

DEVELOPING LOCAL INSTRUCTIONAL THEORIES AND LOCAL THEORIES: PRECONCEPTIONS OF LESSON STUDY

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ABSTRACT

Lesson study (LS) in Mathematics education is often restricted to the assumptions of education theory and its impact on practice. The paper discusses preconceptions of LS to develop Local instructional theory (LIT). To facilitate LS, two groups of students in a university fourth year Mathematics education class partake in the design of a research lesson. The aim was to determine how final year Mathematics education students depict Lesson study in theory and practice through a LIT, and how these depictions inform the development of a Local theory (LT) as preconceptions of LS. The results indicate LIT produce constructs that informs the development of theory. Recommendations follow on how LS can be theorised about and facilitated through developing theory.

Keywords: Mathematics education, Lesson study, Local instructional theory

1. INTRODUCTION

It was close to the 1980's that Gehlbach (1979) reported on the differences between instructional theory and learning theory. A Local theory (LT) of learning considers the descriptive process, explaining the relationship between constructs of teaching and learning. On the other hand, a Local instructional theory (LIT) is prescriptive as it provides guidelines to facilitate teaching and learning experiences. In Mathematics education, however, the subject matter and the types of theories involved in modelling knowledge in practice can have a marked influence on theory development. Gravemeijer (2004) explains this development process as provisional in the sense that the theory must be evaluated and tested constantly as new knowledge or new theory emerge. Prospective teachers have to be prepared to, at least, manage the pedagogical challenges of their future classrooms. As such, Lesson study is identified as one of the mechanisms that can assist in preparing students for the Mathematics education profession (Cajkler, Wood, Norton & Pedder, 2013). In the current study content, skills and context intertwines teaching and learning of Mathematics as well as recognizing pedagogy, and its implicational value for practice.

2. CONCEPTUAL-THEORETICAL FRAMEWORK

Mathematics education theory is concerned about those theories that aim to understand and improve teaching and learning of Mathematics in context sensitive ways (Sriraman & English, 2010). Lingard (2013) stresses the importance of developing Mathematics education theories that filter the purposes, nature, and intend of theory to model and define relationships between the teaching, learning and doing of Mathematics. In addition, it is the researcher's philosophical stance, or contextualised worldview, that contributes to the design of Local theory (Cobb et al., 2013). In turn, the context of educational theories integrates theory with practice and can form new Local instructional theories (LIT), such as the type proposed by Silver and Herbst (2007). When the focus is not to instruct, but to explain the nature of the relationship between the constructs, LT can be developed.

2.1 Underlying assumptions of Lesson study

Craddock, O'Halloran, McPherson, Hean and Hammich (2013) propose that teachers' professional development and the reinforcement of teaching and learning practice, strengthens the value of theory

by highlighting its implications in educational practice. While education theory influences the teaching practice, it also reveals new knowledge about the teaching and learning experiences and put forward alternative practices and ideas that result from these experiences (Bernath & Vidal, 2007). This pragmatic view on the development of effective teaching and learning experiences relates to the Japanese model of adapted Lesson study (LS). To apply, understand and explain constructs as components of the knowledge that emerge from and result in theory, Bernath and Vidal (2007) argue that such theories shift from traditional educational pedagogy towards practically relevant educational theory. LS can then be facilitated by aligning its' principles in practice and revisit them with theory. Nickerson and Whitacre (2010) claim that the knowledge and skills of conducting LS include planning, analysing, testing out, reflecting on and refinement of lessons.

In doing so, the value of LS in Mathematics education seems indispensable. In support of this, Cobb et al. (2013) suggests that pedagogies should be re-examined to bring theory and practice together and to develop new theory. Furthermore, to conduct LS requires deep reflection when planning, monitoring and evaluating the effectiveness of the lesson. Flavell (1979) defines this reflection as Metacognitive skill (also see Frith, 2012). Likewise, individuals can find it challenging to express their thinking about these Metacognitive skills when they have to explain their reasoning to other members of the LS group. During such collaboration on the design and refinement of lessons, group members (usually between 5 and 8) plan together, observe and reflect on each other's inputs and learn to work collegially in a network. Theory development to facilitate LS therefore includes these skills to hypothesise about the route to follow (see Table 1 in Addendum) and what learning trajectory to plan for. Stemming from these two assumptions LIT can be developed to facilitate LS.

