International Journal of Learning, Teaching and Educational Research
Vol. 22, No. 5, pp. 281-301, May 2023
https://doi.org/10.26803/ijlter.22.5.14
Received Mar 14, 2023; Revised May 17, 2023; Accepted May 22, 2023

Changes in Lesson Plans as Teachers Participate in a Professional Development on Statistical Literacy

Dung Tran
Federation University Australia

An Thi Tan Nguyen*
University of Education, Hue University, Vietnam

Duyen Thi Nguyen
University of Education, Hue University, Vietnam

Phuong Thi Minh Ta
University of Education, Hue University, Vietnam

Nga Thi Pham
Chau Thanh high School, Vietnam

Binh Tri Huynh
Quy Nhon University, Vietnam

Abstract. Research on mathematics teacher knowledge has gained momentum recently; however, research on teacher planning is scarce, especially using lesson plans as the primary data source. This study examines how teachers' lesson plans change as they participate in a professional development, supporting them in implementing the Vietnamese reformed Curriculum 2018. Using a design-based research methodology, we developed a research-informed framework that assesses teachers' lesson plans for developing students' statistical literacy as emphasized in the mathematics Curriculum. Informed by research literature and data collected from teachers, the framework including seven criteria was shared and used by 61 teachers to reflect on the quality of their lessons. The analysis of 38 lesson plans shows all criteria have improved from pre- to post-lesson plans. The teachers included more explicit and comprehensive learning intentions in their post-lessons. Tasks in the post-lesson plans afforded more opportunities for students to develop statistical literacy, helped them engage in the statistical

* Corresponding author: *An Thi Tan Nguyen*, *nttanan@hueuni.edu.vn*

investigation using real data, and included multiple representations. Finally, the post-lesson plans tended to follow the constructivist teaching principles. Implications on ways to develop teachers' planning competence and suggestions for future studies are included.

Keywords: statistical literacy; lesson plan; professional development; teacher planning competence; reform

1. Introduction

The reformed Curriculum in Vietnam (Vietnam Ministry of Education and Training, 2018) adopts a competency-based approach to education. This approach emphasizes skills and competencies that enable students to apply their knowledge effectively in real-world situations and prepare them for success in life and work. The Curriculum also promotes student-centered learning, prioritizing active and collaborative learning over traditional teacher-centered approaches. Teachers are encouraged to use various teaching methods, such as project-based, inquiry-based, and problem-based, to engage students and develop profound understanding. In addition, the Curriculum emphasizes the importance of formative assessment and feedback to guide learning and promote student progress. By prioritizing student-centered and active learning approaches, the Vietnamese Curriculum aims to create a more engaging and effective learning environment that fosters the development of critical thinking, creativity, and problem-solving skills. Mathematics is part of the larger General Education Curriculum and aims to develop students' mathematical competencies.

Curriculum reform only comes to life through teachers as critical agents in the process (Nguyen & Tran, 2022). It is not merely the curriculum but the teachers who interpret it and translate the content into effective learning in the classroom. In addition, the reform focuses on the content structure and the teaching approaches; teachers need to reshape their practices. These practices require an understanding pedagogical approaches that align with the competency-based learning principles specified in the Curriculum. These practices include planning, teaching, and assessing.

Teacher planning is an essential component of effective teaching, and research has explored its various aspects, including purposes, processes, and outcomes (e.g., Lilly et al., 2022). In particular, designing learning opportunities requires considerable skills, which is challenging and highly context-dependent (John, 2006). However, teacher planning is still an under-researched area (Konig et al., 2020). Nevertheless, research has shown that effective planning is essential to teaching practice (Grossman et al., 2009). Research has also investigated what shapes teacher planning (e.g., Bieda et al., 2020; Grossman et al., 2009), the challenges they face (e.g., Mutton et al., 2011), and teachers' focus when planning (Lim et al., 2018). However, a scarcity of research has focused on investigating lesson plans themselves (Konig et al., 2020). Therefore, this study aims to develop and use a framework to assess teacher lesson plans when they implement the reformed Curriculum. It also examines how the quality of lesson plans changes as they participate in a professional development focusing on a new content area in the Curriculum, statistics. In particular, we address the research question: How

do mathematics teacher lesson plans change as they participate in a professional development focusing on helping students develop statistical literacy?

2. Literature Review

This section will review mathematics curriculum reform in Vietnam and link it to other works worldwide. We then synthesize research on mathematics teacher planning, especially studies that focus on lesson plans. Finally, we will discuss statistical literacy to set the stage for the quality we aim to help teachers develop in our professional development.

2.1 Vietnamese Reformed Curriculum

Education systems' changes differ due to their social-cultural contexts and motivations. As part of preparing students for the demands of society, the Vietnamese Department of Education and Training puts forward a curriculum that adopts a competency-based approach to teaching and learning. In this approach, the reformed curriculum (Vietnam Ministry of Education and Training, 2018) advocated for a comprehensive view of learning outcomes used in diverse situations. The approach focuses on developing a rich and powerful mathematical understanding for students, highlighting both the content matter of mathematics and the process of doing mathematics. This approach is aligned with other views about mathematics learning developed in the research literature and other cultures, such as mathematical proficiency (Kilpatrick et al., 2001). Kilpatrick et al. built on extensive research on mathematics learning and specified the five intertwined strands a mathematics learner should develop, including *adaptive reasoning* (capacity to provide logical thought, reflect, explain, and justify), *strategic competence* (ability to formulate and solve mathematical problems), *conceptual understanding* (comprehension of mathematical concepts, operations, and relations), *procedural fluency* (skills in carrying out procedures flexibly, accurately, efficiently, and appropriately), and *productive disposition* (inclination to view mathematics as sensible, useful, and belief in self-efficacy). These comprehensive views of mathematics learning have been highlighted in different curricula (standards) with different names, such as mathematical processes (NCTM, 1989) and mathematical practices (CCSSM, 2010).

Common among these approaches is the emphasis on teaching for understanding (e.g., Hiebert, 1986), such as (a) specifying the features of a concept and providing concrete examples and counterexamples of the mathematical/statistical objects, (b) comparing, contrasting, and analyzing mathematical/statistical objects, (c) using the objects in different situations, (d) transferring between different representations, and (e) addressing the *why* questions when using and developing a procedure. This view is consistent with research advocating for representations as a means for learning mathematics and the ends themselves. Representational fluency is considered the ability to translate across representations, draw meaning about a mathematical/statistical entity from the representations, and generalize across different representations (e.g., Duval, 2006). It helps develop conceptual understanding and offers ways for students to express their understanding. These studies suggest that when investigating the quality of lesson plans, it is crucial to examine how lesson plans (a) help students develop comprehensive

mathematics/statistics outcomes, (b) attend to multiple representations, and (c) help students actively construct knowledge (addressing constructivist principles). When used as one bookend to improve education, the reformed curriculum comes to life through teachers, who plan for and implement student learning programs. We discuss, next, research focusing on mathematics teacher planning.

