Lesson Design Study: A research pathway to connect to mathematics teachers’ professional development and classroom improvement

（课堂教学设计研究：一个与数学教师职业发展和数学课堂深度学习教学学习和行为改进相链接的研究途径）

Liping Ding 丁莉萍
Email address: liping.ding@ntnu.no
Research Group of Lesson design study & teaching resources
https://www.ntnu.edu/ilu/lesson-design-study-teaching-resources
NTNU, Norway
3. April, 2019
Content

I. What is Lesson Design Study (LDS)?

II. Conceptualizing a Chinese expert teacher’s expertise in the LDS (Ding & Jones, 2018)

III. The interconnectedness and difference between our LDS and the depiction of action research by AERA AR SIG (Ding, Jones & Sikko, 2019)

IV. A methodological challenge of the use of the LDS model in in a pilot study of a NTNU Master Mathematics Education Course.
I. What is Lesson Design Study (LDS)?
1. 课堂教学设计研究 (LDS)

- Wittmann’s (1995) view of *mathematics education* as a ‘design science’:
  “Scientific knowledge about the teaching of mathematics … presupposes a specific didactic approach that integrates different aspects into a coherent and comprehensive picture of mathematics teaching and learning and then transposing it to practical use in a constructive way.” (Wittmann 1995, 356)

- We refer to Brown’s (2009) conception of *teaching as design*. “Design is about *crafting* something in order to solve a human problem, to change the state of a particular situation from a current condition to a desired one, and to accomplish a goal. … Whether teachers modify an existing set of materials or integrate them in a literal manner, they are engaging in the sort of *goal-directed activity* as design.”
2. LDS课堂教学设计研究的主成分 Components

Perspective: a hypothesized learning process and the means of supporting it

**Phase 1. 预设计**
Preliminary design

**Phase 2. 教学实验**
The teaching experiment

LDS community: researchers with teachers and expert teachers

(Gravemeijer, 2004)

**Phase 3. 回顾分析**
Retrospective analysis

Reflective: conjecture-driven tests, often at several levels of analysis.

Its pragmatic roots: Theories developed during the process of experiment (The theory must do real work).
3. The LDS model for TPD and classroom improvement

- LDS is of both a classroom design study and a professional development design study (Cobb, Jackson & Dunlap Sharpe, 2017).
- LDS model is based on the ‘Action Education’ model 行动教育的基本模式--以课例为载体的教师教育模式研究(三行动两反思模型）（顾泠沅与王洁，2003）。
4. The LDS model

School-based LDS community: Researchers, Teachers, Expert teachers, school principal.

(Ding, Jones & Sikko, 2017; 2019)
5. Critical aspects of LDS

- Theory of learning & instruction with variation
- Roles of researchers, teachers, & pupils
- Context
- Lesson design-oriented TPD model

LDS—Engineering forms of deep mathematical learning in classrooms
II. Conceptualizing a Chinese expert teacher’s expertise in the LDS (Ding & Jones, 2018)
1. Current trends within discussion on teacher education and practising teachers—Situated aspects (Gabriele Kaiser, 2019)

Mathematical Knowledge in Teaching (Rowland & Ruthven, 2011)

Models of teacher expertise “are unlikely to be meaningful or successful unless they take the classroom context of teachers’ professional work into account”; then the question is “whether mathematical knowledge in teaching is located ‘in the head’ of the individual teacher or is somehow a social asset, meaningful only in the context of its applications.” (p. 3)
2. Various perspectives on (future) teachers’ professional expertise/knowledge/competencies.

(Clarke and Hollingsworth, 2002, p. 949)
Fig. 3. The interconnected model of professional growth.

(Clarke and Hollingsworth, 2002)
The cyclic process of 教科研组教研活动 (Teaching Research Groups, in English Lesson Study) emphasised within in-service teacher professional development in China (杨玉东 & Ricks, 2012).

Figure 1. Three sub-activities during TRG (杨玉东 & Ricks, 2012, p. 54)
IEA Teacher Education and Development Study in Mathematics (TEDS-M) (Kaiser et al., 2017)
3. Research aim and question in Ding & Jones (2019)

Research aim:
To conceptualizing the nature of a Chinese expert teacher’s expertise in our Lesson Design Study (LDS) in Shanghai (SH) by utilising Greeno’s (1998) situative theoretical perspective.