2.2. The value of LIT and LT in the facilitation of LS

The purpose of LIT is to design instructional guidelines that address the issues emerging from facilitating subject content. In contrast, the purpose of a LT is to explain the nature of these emerging constructs in terms of a local setting.

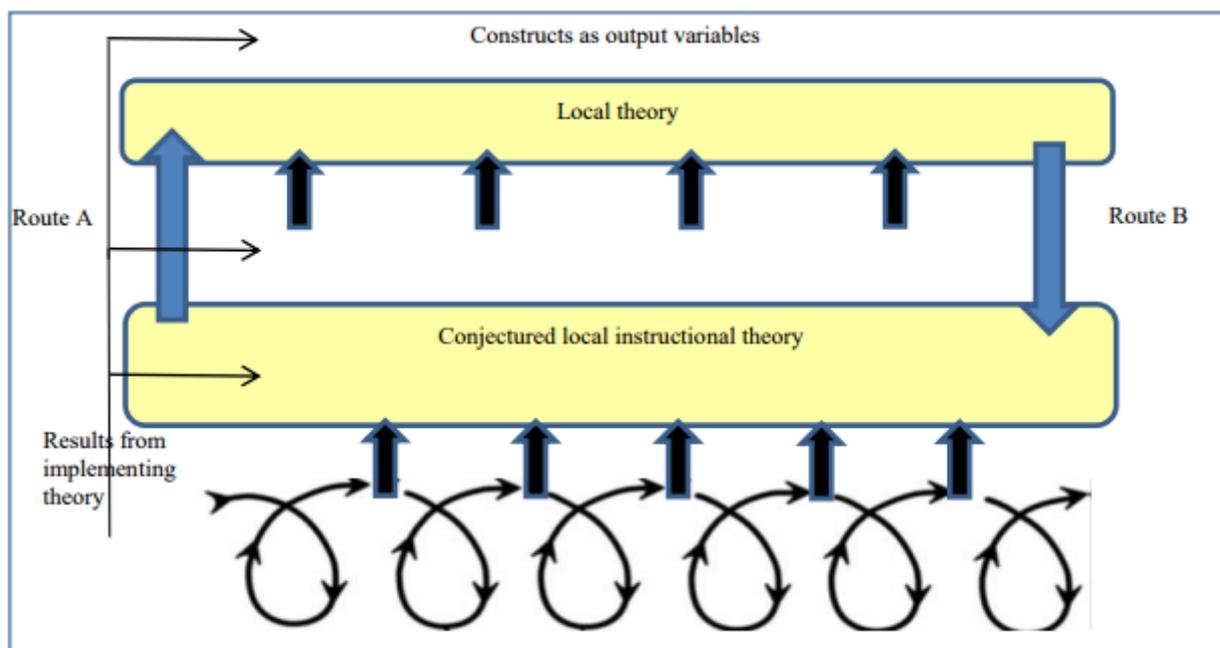


Figure 1 The design cycles of LIT to produce LT Conceptualised from: Gravemeijer (2004); Bustang et al. (2013)

According to Craddock et al. (2013), this reinforces professional development and suggests a relationship between LS's theory and practice. As an argument to include both LIT and LT in the facilitation of Lesson study, Bernath and Vidal (2007) suggest that improving educational quality takes place when researcher (e.g. facilitators and teachers concerned with theory and practice) bring forward new ideas and strategies to progress not only the teaching experience at the present but also to predict the quality of the learning experiences in the future. To accomplish this in the current study, the local route of LS with its hypothesised learning trajectory (HLT) is aligned against the design of LIT. The LIT's theoretical structure contextualises the teaching and learning environment and describes, interprets, explains and justifies the observations and reflections of the constructs that emerge when applying the LIT. The LIT then transforms the practical issues (such as what skills are necessary? how can these skills best be communicated, and how are these skills connected?) into research problems that can be studied in terms of mini-pedagogical experiences or research lessons (Cobb et al., 2013). Then the LIT does not only provide guidelines for the educational experience, but also play a role in the rationale of the theoretical constructs that emerge from the LIT which, in turn, inform the LT. When LS is done, new ideas regarding best practices and effective teaching can develop through observations of, and reflections on the teaching and learning experience. The experiences can then be researched to determine how the emerging the underlying constructs of LS informs LIT and LT. To do so, the constructs have to be explored, examined and understood as parameters of the LIT and their relationship has to be explained through LT to inform LIT.

