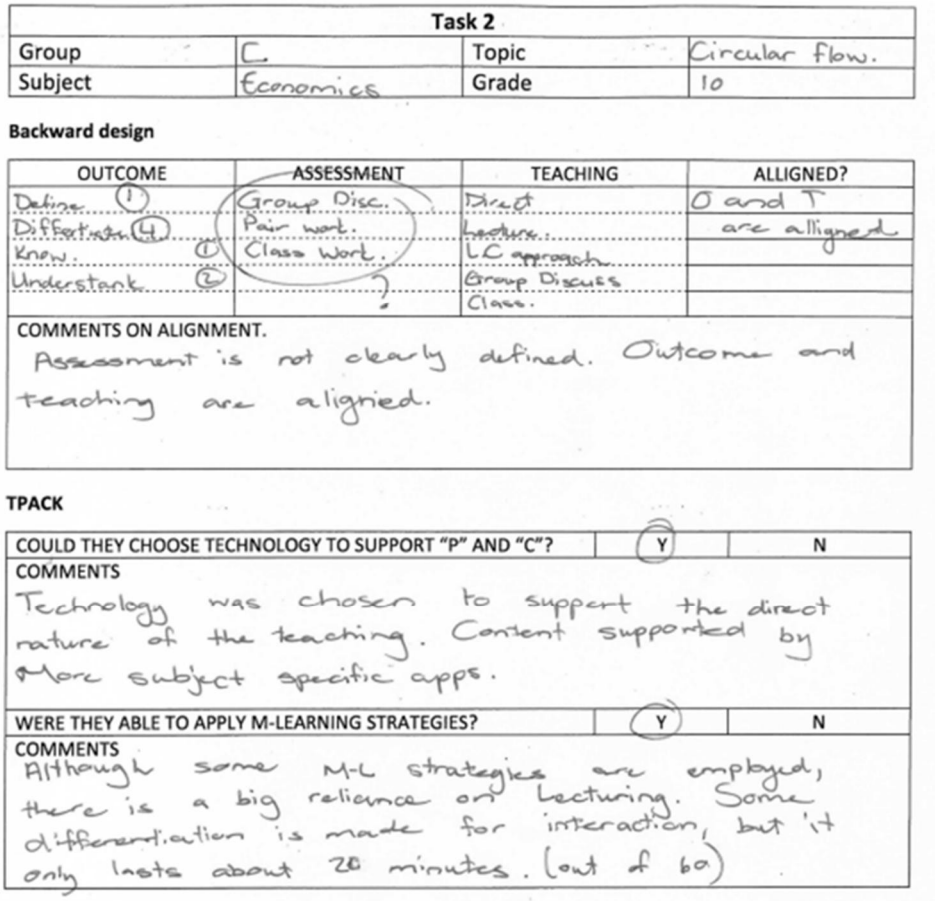
The backward design process was observed by evaluating the outcome (1.1) in terms of its level on Bloom's taxonomy (Bloom and Anderson 2014). The levels of the assessment (1.2) and teaching strategy (1.3) was evaluated next. Lastly, the alignment of the outcome, assessment and teaching on the levels of Bloom's taxonomy was considered (1.4). Backward design was considered aligned (all three parts align); partially aligned, (two parts align) or not aligned.

Secondly, the lesson plan was interrogated to determine whether teachers selected technology supported the pedagogy and content. This allowed for a binary answer (yes/no) and a comment on the choice. This could be, for example, choosing a mathematics practice app focusing on triangles for the partial lesson plan indicated in Fig. 7.

Lastly the application of mobile learning strategies was investigated. This also allowed for a yes/no choice. The researcher examined the activities set out in the lesson plan to assure that they were short, modular activities, learner centred

and varied, before assuring that participants made use of relevant mobile technology in their activities.

In Fig. 9 we give a scanned image of one of the completed observation schedules. Note that the annotations are concise and specific to the investigation as suggested by McKechnie (2008).



Task 2

Group	C.	Topic	Circular flow.
Subject	Economics	Grade	10

Backward design

OUTCOME	ASSESSMENT	TEACHING	ALLIGNED?
Define (1)	Group Disc.	Direct	O and T
Differentiate (4)	Pair work.	Lecture.	are alligned.
Know. (3)	Class Work.	LC approach.	
Understand. (2)	?	Group Discuss	
		Class.	

COMMENTS ON ALIGNMENT.
Assessment is not clearly defined. Outcome and Teaching are aligned.

TPACK

COULD THEY CHOOSE TECHNOLOGY TO SUPPORT "P" AND "C"?	Y	N
COMMENTS: Technology was chosen to support the direct nature of the teaching. Content supported by more subject specific apps.		
WERE THEY ABLE TO APPLY M-LEARNING STRATEGIES?	**Y**	**N**
COMMENTS: Although some M-L strategies are employed, there is a big reliance on Lecturing. Some differentiation is made for interaction, but it only lasts about 20 minutes. (out of 60)		

Fig. 9: Completed observation schedule

4.3 Data analysis

The conceptual framework (Fig. 2) was used to guide the analysis of the data. Some aspects were identified from literature (some examples indicated in *italics* in section 2), after which participant data was scrutinised for references to these aspects and identify new aspects. Next, concept maps of potential aspects were compiled (Fig. 10).

Survey questions were analysed according to themes linked to the conceptual framework and emerging codes from literature. All responses were scrutinised, whereafter any similarities in responses or correspondences to the framework were noted. These similarities informed themes that would emerge to inform the claims made in this study

The observation schedules of the two refined lesson plans of each participating group were captured and collated in MS Excel.

5 Results – aspects identified per LS phase

This section commences with an illustration of concept maps (Fig. 10) that summarises the aspects identified in each LS phase. The process of determining aspects is described in full in Joubert (2019). Table 1 provides a summary of all aspects, as well as the relevant LS phase/s where identified.