Research question:
In what ways does Greeno’s (1998) model help to conceptualize the nature of the Chinese expert teacher’s expertise in our Lesson Design Study?
5. The situative model (Greeno, 1998)

<table>
<thead>
<tr>
<th>Terms</th>
<th>Explanations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constraints</td>
<td>if-then regularities of social practices, and of interactions with material and informational systems, that enable a person to anticipate outcomes and to participate in trajectories of interaction (involving co-occurrences of properties and relations in types of situations)</td>
</tr>
<tr>
<td>Affordances</td>
<td>qualities of systems that can support interactions and hence present possible interactions in which an individual can participate</td>
</tr>
<tr>
<td>Attunements</td>
<td>“regular patterns of an individual’s participation”, … well-coordinated patterns of participating in social practices, including the conversational, and other interactional, conventions of communities</td>
</tr>
</tbody>
</table>
6. Data and data analysis

(The concepts of *attunements to constraints* and *affordances of activity systems* (Greeno, 1998))

Interactive systems

Textbooks
Lesson design

Teaching diary
Interview

Video-recorded lesson

Informational aspects: Behavior & cognitive processes of the teacher and pupils

Video-recorded lesson

备课1
反思1

备课2
上课2
反思2

备课3
上课3
反思
7. The multiple layers of the interactive and informational aspects of lesson design and implementation in the LDS

1. Preliminary design

Interactive systems

Material & informational systems of teaching & learning mathematics

Constraints of activity systems

Attunements by expert teacher, the teacher, pupils

Affordances of activity systems

2. Teaching experiment

Behavior & cognitive processes of teacher

Behavior & cognitive processes of pupils
<table>
<thead>
<tr>
<th>LDS (Ding et al., 2017; 2019)</th>
<th>The Situative Model (Greeno, 1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>每一轮教学设计活动的教师和研究者教案设计（备课）与实践围绕教学设计三个主成分(Gravemeijer, 2004)</td>
<td><strong>Analytical framework:</strong></td>
</tr>
<tr>
<td>教案设计:</td>
<td>(1) Constraints (e.g., goals)</td>
</tr>
<tr>
<td>(1) 教学目标,</td>
<td>(2) Affordances (e.g., task,</td>
</tr>
<tr>
<td>(2) 教学内容，活动和教学具等的设计与组织,</td>
<td>classroom activity,</td>
</tr>
<tr>
<td>(3) 教师教学设计的默会的理念</td>
<td>tools design)</td>
</tr>
<tr>
<td>LDS targeted theories:</td>
<td>(3) Attunements (e.g.,</td>
</tr>
<tr>
<td>• 顾泠沅先生的变式教学与Marton的变式理论</td>
<td>teachers’ tacit ideas,</td>
</tr>
<tr>
<td>• 数学探究的基本活动和基本思想（国家中小学数学课程</td>
<td>local instructional</td>
</tr>
<tr>
<td>大纲的‘四基’，‘数学核心素养’等）</td>
<td>theory)</td>
</tr>
<tr>
<td>• 学生是课堂学习的主体Participation-oriented lesson design; in Greeno’s words (1998, p. 19), “not only what their students have come to know and understand, but also to how their students are currently able to participate in inquiry, discourse, and reasoning, and how they can help them advance to more successful participation”</td>
<td>• Attunements (e.g., targeted theories)</td>
</tr>
<tr>
<td>Sub-categories</td>
<td>Explanation in Greeno (1998)</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Cognitive</td>
<td>cognitive knowledge-structure principles</td>
</tr>
<tr>
<td>Behaviour</td>
<td>Skill-acquisition principles</td>
</tr>
<tr>
<td>Interactive systems</td>
<td>Situative principles</td>
</tr>
<tr>
<td>Sub-cATEGORIES</td>
<td>Explanation in Greeno (1998)</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Constraints</td>
<td>involving co-occurrences of properties and if-then relations in types of situations; The condition-action pair is a constraint.</td>
</tr>
<tr>
<td>Affordances</td>
<td>the condition designates an affordance for performing the action.</td>
</tr>
<tr>
<td>Attunements</td>
<td>regular patterns of an individual’s participation.</td>
</tr>
</tbody>
</table>
Coordinating multiple levels of analysis of the ‘dual nature’ of the expert teacher’s expertise (1)

Interactive systems

Knowledge-structure of teacher
1. Subject matter knowledge (SMK)
2. Knowledge of curriculum/textbook (KCC)
3. Knowledge of subject-learning theory (e.g. van Hiele levels) (KCS)
4. Pedagogical content knowledge (PCK)

(Ball, Thames, & Phelps, 2008)

Constraints of activity systems

Q1:为什么要选择这个知识点来进行研究?

Q2&3:这样的课从学生的角度讲...的建构是否符合我们基础理论的，是否符合我们主流的价值观?