2.2 Mathematics Teacher Planning

Research on mathematics teacher planning has also been conducted, focusing on understanding how teachers plan for mathematics instruction and the factors influencing their planning processes (e.g., Lilly et al., 2022). These practices include introducing key ideas, choosing appropriate tasks to address learning intentions, and creating assessments that capture students' learning. Teacher planning has shaped students' opportunities to learn (Amador & Lamberg, 2013) as evident when they choose educational tasks to address key ideas in learning. Also, this process is shaped by teachers' beliefs and understandings of mathematics teaching and learning (Drake & Sherin, 2006; Nguyen & Tran, 2022) and school context dependent (Superfine, 2008). For example, in the USA, teachers associate teacher guides with curriculum in planning, referred to as curriculum implementers (Superfine, 2008). The study highlighted that curriculum materials serve as a starting point for planning. In contrast, Nguyen and Tran (2022) found that teachers in their study play a role of curriculum makers as they develop more agency when planning learning for their students. In addition, when reflecting on their philosophy about important mathematics for their students, they consider the curriculum as only part of the resources that they need to draw on. Similarly, research also revealed that teachers from different countries focus on different aspects when planning. For example, Fernandez and Cannon (2005) argued that Japanese teachers emphasize students' discovery of concepts and develop a positive disposition towards learning. In contrast, focusing more on the relationship between content and teaching methods, Homqvist and Wennas Brante (2011) found that Swedish teachers separate teaching methods from the content, whereas Hong Kong teachers consider the content concurrently with the methods. The culture, especially the constraint of institutional curriculum, arguably influences these different foci. Therefore, some research has examined the process, and priorities teachers have in planning for teaching mathematics (Sullivan et al., 2013), mainly when the system adopts a reformed curriculum.

A prominent model for professional development is lesson study originated in Japan, which has been adopted into different cultures. In this model, much can be learned about how teachers plan. Lesson study includes a group of teachers sets a research focus, plans, and teaches the lesson. Others observe it and then reflect on their research goals and how they achieve them (Nguyen & Tran, 2022). These studies indicate how effective lesson plans should include as well as what teachers can learn during this process. Although, part of the study examines the quality of lesson plans and interprets teacher knowledge, this study does not focus on lesson plans as the main data source. Therefore, there is a need for more research that focuses on lesson plans as a primary data source because the documents are crucial in teaching and learning.

2.3 Lesson Plan as a Primary Research Focus

Previous studies have highlighted the process of planning, and now we shift our focus to studies on the product of planning, lesson plans. In teacher education programs, it is common for preservice teachers to be required to plan lessons as part of their coursework (Schmidt et al., 2011). To measure planning skills, researchers have developed frameworks such as the Performance Assessment for California Teachers (PACT) (Darling-Hammond et al., 2013; Pecheone & Chung, 2006) in the USA and adaptivity (König et al., 2020) in Germany.

The PACT framework assesses how teachers address components related to planning, teaching, assessing, and reflecting on teaching. Specifically, the planning component includes guiding questions on how students access the curriculum, how the curriculum is addressed in a coherent and balanced manner, how students' interests and needs are addressed, and how aligned the learning goals, instruction, and assessments are (Darling-Hammond et al., 2013). Meanwhile, König et al. (2020) focus on the pedagogical adaptivity construct, which requires accounting for students' characteristics in lesson plans. They investigate how teachers perceive and interpret student dispositions to make planning decisions, focusing on selecting and adapting tasks. These studies have shown that the measures of lesson plans predict student achievement (Darling-Hammond et al., 2013) and impact teachers' instructional practices when teaching that lesson, as reported by the teachers (König et al., 2020). These studies have supported that lesson plans' quality serves as a valid predictor of teaching practice. The previous frameworks help analyze lesson plans in those contexts; however, as reform is context-dependent and we need a framework to analyze lesson plans in a specific content area, this research addresses this gap. In addition, previous studies try to analyze lesson plan quality without documenting how the qualities change as they participate in a teacher education program or professional development. These programs are crucial in supporting teachers in implementing curriculum reform. The current study addresses this research gap.

2.4 Research Related to Statistical Literacy

Statistical literacy is the ability to understand and interpret statistical information and to use that information to make informed decisions (Watson & Callingham, 2003). The literacy is considered an essential skill for individuals to navigate the ever-increasing amount of data and statistical information in today's society. As such, it has become a focus in many countries' curricula, including the USA (CCSSM, 2010), Australia (Australian Curriculum, Assessment, and Reporting Authority, 2022), and Vietnam (Ministry of Education and Training, 2018). In addition, statistics educators (Franklin et al., 2007; Watson & Callingham, 2003) have advocated for developing statistical literacy for school students as an essential learning outcome. However, the ways researchers conceptualize and measure it are not consistent. Some use the same term with different meanings, and others use different terms for the same meaning (see Sabbag, 2016, for an overview of the conceptualization and measurement). In this study, we adopted Gal's (2002) definition of statistical literacy as, "the ability to interpret, critically evaluate and communicate about statistical information and messages" (p. 1).

Although important, research has shown that students often struggle with statistical literacy (Watson & Callingham, 2003) and that teachers may not have the necessary skills and knowledge to teach it (Watson & Callingham, 2013) effectively. One effective approach to developing statistical literacy is through using tasks that involve presenting students with real-world problems or situations that require statistical analysis and interpretation (Watson et al., 2018). Additionally, these tasks effectively help develop students' statistical communication skills, as they must present their findings and interpretations to others. In doing this, learners have been involved in statistical practices, participating in a statistical investigative process (Watson et al., 2018). Statistics education researchers argue that students must have experience dealing with real data when solving real-world problems (Tran & Tarr, 2018) as they participate in statistical investigations. However, students currently have limited experience as they are often engaged with data analysis and in some cases, interpreting results without knowing which statistical questions they are investigating, and the types of data needed for the questions. Furthermore, due to pedagogical concerns, students mainly deal with contrived data and usually with a small sample size in statistical lessons (Tran & Tarr, 2018). These studies suggest some aspects of statistical lessons to be considered when planning including: (a) developing statistical literacy, (b) helping students experience statistical investigations, and (c) using real data in statistical experience.