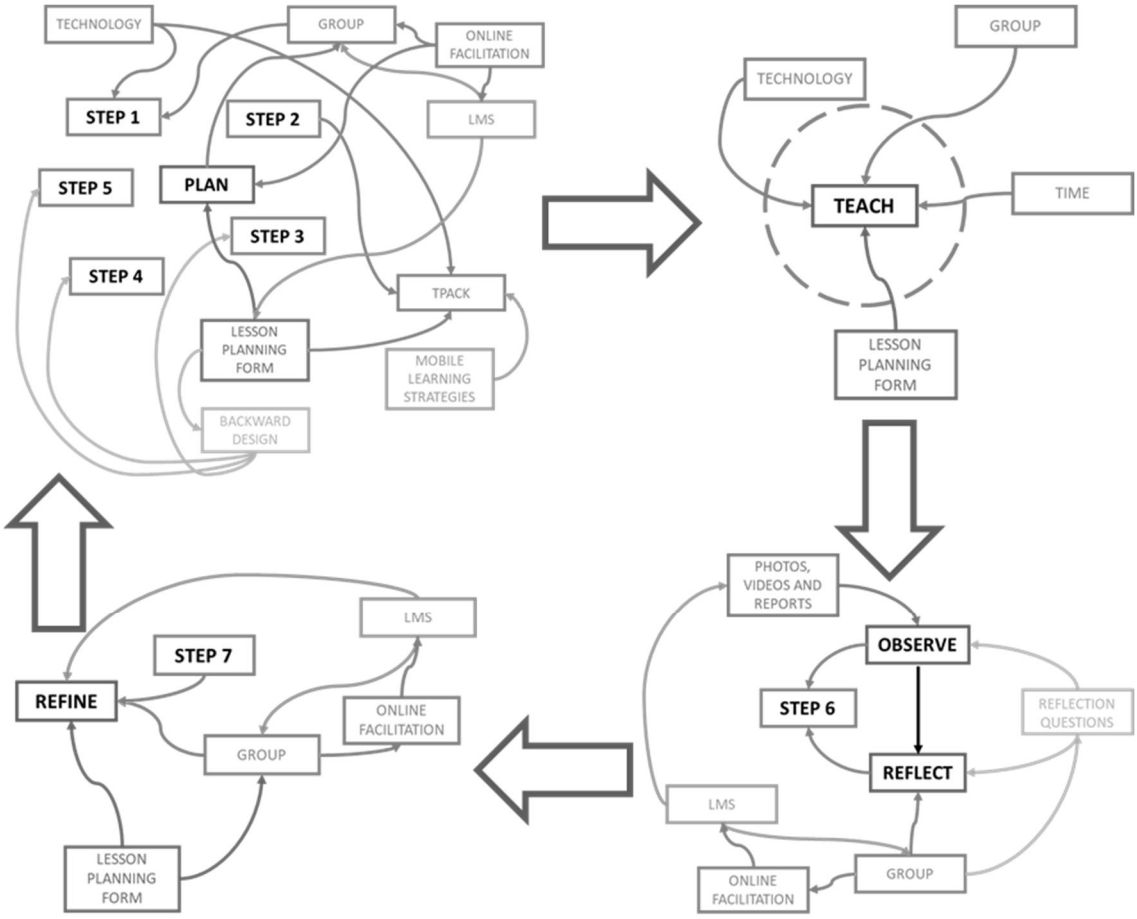


Fig. 10: Aspects identified in LS phases

Fig. 10 illustrates that eight aspects were identified in the LS Plan phase (TIP steps 1 to 5); four aspects in the LS Teach phase; three in LS Observe and four in LS Reflect (TIP step 6); and five aspects in the LS Refine phase (TIP step 7). This is unpacked in Table 1.

Table 1: Summary - aspects linked to LS phases

Aspect	Plan	Teach	Observe	Reflect	Refine
1. Technology	x	x			
2. Group	x	x		x	x
3. LMS	x		x	x	x
4. Online facilitation	x			x	x
5. TPACK	x				
6. Mobile learning strategies	x				
7. Lesson planning form	x	x			x
8. Backward design	x				
9. Time		x			
10. Photos, videos and reports			x		
11. Reflection questions			x	x	x

Each aspect is presented next in brief discussion of how it emerged from the research, linked to the relevant LS cycles and data sources.

5.1 Aspect 1: Technology

Plan Data sources providing information were the final survey and the lesson plans.

Question 1 (final survey): Which technology interventions are in your school?

Interventions noted included the solution provided by the software company (19 of the 33 participants), technology through a municipal initiative (2), two "Smart Classrooms" which were equipped with "internet-connected tablets", and a departmental initiative and an e-learning classroom initiative.

Devices available were tablets (7), laptops (3) and desktop computers (2). Six participants confirmed that all their learners had tablets, with another stating that only some learners had tablets. Two participants mentioned that their learners had laptops and another that only the teaching staff had laptops. Schools supplied with technology from the municipality had desktop computers available.

The two refined lesson plans per group (submitted at the end of each LS cycle) were analysed to determine which technology the teachers preferred to include in their lessons. Fig. 11 summarises these technologies.