2.3. The relationship between LIT and LT

First, LIT and LT do not appear to exist alone; instead, they underpin meta-or-standard theory, which supports and explains the instructional activities as well as the implications of these activities in practice. Furthermore, the instructional theories explain through a particular instructional sequence and conduct teaching and learning experiences. It appears that the instructional sequence serves as a guideline and structures, predetermined, the conjecture of the LIT. This is done on four conditions. First the theory requires deep reflection on the constructs as output variables that support and explain the LIT's guidelines to test and refine theory (Cobb et al., 2013). Second, by implementing the LIT, new knowledge emerge that supports the impact of the LIT and results in a localised or contextualised explanation of the LIT's structure and function. Third, a meta-theory can act as a standard theory to refine the LIT and inform the development of LT. The meta-theories mainly focus on the effect(s) of the teaching practice and do not only explain the relationship between the constructs that emerge but also support the purpose of both LIT and LT. Lastly, the constructs that emerge from LIT and LT can be predetermined, making them purposively conveyed in the design of the theory. This predetermined, hypothetical conjecture can be implemented by following the theory's guidelines.

LT, therefore, predicts and explains the nature of the constructs which, do not necessarily have form part of the steps or guidelines of LIT. Rather, LT regards constructs as the result or output of LIT. Similarly, Cobb et al. (2013) and Gravemeijer (2004) have reported on the input and output variables in the development of LIT as part of LT's development. Figure 1, shows design cycles to develop LIT and LT. Route A suggests that the LIT informs the LT as indicated by Larsen and Lockwood (2013). On the other hand, Route B indicates that the LT can also inform the LIT, as is the case with a study done by Nickerson and Whitacre (2010). The design cycle (also called macro cycle) indicates similar continues cycles (micro cycles) that produce recurring or comparable results and enables the teacher as a researcher to formulate, test and refine the conjectured LIT. In these design cycles, the teacher, as a researcher-facilitator makes use of a teaching experiment. Cobb et al. (2013) and Gravemeijer (2004) explain that the role of the teaching experiment is to test and improve the LIT. The design of these teaching experiments forms the basis of a hypothetical learning trajectory as a set of classroom activities (Bustang et al., 2013). The primary research question this study then sought to answer is:

What do final year Mathematics education students' depictions of LS entail when developing a LT through the facilitation of a LIT of LS?

3. METHOD

Route A, in Figure 1, was followed by employing a qualitative methodology to interpretively explore emerging constructs from the LIT of LS to determine how these constructs inform LT. The study began by inviting two groups of fourth year Mathematics education students enrolled for a course on the didactics of intermediate phase Mathematics. As part of their coursework, students had to plan and design a Mathematics lesson to present to a Grade 6 class at a nearby primary school.

The participants represent both male and female students from various ethnic backgrounds and were involved in lesson planning since their first year at the university. They have also observed, planned and presented Mathematics lessons in similar schools during the work integrated learning opportunities the campus offered. In Group A there were 6 students represented by 1 male and 5 females while in Group B there were 5 students represented by 1 male and 4 females. The participants were encouraged to think aloud and share ideas during three design sessions, similar to a focus group context. They were expected to design, present and refine a lesson for Grade 6 Mathematics on the topic of Place value as it is part of a larger research project. The aim of the design sessions was to create an opportunity for participants to engage in LS to observe and analyse participants' depictions of LS. Data include video recordings of all the design group sessions. A framework to outline the design sessions was borrowed from the work of Cobb et al. (2013) and include four cyclic stages: (1) investigate problems and set goals, 2) plan the lesson and resources, 3) research the lesson's effectiveness, 4) reflect and refine the lesson (see Table 1). As arranged with appropriate authorities, LS was facilitated at the university where participants were enrolled and, on completion of the first draft of the research lesson, a volunteer from each group was asked to video record and present the lesson while other members of the group observe and reflect to generate notes and recommendations for refinement. This also added validity and trustworthiness to the data as it resembles multiple perspectives on the same phenomenon. The sessions' transcriptions were analysed through conversation analysis to describe, summarise and explain the constructs to refine LIT and inform LT

4. RESULTS

The design sessions allowed the researcher to explore the constructs that emerged as a result of the LIT. The verbatim transcribed responses, analysed and coded, were arranged in three themes that highlight the constructs of students' depictions of LS during the four LS stages (see Table 1). The constructs were identified as: Metacognitive skills, Language and Networking. Underpinning these constructs are students' expectations, understandings of one another, available time and working together in determining their success in LS.