The previous reviews highlighted the nature of the curriculum reform and the role of teachers in reform, especially in planning. However, research is scarce on the quality of lesson plans, especially on how the quality of statistics lessons changes as they participate in professional development programs, helping teachers interpret the reformed curriculum. The current study addresses that gap.

3. Methodology

We adopted design-based research (DBR), a methodology that involves iterative cycles of design, implementation, and evaluation of interventions in real-world educational settings (Anderson & Shattuck, 2012; Cobb et al., 2003). The methodology aims to create and refine educational solutions grounded in theory and practice, aiming to improve teaching and learning outcomes (Design-Based Research Collective, 2003). Critical features of DBR are collaborative and participatory, which involves working closely with teachers to ensure that the interventions are relevant and feasible in the teacher's context. This approach allows researchers to gain a rich understanding of the complex interactions between the intervention, the context, and the participants, which can inform the refinement and improvement of the intervention.

From a theoretical perspective, we systematically reviewed relevant research on reform, planning, and statistical literacy to develop a framework to capture the essence of reform and make it concrete for teachers. From a practical perspective, we refined the framework based on teachers' products, lesson plans and in consultation with teachers in interpreting and revising the framework. After refinement cycles, a final version was developed by Tran et al. (In press).

Context of the study

In 2018, the Vietnam Ministry of Education and Training mandated a shift towards a competency-based approach in the mathematics curriculum, which emphasized statistics as one of the three content strands, alongside geometry and algebra. This content strand is relatively new to teachers, and it has been argued that statistical thinking is not the same as other mathematical thinking (Tran & Tarr, 2018). As the Curriculum changes in content structure and teaching approaches, teacher professional development is needed to help them implement the reform in their classroom. In response to this change, we designed and implemented a professional development (PD) program that supports high school teachers in implementing statistics in their classrooms. The program aims to help teachers understand statistics and ways to support their students in developing statistical literacy by using appropriate tasks, careful planning, and enhancing their teacher knowledge.

The PD happened in two phases, from August 2021 to January 2022. In the first phase, 61 teachers attended a four-day meeting in August 2021 focusing on developing their statistical knowledge. In particular, the teachers (a) discussed the differences between mathematics and statistics, (b) engaged in statistical investigation cycles, and (c) prepared ways to integrate statistical literacy into teaching. Realizing the nuances between mathematics and statistics is crucial as it will impact how teachers approach it. Therefore, the nature of contexts, the uncertainty in conclusion, and the types of measurement as part of statistical thinking were highlighted in the PD. Teachers then used the three features to analyze tasks in their textbooks and tasks chosen by PD developers to contrast the nature and find ways to make current mathematical tasks more statistical. In addition, a statistical investigation cycle was introduced using a situation of the Old Faithful Task (Franklin et al., 2007). Finally, we introduced statistical literacy and provide specific examples, such as tasks and ways students respond to tasks that underscore statistical literacy. At the end of the four-day meeting, teachers worked in groups of 3-4 to create lesson plans that focused on developing students' understanding of statistical concepts. They chose a grade level they were teaching, and integrated features discussed in this first round of PD into their lesson. A total of 20 lesson plans were collected during this phase, which are called pre-lesson plans.

The second phase of PD took place for four days, six months later, in February 2022. The focus was on pedagogical decisions in implementing statistical literacy in the classroom, via discussions on lesson planning and teacher questioning. During the training sessions in the second phase, teachers analyzed their lesson plans based on their understanding of the reform. This task was to get their initial interpretation of the reform and how they aligned with lesson planning. The first version of our framework, developed based on reviewing the literature and data collected in the first round of lesson plans, was shared with the teachers to analyze their lesson plans. Data and feedback from teachers were collected to help the researchers refine the framework. This updated version was then shared, and the teachers were asked to redesign their lesson plans to improve them. Teachers were encouraged to teach their lessons in their classes. Eighteen lesson plans were

collected at the end of the second phase of PD, which are called post-lesson plans. In addition, videos about classroom practices were shared for the teachers to discuss the nature of questioning, especially how teachers support students in constructing knowledge (following constructivist principles). See Table 1 for an overview of the program.

Table 1: The research progress

Phase	Time	Actions and Data Collection
1	08/2021-01/2022	Four days meeting on statistical literacy and statistical investigations 20 pre-lesson plans collected First version of research-informed framework design
2	02/2022	Four days meeting on lesson planning and teacher questioning Sharing the framework with the teacher and revising 18 post-less plans collected Final framework for analysis

Data collection. The corpus of data in this study includes 38 lesson plans collected at two time points from 61 teachers (as teachers submitted lesson plans in groups). The 20 lesson plans were collected when it happened right after the four days of professional development in August 2021. The remaining (18) were collected at the end of the second professional development meeting.

Data analysis. Based on the comprehensive literature review on reformed curriculum, statistical literacy, and statistical investigation, Tran et al. (In press) have developed a rubric to examine lesson plans to develop statistical literacy (see Figure 1).

CRITERION	Level 1	Level 2	Level 3	Level 4
Learning Intentions				
M1: explicit and observable	Learning intentions are not stated or not clear (1 mark)	Some learning intentions are clear (2 marks)	Some learning intentions are clear (2 marks)	All learning intentions are clear and observable (3 marks)
M2: comprehensive (fluency understanding, reasoning, and problem solving)	Only focus on fluency (1 mark)	Help students develop two types of outcomes (2 marks)	Help students develop three types of outcomes (3 marks)	Help students develop four types of outcomes (4 marks)
Tasks				
M3: Develop statistical literacy (SL)	Do not develop students' SL (1 mark)	One task helps develop students' SL (2 marks)	One task helps develop students' SL (2 marks)	More than one task help develop students' SL (3 marks)
QT: Statistical investigation (SI)	Help students engage in only one stage of SI (1 mark)	Help students engage in two stages of SI (2 marks)	Help students engage in three stages of SI (3 marks)	Help students engage in four stages of SI (4 marks)
RD: Read data	No real data (1 mark)	Real data are evident (2 marks)	Real data are evident (2 marks)	Real data are used to address SI. (3 marks)
N2: Multiple representations	Only one type of representation, students do not choose it (1 mark)	More than one type of representation, students do not choose them (2 marks)	More than one type of representation, students choose them (3 marks)	Use all types of representation, students choose them (3 marks)
Following constructivist principles				
MT1: Create opportunities for students to construct knowledge	Provides established knowledge (1 mark)	Provides one opportunity for students to construct knowledge (2 marks)	Provides one opportunity for students to construct knowledge (2 marks)	Provides more than opportunity for students to construct knowledge (3 marks)

Figure 1: Rubric to examine lesson plans to develop statistical literacy

A group of four researchers met to develop the rubric. First, we did an open analysis noting down prominent features of three lesson plans. We then elaborated on what we noted down and why they were important. After consulting with the literature, we agreed upon seven features that were worth in-depth consideration. We then focused on how to differentiate the quality of the features. We again described the quality of the lesson plans and discussed how and why they differed. We used the three pre-lesson plans to express the quality difference and then formed the descriptors. We further used three other lesson plans to apply the revised criteria and refined the framework. Collecting another data-informed evidence, we shared the rubric with teachers and checked how they interpreted the framework. Further refinement in wording led to the final version of the rubric. This updated version was used to code all remaining lesson plans. At least two researchers agreed on the coding, and any discrepancy in coding was discussed until consensus. Therefore, the results illustrate 100% agreement on data analysis as part of reliability checking.