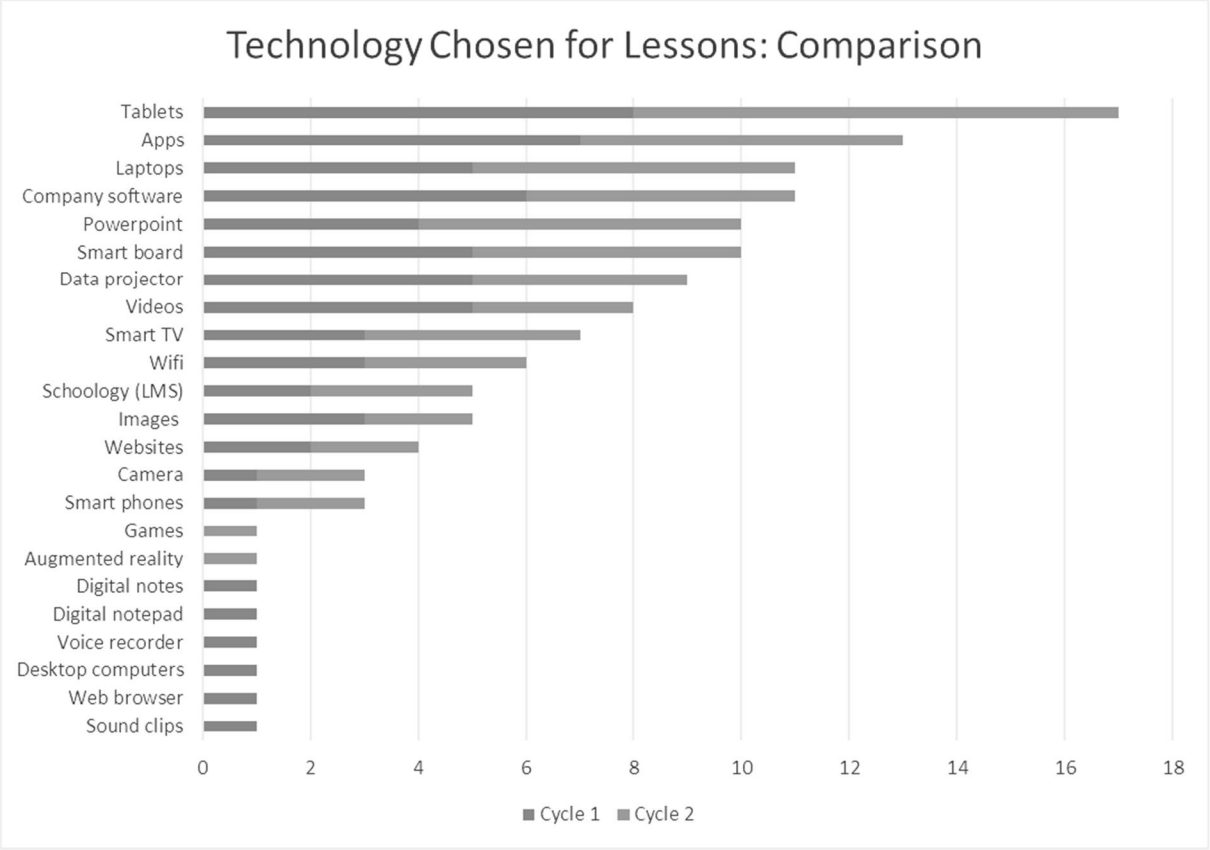


Fig. 11: Technology chosen - 2 Cycle comparison

The figure illustrates the different technological devices; software and apps; and other resources utilised. Notably, only 6 of the 21 lesson plans pertinently stated that a Wi-Fi or internet connection was needed for the lesson.

Teach

Two questions from the final survey are relevant.

Question 7: How did you experience the process of lesson planning – first plan a lesson, then teach the lesson, then refine and submit a final lesson plan?

Technology was a noticeable aspect of the teaching phase of the LS process. Five participants mentioned learner as well as the educator motivation. Learners enjoyed their lessons because (i) it included the use of technology and (ii) they were excited by technology integration in the lesson. One participant mentioned that the availability of technology in their classroom made it possible for them to explore new teaching strategies and move away from old habitual classroom strategies.

Question 15: How did the blended learning course impact your teaching practice?

From seven responses to this question, technology emerged as an important aspect during the teaching phase of the LS process. These participants mentioned that the blended learning course influenced their teaching practice in such a way that they were now including technology in their teaching. A participant mentioned that technology now "is part of [my] system of teaching …"

5.2 Aspect 2: Group

Plan

The group aspect allowed participants to plan collaboratively and discuss their ideas with other teachers. The LMS facilitated the online processes, allowing participants to be in contact with their groups every week.

Question 3 (final survey): How did you experience the online collaboration?

Of the 29 responses, 17 indicated having only positive experiences. Six of the participants stated that working online was "interesting". They found online collaboration as a pleasant experience due to the "interaction with the facilitators and other groups", "sharing ideas" and "getting feedback … because it was motivation". Three participants commented on the fact that they were isolated from each other and that the online collaboration was "the best way in which [they] could communicate given the distance between everyone", that they had an "amazing experience interacting with my colleagues from [other parts] of the country" and that they "learned to work as a team irrespective of the distance between [them]".

Nine participants had both positive and negative experiences. Four participants indicated that their negative experiences were mainly at the beginning of the online collaboration phase and "but as time went on" they managed to "overcome the challenges and continue with the course".

Three participants experienced online collaboration with their groups as negative because of other group members not participating in the LS process or network issues and technical difficulties with their personal devices.

Question 4 (final survey): How often did you access the LMS to collaborate with your group members?"

Fig. 12 summarises the 29 replies on LMS access for collaboration.

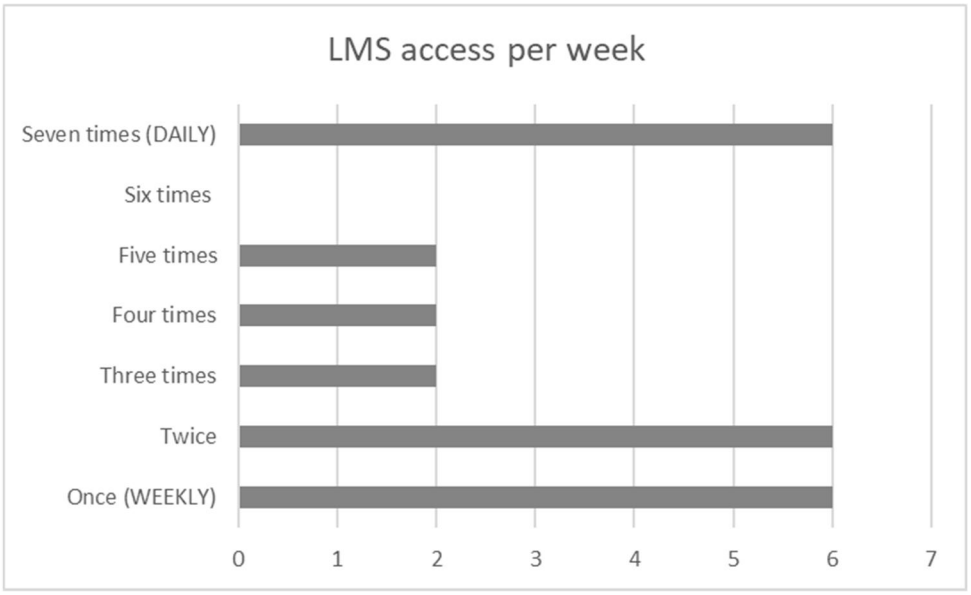


Fig.12: LMS - Access per week

The frequency of accessing the LMS varied, but the responses indicated that it was possible to meet online at least once a week to collaborate with group members.

Three participants indicated that they accessed the LMS seldomly – again because of unresponsive group members or network difficulties.

Teach

Question 7 (final survey): How did you experience the process of lesson planning – first plan a lesson, then teach the lesson, then refine and submit a final lesson plan?

Three participants enjoyed the availability of a group allowing them to share ideas with others. One participant mentioned that "the ability to share play[ed] a huge role in developing [themselves] when it comes to teaching". Two participants mentioned that the group influenced their teaching as they could gain information from their group members and were able to explore new teaching strategies with their groups.

Observe and reflect

The group aspect emerged from the investigation of this phase through the fact that the groups shared their observations and reflected as groups in the initial group discussion forums. Mathematics teachers reported that online collaboration gave them the opportunity to gain mathematical insights as they shared experiences, which allowed them to improve their understanding and teaching approaches, supporting the findings of Li and Qi (2011).

Refine

Question 7 (final survey) above

Nine participants stated that their experience was positively influenced by the fact that they were working in groups. The consensus seems to be that the participants found that their collaboration (4), feedback (2), communication (1) and sharing of ideas (1) lead to their positive experience of the group as an aspect in the refine phase.