4.1. Metacognitive skills

Participants from both groups showed growth in their depictions of LS and its value for practice as they learned to think about their thinking and to manage their ideas, a metacognitive conduct. At first they were unaware of knowing how to plan and set realistic goals for LS. They had diverse ideas that were "scattered" as they were unsure about what activities to include in their lesson and how to choose which ideas are more suitable. They did not know what to focus on, when to focus on the content and when to focus on the methodology of the lesson.

I would say that we were not sure what to expect... We have to start all over... We felt that our ideas were not important as some ideas will work and others' not... Now we are much more confident...

Their growth includes relating the theory of LS with its' practice and communicating about it:

There are many ideas which we can do better...it was very insightful...we looked at how the learners did the work...they all seem to understand the work, but they made the same small errors... If we had to do it again, we will be better prepared...

Participants reflected on the design of the lesson and on its presentation, thus reflecting on the teaching and learning experience. In the second and third session they divided the work amongst themselves and arranged additional sessions. They worked together, collaborated and made decisions about their ideas, specifying what to include and exclude in the lesson. Yet, besides the metacognitive skills of planning and monitoring which they have developed, they had another issue:

We talk past each other and do not understand what the other one means.

4.2. Language

Not being able to express their reasoning clearly, and lacking the vocabulary of their thinking about their thinking, participants explained that, even though they worked together, they often became frustrated when their ideas are not, understood or recognised:

But we do not understand what each other mean. I don't know what they don't know and what someone else is thinking about my idea ...we had too many good activities and we do not know how to say that we do not want to use this or that idea

Participants also seem to have grown their awareness of Language in the sense that: We now know each other and we can say this or that won't work. At first, we were afraid of what someone else might say...we didn't want to demotivate anyone... and felt that we need some way of saying what we think...

In order to get focus, participants discussed what their lesson outcomes should be, this presented a problem, not only for interpreting the curriculum documents, but also to put clearly down in words on the lesson plan what they expect from their learners at the end the lesson:

We have an outcomes, we want them to be able to identify and apply...The outcomes must be smart. It must be specific, measurable, attainable, relevant and traceable...so we have to look at it again...

4.3. Networking

The nature of networking between group members also developed along with their Metacognitive skills and Language. Participants later decided to work with each other's ideas, and not necessarily to come up with new ones all the time.

We are all here, we know what to do. We have to take everyone's ideas into consideration...We started with an idea and talked about it and made a combination of all the ideas. It helped to understand the concept better... Lesson study is difficult if one student feels separated from another... When we get together we can say, this stuff works great and then we take other ideas and we build on that.

Participants had realised what their strengths and weaknesses were, and the nature of their Networking is likely to be the key to overcome the barriers participants had during LS. Metacognitive

skills, Language and Networking appear to form a conceptual framework of students' depictions of Lesson study. When aligned against the LIT, the constructs offer a view on some preconceptions on LS to refine the LIT and to inform the development of LT.

5. DISCUSSION AND RECCOMENDATIONS

To facilitate LS a LIT theory was developed and tested out (see Table 1). From this theory three constructs emerged from students' depictions of LS namely Metacognitive skills, Language and Networking. By aligning the constructs with the LIT and following Route A (See Figure 1 and Table 1), three preconceptions of LS are derived to refine the LIT and inform LT. Students' depictions suggest that it is possible that the LIT of LS can foster Metacognitive skills, promote awareness of students' Language to collaborate and create opportunities for Networking. The following preconceptions outline this discussion:

5.1. The concept of constructs

First, to develop a LIT of LS, the assumptions that underpin LS must be considered. Clarity is needed as to what outcomes of LS will be assessed and/or anticipated. It is possible that similar studies can produce different constructs, depending on the local issues of the theory. In this case, the authors propose that facilitators of LS must first consider what underpinning knowledge, skills and values they want their students to demonstrate these must then be in line with the HLT, in order to develop the LIT. Furthermore the use of a task, such as lesson planning, and the opportunity to carry out this task in a series of manageable sessions, made it possible to observe the emerging constructs. Since Metacognitive skills are an important aspect of LS, it could be expected that students will plan, monitor and evaluate their lessons. The results show that students also planned their time for additional sessions, discussed whether the outcomes are clear enough and reflected on their own experiences. When aligned with the LIT, the construct of Language did not fit with the overall framework, suggesting that communication ought to be promoted in the facilitation session, as it was as a barrier for participants to express their thinking clearly. This will likely infuse a stronger sense of being in the groups.

The concept of developing participation

Since participants felt cautious about their contribution to the group another conceptual point to consider is finding ways to develop participation. This relates closely to the Networking construct that, in a way, depends on the Metacognitive skills and Language as skills can be shared, observed and develops over time (Cajkler et al., 2013). In addition, a stronger capacity to express one's thoughts, to reason and to redefine meaning in the design sessions, was needed and can undermine participation. However being immersed in a group long enough, can imprint a sense of group culture where the group members develop a deeper understanding of their own, and others' contributions.

5.2. Aligning the constructs with LIT to inform LT

When aligned with Table 1, the constructs serve a dual purpose. They indicate possible outputs of the theory and, as Route A in Figure 1 indicates, serve as an input of the theory. At this point, overlaps between the constructs can unfold. This suggests that, for example, Metacognitive skills can be communicated about, associating it with Language. Also, an expression of one's thinking can impact on the nature of others' understanding (Frith, 2012) and associates with Networking. The results point out that the preconceptions are epistemological in nature as they align with the LIT. Participants

recalled not only what they think worked in LS, but also what they think could have been planned and implemented differently. The theory is then connected via a meta-theory that underpins the relationships between the constructs. As such, a LT can be developed about the constructs that emerged from the LIT. This LT can then serve as a meta-theory of the preconceptions on LS.

The findings in this study indicate, that a LT can be developed to explain the constructs that emerge from a LIT. The constructs then play a key role in the nature of the LIT and their presence suggest that the LIT and LT are interrelated. Also, it seems possible that a LT can be developed to explore, test and refine the role existing constructs play in a LIT. Liden (2011) suggests that the theory-practice relationship must be revisited in empirical research since the interpretation of the findings depends on theory and implicates new theory. Several aspects of LIT and LT require further investigation. These aspects include: understanding the nature of the relationship between Metacognitive skills, Language and Networking. The LIT theory produced an understanding of the constructs and preconceptions of LS which include Metacognitive skills, Language and Networking. Because of its output, it is suggested that facilitators who wish to promote these skills in their classroom can consider meaningful activities that include collaborative and problem based learning as teaching approaches.

6. CONCLUSION

The constructs represent students' depictions of LS and outlines the preconceptions that can be used to develop LIT and inform LT in LS as a course component of Mathematics education. LIT seems to support LT indicating interrelatedness when constructs emerge from LIT and inform new theory. The preconceptions outlined above explain that LS can be facilitated with the underpinning assumptions of Metacognitive skills, Language and Networking. As these constructs emerge from students' depictions of LS, they can align with the LIT to refine it for future lessons. It appears, then, that these constructs should be taken into account when facilitating LS as it informs the development of theory. In close, students who work collaboratively in LS can preconceive the LS theory from practice and, in the process, reflect on their own depictions of LS with the emerging preconceptions built into the LIT. In the development of LIT and LT the constructs that underpin LS, inform new theory by scrutinising the preconceptions that the theory holds to refine the theory accordingly.