After we finished coding all lesson plans for all seven criteria, t-tests were conducted to determine if there were any changes in each of the criteria and if the changes are statistically significant. We then selected exemplars to illustrate the changes.

4. Results

Table 2 highlights the shift in quality regarding the seven criteria documented in the lesson plans. Statistically significant improvements were found in all but one criterion ($p<0.05$, t-tests), the focus on developing statistical literacy for students ($p=.057$) when comparing the post-lesson plans to the pre-lesson plans. Concerning learning intentions, they were more explicit (changed from 1.85 to 2.2 out of 3, which means all learning intentions were explicit and observable) and more comprehensive (2.55 to 3.39 out of 4, which means including all four types of intentions). In addition, the post-lesson plans had more opportunities for students to engage in more statistical investigation stages than the pre-lesson plans (1.8 to 2.5 out of 4, meaning all four stages of investigations were included). Similarly, post-lesson plans included real data used to address statistical questions than the pre-lesson plans (1.85 to 2.56 out of 3). In addition, more post-lesson plans included multiple representations for students to make sense of the content compared with the pre-lesson plans (2 to 2.61 out of 4, meaning all types of representations, numerical, tables, graphical, and verbal and students chose the type of representation to help them make sense of the content). Finally, post-lesson plans were designed to follow constructivist principles. As a result, students had more than one opportunity to construct their knowledge in the post-lesson plans compared with the pre-lesson plans (2.15 to 2.72 out of 3).

In contrast, although post-lesson plans had more opportunities for students to develop statistical literacy than the pre-lesson plans (2.4 to 2.72), the change was not statistically significant.

Table 2: Average scores of the lesson plans in each of the criteria

Criteria	Pre (n=20)	Post (n=18)	Maximum level
Explicit LI (M1)	1.85	2.22*	3
Comprehensive LI (M2)	2.55	3.39*	4
Developing SL (M3)	2.4	2.72 (p=.057)	3
Engaging in SI (Q)	1.8	2.5*	4
Using real data (DT)	1.85	2.56*	3
Involving multiple representations (N2)	2	2.61*	4
Constructivist Principles (MT)	2.15	2.72*	3

* $p<0.05$

We will describe the changes in each criterion, next, illustrating with examples drawn from the lesson plans.

Changes in Learning Intentions

Explicit learning intentions. Post-lesson plans included clear learning intentions compared with pre-lesson plans. Mainly, the post-lesson plans included all content-specific learning intentions instead of focusing on the general features of competence in the reformed Curriculum in the pre-lesson plans. For example, in the following pre-lesson plan (Figure 2), there was one explicit learning intention, "knowing the concepts: the mean, median, and mode", and others were generic about various competencies, including self-study, problem-solving, communicating, and using language without referring them to the specific lesson's content. In addition, even when referring to the lesson's content, it was still not clear, "summarizing statistical tables".

MEAN, MEDIAN, AND MODE

Intentions

1. Knowledge

- Knowing the concepts: the mean, median, and mode.
- Summarizing statistical tables.

2. Competence

- *Self-study*: Identify their attitudes and motivation; self-assess and adjust their study plan; identify their mistakes and how to correct them.
- *Problem-solving*: Know how to read questions, and problems, or ask questions, and analyze learning situations.
- *Communicate and argue*: Acquire knowledge, exchange, and learn from friends through group activities; having respectful attitudes, listening, and positive responses in communication.
- *Language*: use appropriate mathematical languages

Figure 2: Learning intentions of a pre-lesson plan

In contrast, most post-lesson plans removed the generic competencies or replaced them with content-focused ones. For example, in the following post-lesson plan (Figure 3), teachers intended for students to calculate measures of variability, including range, interquartile range, and standard deviation, and explain the concepts in real life. The teachers then linked the learning intentions with the tasks/activities used later in the lesson.

VARIANCE, STANDARD DEVIATION, INTERQUARTILE RANGE, AND BOX PLOT

Intentions

1. Knowledge:

- Mastering the concept of variance, standard deviation, and their meanings in statistics.
- Knowing how to determine the interquartile range and drawing box plots.

2. Competence:

a. Mathematical competence:

- Mathematical communication
  - Writing formulas to calculate variance and standard deviation (in Activity 2)
  - Confident when presenting, explaining, and arguing about their knowledge related to their group's products (in Task 1, activity 3).
- Solving problems
  - Solving mathematical situations (in task 3)
  - Solving mathematical problems to develop statistical literacy related to measures of variability (in task 3)
- Using mathematical tools
  - Calculating variance and standard deviation by handheld calculators (in activity 2)
- Mathematical modeling
  - Solving real problems in statistics (in task 3)

b. General competence:

- Autonomy and self-learning: Always proactively and actively do assignments by active exchange and discussion in group activities through tasks 1,2,3

Figure 3: Learning intentions of a post-lesson plan

Comprehensive learning intentions. Another focus of the study was how comprehensive the learning intentions were in ways they addressed mathematical proficiency (Kilpatrick et al., 2001). These proficiency strands include procedural fluency, strategic competence, adaptive reasoning, and conceptual understanding. Not all learning intentions were stated in the lesson plans, especially in the pre-ones; therefore, when coding for this aspect, we sometimes interpreted the learning intentions from the tasks/activities included in the lesson plans. Overall, in the post-lesson plans, more included more than one type of learning intention, and 55.6% included all types of learning intentions. For example, Lesson Plan 4 (pre) included a task asking students to calculate the mean of a data set including 36 students' heights. This instance was coded as addressing fluency only (Level 1) in this feature.

In contrast, in the post-lesson plans, the teachers included tasks asking students to decide what a concept meant (understanding) and how and why it was good to use that measure in situations (reasoning). In some instances, lesson plans included problems where students must decide to carry out a plan to tackle them. For example, in Lesson 5 (Figure 4), through the tasks of choosing the bank to work, students engaged in problem-solving as they needed to solve a problem without a known procedure, and by doing this, they justified their choice

(reasoning), via calculating and creating a table (procedure) and using the measures appropriately in context (understanding).