One participant did not have any support from his group and therefor struggled to come up with a refined lesson. This participant further stated that having access to the larger group, and also seeing the work that those participants did "[he] had an idea of what to do and was able to post [his final] lesson plan."

5.3 Aspect 3: LMS

Plan

Question 2 (final survey): How did you access the LMS?

Seven participants had an internet connection at their home as well as at work. Six participants only had internet access at home and five only had access to the internet at work. Three mentioned that they accessed the internet at their local library. One participant noted that he had internet access at an internet café.

As for devices used for access, 30 participants (of the 31 who answered this question) indicated a device. Most participants had access to laptops (18) and smart phones (16). Eight mentioned the use of desk top computers and six used tablets.

Eleven participants used their personal data accounts to access the LMS. Seven participants stated that they used the internet access available to them in public places such as school Wi-Fi (3) libraries (3) or other public access points (1).

Question 5 (final survey): What did you do when accessing the LMS?

The most common activity that participants were involved in on the LMS was to read and reply on the posts of others (20), followed by submitting material (16), posting comments (12) and downloading material (6).

Observe and reflect

Groups were managed through the LMS, and this created a space where observations and reflections could be shared.

Refine

The LMS served as the facilitation tool for the groups to collaborate and share files and ideas to refine their lesson plans.

5.4 Aspect 4: Online facilitation

Plan

Question 6 (final survey): How did you experience the online facilitation process?

Of the responses, 21 of 28 indicated that the aspect of online facilitation is necessary to include in the LS process. Firstly, the participants (7) stated that the use of online facilitation "assisted" the blended learning course. Secondly, the participants (6) explained that the online facilitation made use of "clear instruction" that was "effective", "efficient" and "monitored". The third reason that participants (4) provide is that the use of online facilitation provided them with the experience to be online peer-facilitators themselves.

Two sets of facilitators were involved. The first set was the formal course facilitators. Participants mentioned that their duties were to "monitor" (4) their interactions on the LMS, provide assistance (2) with technical issues as well as misunderstandings related to the blended learning course, and to give feedback (1) were necessary. A second set of facilitators emerged as peer-facilitators. This set included members of the participants' groups, both from the smaller subject groups and the large group of participants. Online facilitation allowed these facilitators to "share [their] ideas" and provide support in order to "overcome challenges"

Observe and reflect

The online facilitation aspect provided a virtual space to share observations and reflections and to guide participants. Results for mathematics participants suggest that after they have reflected collaboratively, they continue to reflect on their own lessons, supporting the findings of Cavanagh and McMaster (2015).

Refine

Seeing that refinement of lesson plans within LS strongly supports the idea of group members going through this process collaboratively, online facilitation and the group members' duties as peer-facilitators became an important aspect in this phase. Once again, the LMS served as a vehicle for interaction whilst refining the lessons.

5.5 Aspect 5: TPACK

Plan

Participants' interaction with the TPACK framework in the lesson planning forms were analysed using the observation schedule.

Observation 2: Could the participants choose technology to support pedagogy and content?

The observation schedule was used to analyse the implementation of TPACK. Fourteen (of the 21 refined) lesson plans illustrated TPACK integration.

5.6 Aspect 6: Mobile learning strategies

Plan

Observation 3: Were the participants able to apply mobile learning strategies?

Evidence of mobile learning strategies were available in six of the 10 refined lesson plans for the first cycle, and six of the 11 in the second LS cycle. The remainder of the groups either did not show evidence of mobile learning strategies or omitted this section in the lesson plan.

5.7 Aspect 7: Lesson planning form

Plan

Question 9 (final survey): How did you experience the lesson planning form for the planning and refinement of lessons?

The 27 responses were mostly positive with only three participants indicating that they had some challenges. Seven participants mentioned that the lesson planning form was easy to use for planning (4), teaching (2) or both (1).

Participants who were challenged by the planning form were challenged in diverse ways. One participant stated that the lesson planning form is "difficult to use when your school has no technology".

Teach

Question 9 (above) is also relevant here. Five participants commented on experience of the lesson planning form in the teaching phase. Four participants' replies indicated that the lesson planning form served as an important guide during the teaching of their lesson as "it is a guide on how to go about teaching".

Refine

Responding to question 9 (above) some participants indicated a positive experience as they could use the lesson planning form to "see what worked and gave [them] an opportunity to improve" and to "correct each other before [submitting]" a refined version. Participants added that the lesson planning form provided "structure and guidance" in their refinement of the lesson plan as it showed them "what was expected" and "work wonders if you want to share the lesson with [others]".

5.8 Aspect 8: Backward design

Plan

Seeing that the lesson planning form was used to facilitate the backward design process, the observation schedule was used for analysis. Bloom's taxonomy was used as a means to assess the level of the Outcome, Assessment and Teaching and as an instrument to check the alignment of the planning process.

Observation 1.1 (observation schedule): Outcomes

The results of outcome levels in LS Cycle 1 are depicted in Fig.13. Participants were not limited to a certain number of outcomes, neither were they given advice on the outcome cognitive levels.

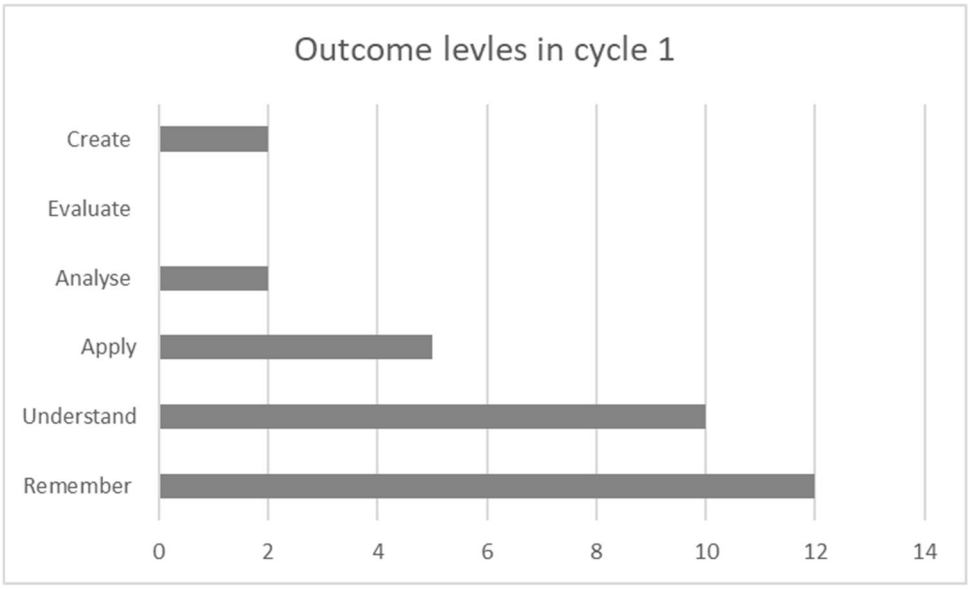


Fig. 13: Outcomes observed - Cycle 1

Note that the outcomes were mostly on the lower levels of Bloom's taxonomy. Fig. 14 depicts the second LS cycle outcome distribution.