Educational value
T/L assessment

Affordances of activity systems

cognitive SMK-structure  ←  educational value of SMK

Problematising the T/L goal, curriculum/textbook topic and content:
educational value; assessment

cognitive PCK-structure  ←  T/L assessment

Norwegian University of Science and Technology
Coordinating multiple levels of analysis of the ‘dual nature’ of the expert teacher’s expertise (2)

### Interactive systems

**Knowledge-structure of teacher**

1. SMK (e.g., the structure of SMK)
2. KCC (e.g., the choice of tasks, the structure of the lesson)
3. KCS (e.g., pupils’ cognitive structure, knowledge anchor, previous learning experiences)
4. PCK

### Constraints of activity systems

- Q4: 老师对教材的处理来构建学程是不是抓住（孩子的）认知起点？
- Q5: 这样的编题过程是否抓住（孩子的）认知起点？
- Q6: 孩子原先学习的基础是什么？
- T/L assessment (e.g., teacher’s craft of lesson content)

### Affordances of activity systems

Lesson design & implementation

- Problematizing: craft textbook, task design, pupils learning experience, assessment (attunements)
- T/L goals (constraints)
- Lesson design & implementation (affordances)
Summary of the ‘dual nature’ of the expert teacher’s expertise

This builds up a coherent theoretical account of the interactional and informational aspects of activity.
9. Conclusion

Our research question was in what ways does Greeno’s (1998) model help to conceptualize the nature of the Chinese expert teacher’s expertise in our Lesson Design Study?

Using Greeno’s (1998) model enabled us to:

- merge emphasis on activity in environments with emphasis on the informational contents of activity.

- focus on analyzing processes of communication and reasoning as trajectories of dynamic systems.

- aim at a coherent theoretical account of interactional and informational aspects of activity for explanatory accounts of learning, transfer, and motivation.
III. The interconnectedness and difference between our LDS and the depiction of action research by AERA AR SIG (Ding, Jones & Sikko, 2019)
The three layers of teachers’ learning to act and reflect in the LDS (Ding et al., 2019)
‘Three-actions-two-reflections’ in the LDS model (LD = lesson design, LI = lesson implementation) (Ding et al., 2019)
Table 2. The interconnectedness and differences between AR and LDS.

<table>
<thead>
<tr>
<th>The differences between AR and LDS</th>
<th>AR (as characterised by Rowell et al. 2015)</th>
<th>LDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>The differences between AR and LDS</td>
<td>AR researcher’s choice of methods.</td>
<td>LDS researcher follows a specific ‘design research’ methodology.</td>
</tr>
<tr>
<td></td>
<td>AR simultaneously directed towards teacher self-change and towards restructuring the organisation or institution within which the teacher works.</td>
<td>LDS concerns more than the practical questions in one local social context and aims to tackle bigger questions across the social contexts in the subject research field.</td>
</tr>
<tr>
<td></td>
<td>AR is a process of authentic collaboration with other teachers seeking to improve their practices.</td>
<td>LDS community includes external researchers and expert teachers who play other roles in the TRG than practicing teachers.</td>
</tr>
<tr>
<td>The interconnectedness between AR and LDS</td>
<td>Both AR and LDS support teachers learning through their personal and reflective teaching in the form of lessons and contribute directly to school-based teacher professional development.</td>
<td>(Ding et al., 2019)</td>
</tr>
</tbody>
</table>
Two issues raised in the LDS

• The dual nature of the learning ecology (Cobb et al. 2003); that is, both pupils’ learning and teachers’ learning in our LDS (中国本土对课堂教学中的双主体的强调-教师主导与学生主体). It is necessary for researchers to develop network with practitioners in the local context to see how people may localise, harness and develop the ‘introduced western’ theories and methods for their own purposes. In so doing, the theoretical framework and methods can be developed and enriched for a much wider application across cultures.

• The significance of the development of school-based teacher-researcher community for supporting teachers’ reflective teaching (‘wisdom of action’) and narrowing the gap between research and practice in the TPD. To enable the development of various operational schemas of the LDS model in ways that meet the teachers’ need for personal learning and identity development in their workplace.
IV. A methodological challenge of the use of the LDS model in a pilot study of a NTNU Master Mathematics Education course.

• the main purpose is to understand in depth the relationship between the university-based knowledge in the master course of mathematics teacher education and the school-based teacher professional competence and identity development.

1. To understand student teachers’ learning of mathematical history and philosophy theory/materials in the course by applying the key elements of a lesson design study model that emphasizes the unity of knowledge and action in teachers’ professional development (e.g., learning by questioning, thinking, reflecting and doing).

2. To develop a coherent theoretical account of interactional and informational aspects of activity of the course for explanatory accounts of student teachers’ learning, transfer, and motivation.
The methodological problem of design study

• The biggest difference between hard sciences and the education sciences involves understanding and dealing with this power of context (Berliner, 2002). The situated nature of design research raises critical questions about generalizability, making warrants that are applicable across multiple contexts difficult (Shavelson et al., 2003; Lamberg & Middleton, 2009).

(Lamberg & Middleton, 2009)
References

  Available online: https://www.tandfonline.com/eprint/Wfz44Ecz9GgFYkDDaG8F/full?target=10.1080/09650792.2019.1579745