Warm Up: Suppose that you were just graduated. You are indecisive between the two big Banks. You know the salary of nine people in each of the banks as follows:
Bank A: 35,15, 5, 8, 15, 18, 15, 28, 5 (million VND)
Bank B:18, 12, 14, 14, 15, 20, 15, 21, 15 (million VND)
Q1 - Create a frequency table for the distributions of the salary of Banks A and B.
Q2 - Calculate the mean salary of each Bank A, B.
Q3 – Based on salary, which bank will you choose to work for? And why?

Figure 4: A task in a post-lesson plan developing four types of outcomes

Overall, post-lesson plans' learning intention quality improved in both levels of explicit and comprehensiveness.

Changes in Task Features

More focus on developing statistical literacy. In the post-lesson plans, more focus explicitly helped students read, write, and interpret statistical concepts/objects in real-world situations or evaluate how and which concept/object was appropriate. For example, in the lesson on measures of centers, the lesson plan included an assignment that provided the data about the salary of two companies and asked students to decide on which company they would choose to work for if they wanted to receive a higher salary. In this task, students could use the measure of centers to inform their decision in that specific context. Overall, 83.33% of the post-lesson plans were coded at a higher level of developing statistical literacy for students.

Diverse experience with statistical investigation cycle. The result showed that in the post-lesson plans, teachers included more stages of the investigation cycle, including posing questions, collecting data, analyzing data, and interpreting results. For example, in Lesson Plan 19 (post), students were to collect data about the number of children in their families and compare them with the national birth rate (Figure 5). All four stages are included. Overall, 3/18 included one stage, 4/18 included two stages, 10/18 included three stages, and 1/18 included four stages in the post-lesson plans.

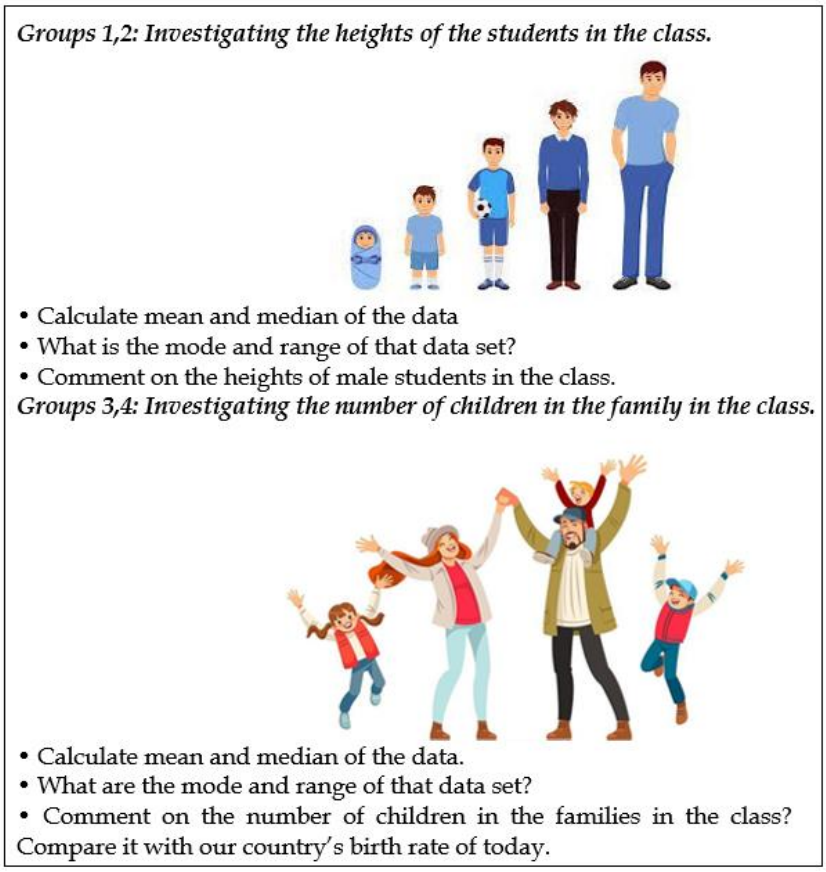
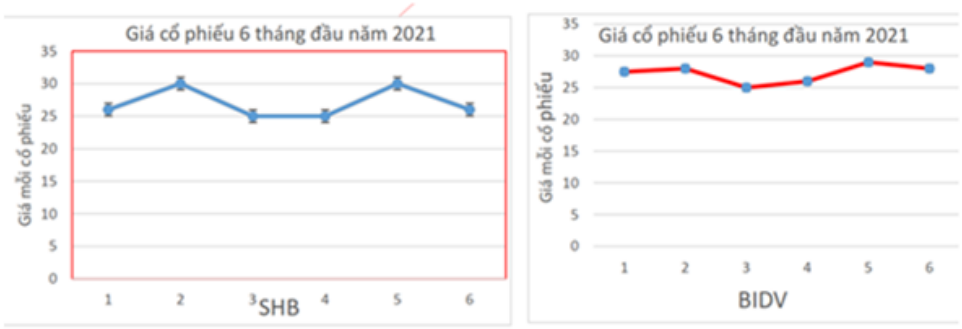


Figure 5: A lesson plan including four stages of statistical investigation cycle

In contrast, most pre-lesson plans (30%) focused mainly on analyzing data when teachers asked students to either calculate some numerical statistics (e.g., mean, mode, standard deviation) or draw a graph (e.g., pie chart).

Using real data. The analysis revealed that more post-lesson plans included real data collected directly from the classroom or from a reliable source to answer statistical questions (61.11%) compared with the pre-lesson plans (10%). In contrast, more data were made up to serve the purpose of introducing statistical concepts and skills. For example, Lesson Plan 5 (Figure 4) included data about the salary, which was contrived and did not provide a reliable source. The purpose is to illustrate how measures of center can be used. In contrast, in the following lesson plan, the data from the Stock markets of two real banks, SHB and BIDV, were provided, and students were asked to decide which bank they liked to invest in and explain their choice (Figure 6).

The following charts show the increase and decrease in share prices of two banks SHB and BIDV for the first 6 months of 2021.



Supposing you are a stock broker and want to show your client that stock prices are consistent. Which chart would you advise for the client? Explain why?

Figure 6: A task using real data

In some cases, even real data were included, but they were not used to address a statistical question (coded as Level 2 for real data) but instead to calculate the mean.