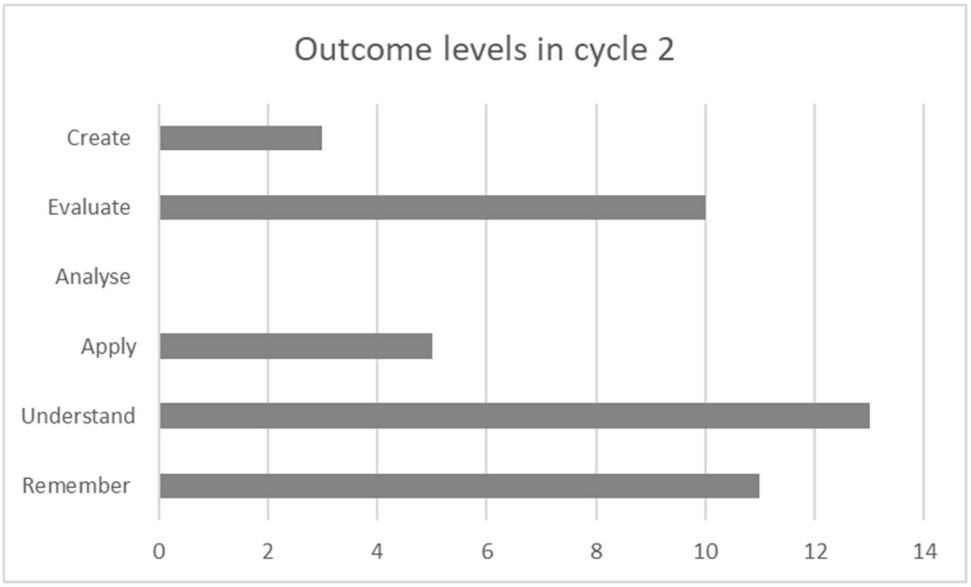


Fig. 14: Outcomes observed - Cycle 2

The lesson in this phase, although still mostly positioned on the lower three levels of Bloom's taxonomy, included more high-level outcomes. This could be an indication that the teachers were more comfortable with this process of planning and expected more from their learners.

Observation 1.2: Assessment

Participants included 11 assessment strategies to determine whether or not the outcomes were reached, as in Fig. 15.

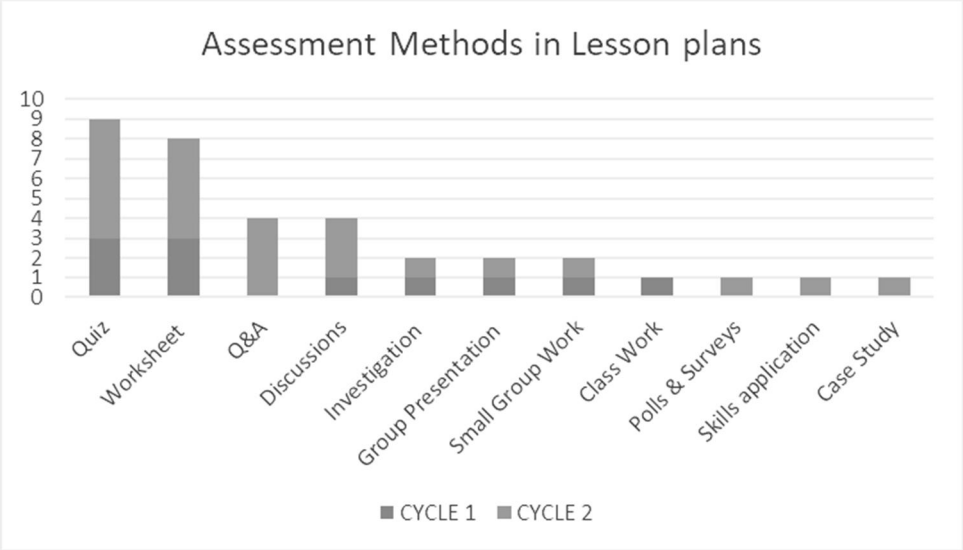


Fig. 15: Assessment methods in lesson plans

Observation 1.3: Teaching

In total 20 different teaching strategies were mentioned by the participants in their lesson plans, as indicated in Fig. 16.

Fig. 16: Teaching strategies in lesson plans

Nine groups included direct instruction, but the results indicate a high level of learner-centred interactive strategies, and a modular approach.

Observation 1.4: Alignment

Bloom's taxonomy was used to determine the levels of the outcome, assessment and teaching strategies respectively.

In the first LS cycle, four of the ten lesson plans had been designed in an aligned fashion, four were partially aligned (for example that the outcome and teaching align well, but the assessment strategies are misaligned) and two lesson plans were not aligned at all.

In the second LS cycle, ten of the 11 lesson plans contained a fully aligned backward design. In this cycle, there were no partially aligned lessons and only one lesson plan that was misaligned. This group also did not have an aligned lesson in the first cycle.

5.9 Aspect 9: Time

Teach

In discussion forums participants mentioned the time that it takes to plan for teaching with technology, as well as of other commitments of teachers, which created a challenge to find resources as well as to find time for the LS process.

Question 10 (final survey): Which challenges did you experience during the teaching of the lessons planned?

Five participants viewed time management as a challenge during the teaching of their lessons.

5.10 Aspect 10: Photos, videos and reports

Observe and reflect

Participants were not physically in each other's classrooms, nor did they observe the lessons that were taught, in a synchronous manner. The participants were rather asked to share their lesson experiences on the discussion boards with their groups. Participants used three avenues, namely photos (82), videos (5) and reports (17).

5.11 Aspect 11: Reflection questions

Observe and reflect

In the first LS cycle, ten refined lesson plans were submitted of which six included this aspect as a group reflection. In the second cycle eight of the eleven lesson plans included this reflection. Individual participants also used these questions to reflect in different discussion forums after each lesson, as mentioned above.

5.12 Relationships between the LS process and aspects

The interconnectedness of the eleven aspects and the various LS phases can be somewhat daunting. In Fig. 17, the aspects are indicated as they link to the LS phases.