REFERENCES

- Bernath, U., & Vidal, M. (2007). The Theories and the Theorists: Why Theory is Important for Research? *Distances et savoirs*, 5(3), 427-458.
- Cajkler, W., Wood, P., Norton, J., & Pedder, D. (2013). Lesson Study: Towards a collaborative approach to learning in Initial Teacher Education. *Cambridge Journal of Education*, 1-19.
- Cobb, P., Jackson, K., Smith, T., Sorum, M., & Henrick, E. (2013). Design Research with Educational Systems: Investigations and Supporting Improvements in the Quality of Mathematics Teaching and Learning at Scale. National Science Foundation.
- Craddock, D., O'Halloran, C., McPherson, K., Hean, S., & Hammick, M. (2013). A top-down approach impedes the use of theory? Interprofessional educational leaders' approaches to curriculum development and the use of learning theory. *Journal of Interprofessional Care*, 65-72.
- Flavell, J. H. (1979). Metacognition and Cognitive Monitoring: A New Area of Cognitive-Developmental Inquiry. *American Psychologist*, 34(10), 906-911.
- Frith, C. D. (2012). The role of metacognition in human social interactions. *Philosophical Transactions of the Royal Society*, 367, 2213-2223.
- Gehlbach, R. D. (1979). Individual differences: Implications for instructional theory, research and innovation. *American Educational Research Journal*, 16, 8-14.
- Gravemeijer, K. (2004). Local Instruction Theories as Means of Support for Teachers in Reform Mathematics Education. *Mathematics Thinking and Learning*, 6(2), 105-128.

- Larsen, S., & Lockwood, E. (2013). A local instructional theory for the guided reinvention of the quotient group concept. *The Journal of Mathematical Behaviour*, 1-17.
- Nickerson, S. D., & Whitacre, I. (2013). A Local Instruction Theory for the Development of Number Sense. *Mathematics Thinking and Learning*, 12, 227-252.
- Silver, E. A., & Herbst, P. (2007). Theory in Mathematics education scholarship. In F. K. Lester, *Second Handbook of research on Mathematics teaching and learning* (pp. 39-67). Charlotte, NC: Information Age Publishing and Reston.
- Sriraman, B., & English, L. (2010). *Theories of Mathematics Education*. New York: Springer.

Addendum

Table 1 Overview of the HLT and LIT to facilitate LS

| Development of LIT | | | |
|--|-----------------|---|---|
| Characteristics of the local route of lesson study (LS) | Stages in LS | Hypothetical learning trajectory of the module (HLT) | Guidelines for the local instructional theory (LIT) |
| The lesson plan is developed and presented locally and data obtained is used to improve instruction Once the lesson plan is presented, evidence of its effectiveness may be weak | Investigation | There is precision in the written and oral presentation There are clear coherent arguments that reflect the style, sophistication and appropriateness of the presented lesson | Long-term goals are considered for learning and development Existing curricula and policies are studied |
| The lesson plan may depend on local materials and resources and this might transform over time | Planning | There is a clear understanding of the local needs in terms of resources and the necessary knowledge and skills to develop and design (new) resources | Plan to conduct a research lesson and to collect data through reflection and observation |
| The lesson plan caters for continuous local adaptations including innovative design changes and changes in theory. Because of its flexibility, the lesson plan is expected to undergo improvement The changes (or innovations) made to the lesson plan may adapt to each other. For example: if prior knowledge is assessed in the beginning of the lesson and it is clear that the route of the planned lesson cannot be followed, possible structures should be in place to accommodate anticipated processes as early as possible. The knowledge that is produced from the locally presented lesson embodies in an understanding of the knowledge and skills needed locally | Research lesson | The presented lesson contributes to the needs and the level of conceptualising the mathematical texts and materials Both basic and deep levels of reflection occurs at this stage as the needs, resources and classroom experiences are aligned with personal beliefs, values and expectations | The data is then presented and discussed in terms of its implications Learning resources, teacher resources and teacher knowledge is strengthened to improve the effectiveness of the lesson through refinement and reflection |
| The local adaptations, improvements and diverse understandings of the product (or outcomes) of the lesson can be used to warrant its effectiveness locally. | Reflection | Observations from the classroom experiences can be reflected upon to accommodate change in needs and instructional approach in order to improve the teaching and learning experiences Reflections on the meaningfulness of the presented lesson are measured against a specific prescribed set of criteria or outcomes | The lesson plan reveals and promote students' thinking whereas the resources support learning collegially during LS Motivation, improvement, collaboration and a sense of accountability is valued and associates with knowledge of the subject, didactics and goals |