Encouraging the use of multiple representations. More post-lesson plans (50%) included various representations, including numerical, verbal, and graphical displays, compared with the pre-lesson plans (10%). In the pre-lesson plans, teachers focused on one type of representation without helping students connect it with others for conceptual understanding. For example, LP5 (pre) illustrated how the outliers impacted the mean. A task asked students to find the mean and median of a data set with and without the outlier (90 kgs) and evaluate how the two numerical statistics were impacted. We considered this task an instance of only numerical statistics representation. A graphical representation was not used to reinforce the connection and meaning of outliers.

In contrast, in the post-lesson plans, teachers in LP2 highlighted the connection between numerical statistics and graphical displays and helped students to transfer between them (Figure 7).

Problem 1. (Agriculture) A seed company implements the model of "investigate two varieties of Nam Roi pomelo" in Binh Minh district, Vinh Long province. Mr. Tuan's family and Thu's family will deploy the test. The area of each family's experimental garden is approximately 4000 m^2. Each family grows one type. Production costs and care conditions for the two types of pomelos are the same. The soil in the two gardens is the same and representative of garden lands in the province. After 3 years of planting, the tree is harvested. The company inspected the product and found that the pomelos in the two gardens are of equal quality. In order to decide which pomelo varieties to plant for mass planting, in addition to testing the quality of pomelos, the Company also cares about the consistency of pomelo weight. Therefore, the Company picked some pomelos from each garden. Data on the pomelos' weights (kg) picked from the two gardens are presented in the table below:

The weight of 10 pomelos in Mr. Tuan's garden:

0,9kg	*1,2kg*	*1,8kg*	*1,4kg*	*1,3kg*	*1,6kg*	*1,5kg*	*1,7kg*	*1,2kg*	*1,4kg*

The weight of 10 pomelos in Ms. Thu's garden

0,9kg	*0,9kg*	*1,2kg*	*1,4kg*	*1,3kg*	*1,3kg*	*1,5kg*	*1,5kg*	*1,8kg*	*2,2kg*

Class I: weighing from 1.4kg or more, Class II: from 1.2kg to 1.4kg, Class III: from 1kg to 1.2kg.
a) Calculate the mean pomelo weights of the two families.
b) Which type of pomelo should you choose for mass planting?

Expected product:

L1

- The mean of pomelo weights of Mr. Tuan's family is

$$\bar{x} = \frac{0,9+2.1,2+1,8+2.1,4+1,3+1,6+1,5+1,7}{10} \approx 1,4 \text{ (kg).}$$

- The mean of pomelo weights of Ms. Thu's family is

$$\bar{x} = \frac{2.0,9+1,2+1,4+2.1,3+2.1,5+1,8+2,2}{10} \approx 1,4 \text{ (kg).}$$

L2 - The company should choose Mr. Tuan's pomelo type because when looking at the dot plot, most of the data is concentrated around the mean. While the weights of Ms. Thu's pomelos are not.

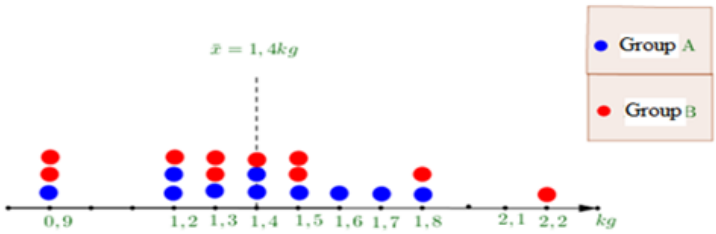


Figure 7: An activity connecting numerical statistics and graphical displays

About 16.67% post-lesson plans were coded at Level 4 of representation. In these situations, the lesson plans included problems for students to solve. Students used and decided on the types of representation that fitted the question the most. Data were provided (Figure 8), and students needed to choose the best-production section among the three. The written hypothetical learning indicated that multiple representations were to be used (table, column graph).

Question 3: *(Industry) A company X producing yogurt is conducting a test run of 3 manufacturing sections A, B, and C. To decide which section should be used, the company took out a carton of milk from each section to study its weight. Data on the weights of each milk carton (grams) for the 3 sections are presented in the table below.*

The frequency distribution table of the weight class of the yogurt carton

Weight (g)	A	B	C
[43 - 45)	4	2	6
[45 - 47)	5	2	9
[47 - 49)	16	30	30
[49 - 51)	56	68	34
[51 - 53)	46	54	12
[53 - 55]	21	5	31
Total number of yogurt carton	**148**	**161**	**122**

Note: the standard weight registered on the carton is 50g (g). Cartons weighing between 49.5g and 50.5g are considered good, and whose weight differs by no more than 3g from the standard (50g) is considered acceptable. If the cartons differ from the standards 3g or more, it is not acceptable.
a) Please help the company choose the "best" section. Justifying your choice using two different ways.
b) Please convince the factory manager to choose the section that you think is "the best"

Expected product:

a)

	Mean	*Standard deviation*
A	*50,67*	*2,23*
B	*50,29*	*1,77*
C	*50,13*	*2,89*

The means in the sections are approximately the same. But the data from Section B has a smaller standard deviation than the other two, so Section B is the best.

b) Frequency distribution table for weight class of the yogurt carton

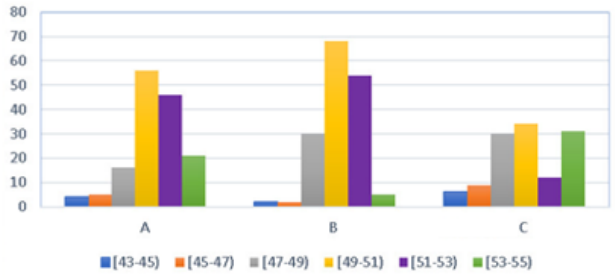


Figure 8: A task coded at Level 4 of representation

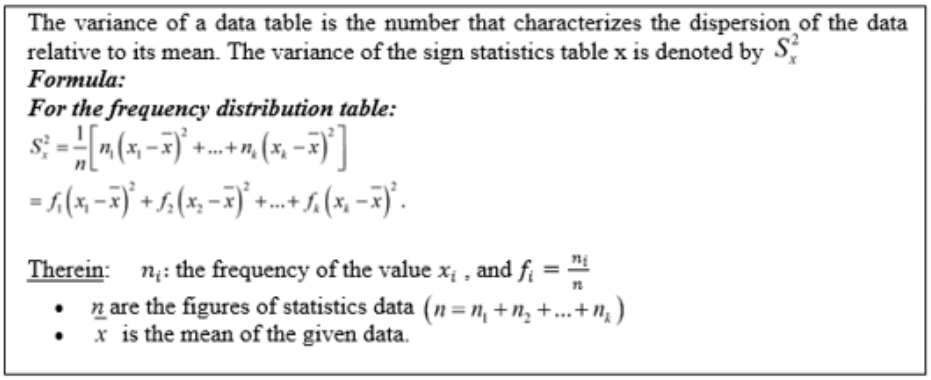
However, 38.89% of the post-lesson plans asked students to draw a graph from a raw data set, which did not help them develop a critical stance about which graph is suitable to address different stories.