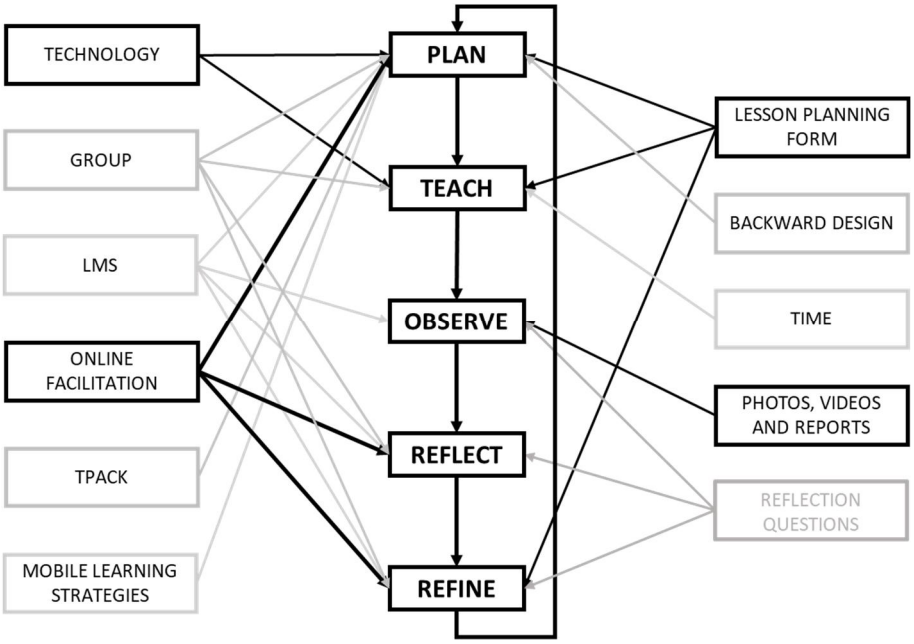


Fig. 17: Relationships between the LS process and aspects.

6 Discussion and conclusions

Traditionally the LS process is conducted in an f2f setting. However, researchers such as Teele et al. (2015) and Lewis and Perry (2017) incorporated videos to introduce an asynchronous approach to the observation and reflection phase. Xiaofeng et al. (2015) investigated online collaborative lesson planning for teachers that are isolated from each other.

We have defined LS as *a collaborative instructional development process that follows continual processes of improvement and allows teachers to consider subject matter, the reasons for their teaching as well as the content and manner in which learners learn.* In our research we investigated which aspects are necessary to support these isolated teachers through all the phases of LS in a blended approach. The eleven aspects that emerged, lead to the development of a framework consisting of three dimensions of LS namely *Collaboration, Instructional Development* and the *Iterative Improvement Process.* Fig. 18 below indicates how the 11 aspects contribute to this framework.

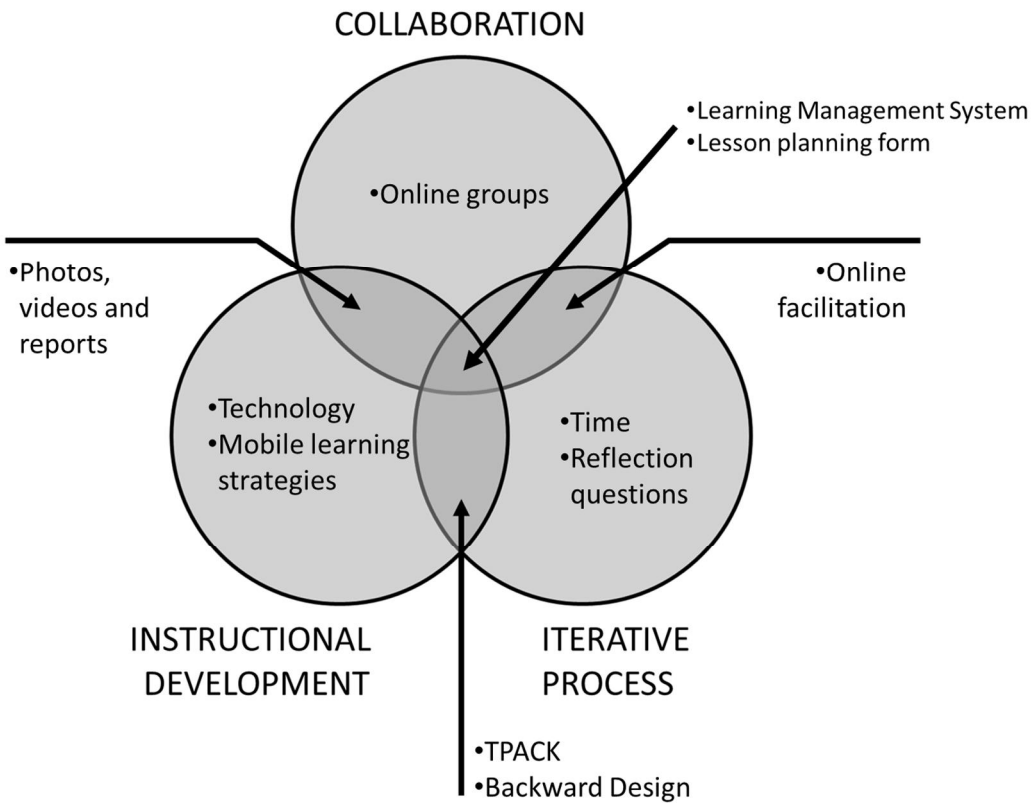


Fig. 18: Framework of LS dimensions with the identified aspects

In the discussion that follows, the aspects will be discussed and how they contribute to the three dimensions of LS, as in Fig. 18. In the discussion the different aspects are in italics to highlight their connection to the dimensions.

6.1 Collaboration

As with more traditional modes of conducting LS, the underlying aspect of collaboration in this study was the subject *groups* that participants were divided into. The blended nature of this course allowed for different types of groups namely, subject groups and the larger course group. *Online facilitation* was provided by various participants and online facilitators. Results indicate motivational value of bringing isolated teachers together through online interaction and "teamwork". Where groups were not functional, collaboration was constrained.

Supporting the LS process through group interactions and facilitation is not uncommon in traditional LS approaches, but in our case, this took place in a blended format, and mostly online. Results indicated that teachers could manage to meet in this virtual environment, as facilitated by an LMS, at least once a week. This approach implied that teachers did not have to be in close proximity to each other or travel long distances to partake in LS.

The online interactions were strengthened at its core by the fact that all the course participants had access to the *LMS*, at least on a weekly basis. This

allowed for the sharing of *photos, videos and reports* that created an opportunity for participants to be closer to each other's reality. *Reflection questions* and a generic *lesson planning form* allowed all collaboration interactions to be focussed and organised. The ability for these teachers to send each other *photos, videos* and *reports* of their lesson presentations was a viable way for the observation phase of the LS to be conducted online. This allowed for asynchronous lesson observation.

Our results show how online environments can support collaboration, but the issue of how online communities can grow as an environment where learning and teaching takes place, remains open (Borba and Llinares 2012).

6.2 Instructional development

The instructional development that was envisaged in this TPD course, required that teachers employ two of the aspects, namely *technology* and *mobile learning strategies.* To support the use of technology, the *TPACK* was used to assist teachers in successfully integrating technology in their teaching. The results show that the participants integrated various forms of technology in their teaching and that two thirds of the lessons planned illustrated a clear illustration of successful *TPACK* integration. The *Backward design* process also assisted in the instructional development as it allowed the teachers to design their lessons collaboratively in well-defined stages. Both of these processes were built into the structured *lesson planning form* to facilitate instructional development.

The structured *lesson planning form* supported coherent planning processes and guidance in implementation of agreed aspects in the planning, especially for teachers who are isolated from each other. The results show that as participants became more used to the structure of the lesson planning form, they were able to design lessons with increasing quality

Photos, videos and reports as well as the *reflection questions* provided the instructional development process with information that could inform upcoming LS cycles.

6.3 Iterative improvement process

It is clear from the literature that in its nature, LS is reliant on the ongoing improvement that it brings to teaching and learning. Learning from each round of the LS process, participants improve on their teaching approach in the next iteration of the process.

The aspect required for this process to be successful in an online environment is *time*. The results show that time was not only a necessity in the classroom, but also in the preparations of lessons. *Time* emerged as an important aspect when implementing this LS approach on a large scale. Our results indicated that teacher time should be carefully considered to allow teachers to make the most of their collaboration with others without being overloaded by other commitments. The schedule of such an approach should also be kept flexible to

allow the interaction of teachers not to interfere with the schools' internal schedules.

An aspect such as the *lesson planning form*, incorporating both *TPACK* and the *backward design process*, allowed for time spent on the preparation to be focussed and supported.

The *LMS*, with all its functionalities and *online facilitators* it brought with it, provided assistance to teachers in a timely manner. The strong online presence of the *facilitators* in this adapted LS approach played an important role. Teachers who participated in the activities also discovered their role as online peer-facilitators of the LS approach. It was seen from the approach followed in this study that the groups should be kept small (3-5 participants) to ensure the success of peer-facilitation. Results show that *online facilitation* was successful in that it was monitored in a timely manner.

Reflective practice was a guided process. It is the researchers' opinion that the use of positive reflection questions motivated participants to reflect on their practice individually and as a group. The use of the guided reflection also provided a way for the participants to create a collaborative reflection with ease.

6.4 Framework intersections

The diagram provided in Fig. 18 shows four intersections between the three dimensions of LS. At the very centre are the *LMS* and the *lesson planning form*. These two aspects strongly supported the LS process for the isolated teachers. The *LMS* enabled the sharing of *photos, videos and reports.* Furthermore, the LMS allowed for real time and asynchronous conversations to be conducted with *online facilitators*.

Our study clearly shows that isolated teachers need some guidance and structure to support them in participating in LS in a blended environment. Structure was provided in the form of the *lesson planning form* that incorporated other structures such as the *backward design* and *TPACK*. The *reflection questions* also provided structure to the reporting that teachers did online and made it easier for *online facilitation* to support any arising gaps.

The initial blended professional development course was an important driver for the LS process presented here.

The blended nature of the course proved to be beneficial. The initial f2f session were valuable as teachers were introduced to the concepts (as with other professional development courses) and to group members and facilitators. This was followed by the online session including aspects such as *group, LMS, online facilitation, lesson planning forms* and the *reflection questions.*

Lastly, our research indicates that this adaptation of LS is relevant to mathematics teaching, but also generic in that results were similar for all the other subjects represented in the research.

Our results confirm that LS, done through a blended approach is a viable solution to support isolated teachers in teaching with technology.

7 Shortcomings and limitations

The course programme was presented during a time that some schools had examinations and others had holidays. This impacted negatively on the first LS cycle, and thus the available data. This was, however, not the case for the second LS cycle.

Some participants reverted to also work through the WhatsApp messenger application during the first cycle. The researchers did not have access to these group discussions. It was also corrected for the second LS cycle.

8 Proposed new research

It would be interesting to see the application of this blended approach to LS in a setting where it is not administered by an academic institution. This could be done, for example if the Department of Basic Education would implement this form of LS on a national or provincial level in mathematics education initiatives.

9 Final conclusions

The most significant contribution of this study is the practical illustration of applying LS in a blended format on a relatively large scale despite distance between participants. The ensuing core aspects can support the adaptation of the traditional LS process for a blended environment. This expands on the work of Teele et al. (2015), Lewis and Perry (2017) and Xiaofeng et al. (2015) in the quest to adapt LS for isolated teachers. The combination of the TIP model and the LS process is also unique to this study.

This LS approach can be a teacher development tool that can address some of the challenges and expectations that isolated teachers are introduced to in their everyday life. LS is already a recognised TPD process in mathematics education. This adaptation can open up possibilities for these educators that can enhance mathematics teaching and learning in guiding them to collaborate and share their practice and grow professionally regardless of where they are in the country and maybe even in the world.

References

Bloom, B. S., & Anderson, L. W. (2014). A taxonomy for learning, teaching, and assessing: A revision of Bloom's. Harlow: Pearson.

Burghes, D., & Robinson, D. (2010). Lesson study: Enhancing mathematics teaching and learning. Reading: CfB

Borba, M. C. & Llinares, S. (2012). Online mathematics teacher education: Overview of an emergent field of research. *ZDM Mathematics Education 44,* 697–704. DOI 10.1007/s11858-012-0457-3

Cakir, R., & Yildirim, S. (2013). ICT teachers' professional growth viewed in terms of perceptions about teaching and competencies. *Journal of Information Technology Education*, 12, 221-237.

Callaghan, R. (2018). Developing mobile teaching practice: A collaborative exploration process. *Technology, Knowledge and Learning*, 23(2), 331-350.

Cavanagh, M. & McMaster, H. (2015). A professional experience learning community for secondary mathematics: Developing pre-service teachers' reflective practice. *Mathematics Education Research Journal, 27,* 471–490.

Chong, J. S. Y., Han, S. H., Abdullah, N. A., Chong, M. S. F., Widjaja, W., & Shahrill, M. (2017). Utilizing Lesson Study in improving year 12 students' learning and performance in mathematics. *Mathematics Education Trends and Research*, 1, 1-8.