Addressing Constructivist Teaching Principles

At the end of the research project, more teachers designed lesson plans that helped students construct knowledge (concepts and skills) through engaging in statistical tasks. For example, in LP5 post, via solving a task, students understood that using mean or median was inadequate to describe and compare two data sets. They needed to use another statistic, the measure of variation. By seeing the deviation and then formally formulating ways to come up with the numerical statistics, students could construct their meaning. The context was used to motivate

students to know the purpose of learning and develop a new piece of knowledge that helped solve a problem or the lesson's purpose. Students were guided in this process to regenerate knowledge and apply it instead of accessing an already well-established one to use in various situations.

In contrast, pre-lesson plans (30%) often introduced established knowledge, defined it, provided formulas or computations, and then asked students to apply it in closely related exercises (Figure 9).


The variance of a data table is the number that characterizes the dispersion of the data relative to its mean. The variance of the sign statistics table x is denoted by S_x^2

Formula:

For the frequency distribution table:

$$S_x^2 = \frac{1}{n}\left[n_1\left(x_1 - \overline{x}\right)^2 + ... + n_k\left(x_k - \overline{x}\right)^2 \right]$$

$$= f_1\left(x_1 - \overline{x}\right)^2 + f_2\left(x_2 - \overline{x}\right)^2 + ... + f_k\left(x_k - \overline{x}\right)^2 .$$

Therein: n_i: the frequency of the value x_i , and $f_i = \frac{n_i}{n}$

- n are the figures of statistics data $\left(n = n_1 + n_2 + ... + n_k\right)$
- $\overline{x}$ is the mean of the given data.

Figure 9: A lesson plan providing established knowledge for students

5. Discussion and Implications

This study adopts a design-based research methodology to document how the quality of teachers' lesson plans changes as they participate in a professional development, supporting them in implementing the reformed curriculum with statistics as a content of focus. Results showed that all criteria improved significantly except for developing statistical literacy after their second phase of PD. All the changes can be linked to their experiences in the PD, where teachers actively discussed the criteria, compared them with their experience in the course, and evaluated their work. The discussion on the role of real data in a statistical investigation in the first phase of the PD and revising the understanding in the second phase via analyzing their lesson plans helped teachers realize the opportunities to learn for students. Even significantly higher, most post-lesson plans did not include all four investigative stages. These results resonate with findings in the literature where textbooks were limited in those opportunities (Tran & Tarr, 2018). The result implies that more opportunities for teachers to conduct statistical investigations are needed. A project-based approach might be more helpful than writing traditional-formatting lesson plans as currently required.

Another area of improvement was that teachers wrote more explicitly and comprehensive learning intentions. We find that before the PD, most teachers did not consider the learning intentions important enough but focused on the tasks in their lesson plans. Also, they did not analyze the types of learning intention either. The framework helped the teachers focus on this critical aspect and how to use it to inform their teaching. Research literature highlighted that expert teachers' (Grossman et al., 2009) lesson plans did not include all what they plan to teach in a classroom. However, when teachers implement the reformed curriculum,

thinking carefully about the intentions is helpful for the teachers to justify what they are doing.

The teachers also improved their lesson plans in adhering to a more student-centered approach. This result highlights the reformed principles came to life in the lesson plans. The discussion on the role of teachers and students in the second PD phase and teacher questioning helped make it happen. Before the reformed curriculum was published, the discussion around activating student knowledge existed in the teaching discourse in Vietnam (cf. Neubrand et al., 2013) existed. The direction of cognitive activation is aligned with the PD and supports teachers in implementing constructivist teaching principles in their classrooms. Similarly, the use of multiple representations to meet student's diverse needs and skills was highlighted in the post-lesson plans.

Finally, even though the development of statistical literacy was improved in post-lesson plans, the results were statistically insignificant. This finding might be explained by that the pre-lesson plans already addressed this aspect as the first PD phase spent significant time discussing this issue, and the pre-results were already high.

6. Conclusion

This study contributes to research focusing on lesson plan analysis (Darling-Harmond et al., 2013; Kornig et al., 2020). Our unique contribution is the use of a design-based research methodology to develop and evaluate a content- and context-specific framework helping teachers to interpret the Vietnamese reformed Curriculum. This framework serves as a tool for teachers to reflect on and inform their practice. In addition, this study finds that the PD on teachers' developing statistical literacy for students helps teachers improve their lesson plan quality.

Limitations and Future Studies. This study was conducted only with 61 teachers from seven provinces and cities in Vietnam, which might not be representative of all teachers in Vietnam. In addition, although we find positive improvements in lesson plans, research also highlights the nuances between different levels of curriculum: teacher-intended (e.g., lesson plans) and enacted (lessons taught). Teachers sometimes do not write down all their decisions (e.g., Borko & Livingston, 1989; Nguyen & Tran, 2022) when planning and do not implement lessons as planned (Stein & Lane, 1986). Future research can build on the current study to document how teachers implement their lessons in classrooms. In addition, research can further examine how the quality of lesson plans (measured by how well they address the framework) impacts student learning.

Acknowledgment: This study was funded by Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 503.01-2020.313.

7. References

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher, 41*(1), 16-25. https://doi.org/10.3102/0013189X11428813

Amador, J., & Lamberg, T. (2013). Learning trajectories, lesson planning, affordances, and constraints in the design and enactment of mathematics teaching. *Mathematical Thinking and Learning, 15*(2), 146–170. http://dx.doi.org/10.1080/10986065.2013.770719

Australian Curriculum, Assessment and Reporting Authority (2022). *Mathematics: Curriculum.* https://v9.australiancurriculum.edu.au/f-10-curriculum/learning-areas/mathematics

Bieda, K. N., Lane, J., Evert, K., Hu, S., Opperman, A., & Ellefson, N. (2020). A large-scale study of how districts' curriculum policies and practices shape teachers' mathematics lesson planning. *Journal of Curriculum Studies, 52*(6), 770–799. https://doi.org/10.1080/00220272.2020.1754921