Creswell, J. W. (2007). Qualitative inquiry & research design: choosing among five approaches (Second ed.). Thousand Oaks: Sage Publications.

Elliott, J. C. (2017). The evolution from traditional to online professional development: a review. *Journal of Digital Learning in Teacher Education*, 33(3), 114-125.

Estes, L. A., McDuffie, A. R., & Tate, C. (2014). Lesson planning with the common core. *Mathematics Teacher*, 108(3), 206-211.

Fujii, T. (2018). Lesson Study and teaching mathematics through problem solving: the two wheels of a cart. In M. Quaresma, C. Winslow, S. Clivaz, J.P. da Ponte, A. Ní Shúilleabháin, A. Takahashi (Eds.): *Mathematics lesson study around the world,* 1-21. Switzerland AG: Springer.

Fürstenberg, U., & Kletzenbauer, P. (2015). Language-sensitive CLIL teaching in higher education: Approaches to successful lesson planning. ELTWorldOnline. com. Special Issue on CLIL.

Grant, M. M. (2019). Difficulties in defining mobile learning: analysis, design characteristics, and implications. *Educational Technology Research and Development,* 67(2), 361-388.

Gudmundsdottir, S., & Shulman, L. (1987). Pedagogical content knowledge in social studies. *Scandinavian Journal of Educational Research*, 31(2), 59-70. doi:10.1080/0031383870310201

Hart, L C., Alston, A. S., & Murata, A. (2011). Lesson Study Research and Practice in Mathematics Education, Learning Together, New York: Springer.

Herselman, M., Botha, A. I., Dlamini, S., Marais, M., & Mahwai, N. J. (2019). *Findings from a mobile tablet project implementation in rural South Africa.* Paper

presented at the 15th International Conference on Mobile Learning. Retrieved 10 October 2019 from https://researchspace.csir.co.za/dspace/handle/10204/11083

Hooks, M. (2015). Pinterest: A tool for lesson planning. *Mathematics Teacher*, 108(6), 466-468.

Joubert, J. (2019). Adapting Lesson Study towards a blended approach to support isolated teachers in teaching with technology. Unpublished MEd dissertation, University of Pretoria.

Juhler, M., & Håland, B. (2016). The impact of lesson study and content representation on student-teachers' science teaching. In Hallås, B.O.,Grimsæth, G. (Eds). *Lesson Study i en nordisk kontekst*, pp. 195-213. Copenhagen: Gyldendal.

Kadroon, T., & Inprasitha, M. (2013). Professional development of mathematics teachers with Lesson Study and open approach: The process for changing teachers values about teaching mathematics. *Psychology,* 4(2), 101-105.

Kamau, L. M. (2014). The future of ICT in Kenyan schools from a historical perspective: a review of the literature. *Journal of Education & Human Development, 3*(1), 105-118.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary issues in technology and teacher education*, 9(1), 60-70.

Kolb, D. A. (1984). Experiential learning : experience as the source of learning and development. Upper Saddle River, NJ: Prentice-Hall.

Krulatz, A. (2014). Teaching Norwegian to beginners: Six principles to guide lesson planning. *Journal of the National Council of Less Commonly Taught Languages*, 15, 1-14.

Lewis, C., & Perry, R. (2017). Lesson study to scale up research-based knowledge: A randomized, controlled trial of fractions learning. *Journal for Research in Mathematics Education*, 48(3), 261-299.

Li, Y., & Qi, Ch. (2011). Online study collaboration to improve teachers' expertise in instructional design in mathematics. *ZDM Mathematics Education, 43(6–7),* 833–845.

McKechnie, L. E. F. (2008). Observational research. In L. M. Given (Ed.), *The Sage encyclopaedia of qualitative research methods* (pp. 573–577). Thousand Oaks, CA: Sage.

Mee, L., & Oyao, S. G. (2013). Establishing learning communities among science teachers through Lesson Study. *Journal of Science and Mathematics Education in South East Asia,* 36(1), 1-22.

Naresh, N. (2013). Traverses through the landscape of reflective thinking: Teachers' actions in the context of lesson study. *Fields Mathematics Education Journal,* 1(1), 21-42.

Ndongfack, M. N. (2015). Mastery of active and shared learning processes for techno-pedagogy (MASLEPT): A model for teacher professional development on technology integration. *Creative Education*, 6(1), 32-45.

Roblyer, M. D., & Doering, A. H. (2014). *Integrating educational technology into teaching (6th ed.)*. Harlow, England: Pearson.

Schraudner, M. (2014). The online teacher's assistant: using automated correction programs to supplement learning and lesson planning. *CELE Journal*, 22, 128-140.

Shapiro, G. M. (2008). Sample. In P. Lavrakas (Ed.), *Encyclopaedia of survey research methods.* Thousand Oaks, California.

Souza, L., Lopes, C. E., & Pfannkuch, M. (2015). Collaborative professional development for statistics teaching: A case study of two middle-school mathematics teachers. *Statistics Education Research Journal*, 14(1), 112-134.

Stigler, J., & Hiebert, J. (1997). Understanding and improving mathematics instruction: An overview of the TIMSS video study. *Phi Delta Kappan*, 79(1), 14–21.

Stigler, J., & Hiebert, J. (1999). *The teaching gap.* New York: Free Press.

Stigler, J. W., & Hiebert, J. (2009). The teaching gap: Best ideas from the world's teachers for improving education in the classroom. New York: Simon and Schuster.

Sweeney-Burt, N. (2014). Implementing digital storytelling as a technology integration approach with primary school children. *Irish Journal of Academic Practice,* 3(1), 4.

Takahashi, A. (2014). *Implementing lesson study in North American schools and school districts.* Online at http://hrd.apec. org/images/a/ae/51.2.pdf. Retrieved, 11 September 2019.

Tall, D. (2008). Using Japanese lesson study in teaching mathematics. *The Scottish Mathematical Council Journal,* 38, 45-50.

Teele, S., Maynard, D. F., & Marcoulides, G. A. (2015). The Lesson Study process - An effective intervention to reduce the achievement gap. *US-China Education Review*, 5(4), 229-243.

Wake, G., Foster, C., & Swan, M. (2013). *A theoretical lens on lesson study: Professional learning across boundaries.* Proceedings of the 37th Conference of the International Group for the Psychology of Mathematics Education, Kiel, July 2013.

Wiggins, G., & McTighe, J. (2005) *Understanding by design* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development ASCD.

Xiaofeng, W., Qi, W., & Ling, C. (2015). *A case study of online-based collaborative lesson planning.* Proceedings of the Eighth International Conference on E-Learning in the Workplace (ICELW 2015), Kaleidoscope Learning, New York, June 2015.