Bộ Giáo dục và Đào tạo Việt Nam [Vietnam Ministry of Education and Training] (2018). *Chương trình môn toán* [*School Mathematics Curriculum*]. https://data.moet.gov.vn/index.php/s/m6ztfi7sUIIGQdY#pdfviewer

Borko, H., & Livingston, C. (1989). Cognition and improvisation: Differences in mathematics instruction by expert and novice teachers. *American Educational Research Journal, 26*(4), 473–498. https://doi.org/10.3102/00028312026004473

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9-13. https://doi.org/10.3102/0013189X032001009

Common Core State Standards Initiative (2010). *Common Core State Standards for Mathematics.* National Governors Association Center for Best Practices and the Council of Chief State School Officers. http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

Darling-Hammond, L., Newton, S. P., & Wei, R. C. (2013). Developing and assessing beginning teacher effectiveness: The potential of performance assessments. *Educational Assessment, Evaluation and Accountability, 25*(3), 179–204. https://doi.org/10.1007/s11092-013-9163-0

Design-Based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8. https://doi.org/10.3102/0013189X032001005

Drake, C., & Sherin, M. G. (2006). Practicing change: curriculum adaptation in the context of mathematics education reform. *Curriculum Inquiry, 36*(2), 153–187. https://doi.org/10.1111/j.1467-873X.2006.00351.x

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics, 61*, 103–131. https://doi.org/10.1007/s10649-006-0400-z

Fernandez, C., & Cannon, J. (2005). What Japanese and U.S. teachers think about when constructing mathematics lessons: A preliminary investigation. *The Elementary School Journal, 105*(5), 481–498. http://dx.doi.org/10.1086/431886

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R. (2007). *Guidelines and assessment for instruction in statistics education (GAISE) Report: A Pre-K-12 curriculum framework.* American Statistical Association.

Gal, I. (2002). Adults' statistical literacy: Meanings, components, responsibilities. *International Statistical Review, 70*(1), 1-25. https://doi.org/10.1111/j.1751-5823.2002.tb00336.x

Grossman, P., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching, 15*(2), 273-289. https://doi.org/10.1080/13540600902875340

Hiebert, J. (1986). *Conceptual and procedural knowledge: The case of mathematics.* Routledge.

Holmqvist, M., & Wennås Brante, E. (2011). What is discerned in teachers' expressions about planning? —Similarities and differences between teachers from Sweden and Hong Kong. *Education Inquiry, 2*(3), 497–514. https://doi.org/10.3402/edui.v2i3.21996

John, P. D. (2006). Lesson planning and the student teacher: Re-thinking the dominant model. *Journal of Curriculum Studies, 38*(4), 483–498. https://doi.org/10.1080/00220270500363620

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. The National Academies Press.

König, J., Bremerich-Vos, A., Buchholtz, C., & Glutsch, N. (2020). General pedagogical knowledge, pedagogical adaptivity in written lesson plans, and instructional practice among preservice teachers. *Journal of Curriculum Studies, 52*(6), 800-822. https://doi.org/10.1080/00220272.2020.1752804

Lilly, S., Bieda, K. N., & Youngs, P. A. (2022, online first). How early career elementary teachers vary in planning mathematics instruction. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-022-09551-6

Lim, W., Son, J. W., & Kim, D. J. (2018). Understanding preservice teacher skills to construct lesson plans. *International Journal of Science and Mathematics Education, 16*(3), 519–538. https://doi.org/10.1007/s10763-016-9783-1

Mutton, T., Hagger, H., & Burn, K. (2011). Learning to plan, planning to learn: The developing expertise of beginning teachers. *Teachers and Teaching, 17*(4), 399–416. https://doi.org/10.1080/13540602.2011.580516

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards.* NCTM.

Neubrand, M., Jordan, A., Krauss, S., Blum, W., & Löwen, K. (2013). Task analysis in COACTIV: Examining the potential for cognitive activation in German mathematics classrooms. In M. Kunter, J. Baumert, W. Blum,U. Klusmann, S. Krauss, &M. Neubrand (Eds.), *Cognitive activation in the mathematics classroom and professional competence of teachers* (pp. 125–144). Springer.

Nguyen, T. D., & Tran, D. (2022, online first). High school mathematics teachers' changes in belief and knowledge during lesson study. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-022-09547-2

Pecheone, R. L., & Chung, R. R. (2006). Evidence in teacher education: the performance assessment for California teachers (PACT). *Journal of Teacher Education, 57*(1), 22–36. https://doi.org/10.1177/0022487105284045

Sabbag, A. G. (2016). *Examining the relationship between statistical literacy and statistical reasoning*. Unpublished doctoral dissertation. University of Minnesota.

Schmidt, W. H., Cogan, L., & Houang, R. (2011). The role of opportunity to learn in teacher preparation: An international context. *Journal of Teacher Education, 62*(2), 138–153. https://doi.org/10.1177/0022487110391987

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation*, *2*(1), 50-80. https://doi.org/10.1080/1380361960020103

Sullivan, P., Clarke, D. J., Clarke, D. M., Farrell, L., & Gerrard, J. (2013). Processes and priorities in planning mathematics teaching. *Mathematics Education Research Journal, 25*(4), 457-480. http://dx.doi.org/10.1007/s13394-012-0066-z

Superfine, A. C. (2008). Planning for mathematics instruction: a model of experienced teachers' planning processes in the context of a reform mathematics curriculum. *The Mathematics Educator, 18*(2), 11–22. https://files.eric.ed.gov/fulltext/EJ841570.pdf

Tran, D., Nguyen, A., Nguyen, D., Ta, P., Huynh, B. Phan, P., Pham, N., & Nguyen, N (In press). Planning for developing students' statistical literacy: A research-informed framework development. *Vietnam Journal of Education.*

Tran D., & Tarr, E. J. (2018). Examination of bivariate data tasks in US high school textbooks through the statistical investigation and cognitive demands frameworks. *International Journal of Science and Mathematics Education, 16,* 1581-1603. https://doi.org/10.1007/s10763-017-9851-1

Watson, J., & Callingham, R. (2003). Statistical literacy: A complex hierarchical construct. *Statistics Education Research Journal, 2*(2), 3-46. https://doi.org/10.52041/serj.v2i2.553

Watson, J., & Callingham, R. (2013). Likelihood and sample size: The understandings of students and their teachers. *The Journal of Mathematical Behavior, 32*(3), 660-672. https://doi.org/10.1016/j.jmathb.2013.08.003

Watson, J., Fitzallen, N., Fielding-Wells, J., & Madden, S. (2018). The practice of statistics. In D. Ben-Zvi, K. Makar, & J. Garfield (Eds). *International handbook of research in statistics education* (pp. 105-137). Springer.