Preparing prospective primary school teachers in teaching informal statistical inference

PER BLOMBERG

In recent decades, the statistics education community has focused extensively on research aimed at modernising mathematics curricula by integrating powerful statistical concepts relevant to the 21st century. As a result, the professional development needs of statistics teachers are evolving. There is an increasing demand for teachers to be well-equipped to teach foundational statistical concepts, including inferential statistics, and gaining these insights has become essential. This paper presents findings from an educational design research study conducted with participants in primary teacher education. The study outlines a design principle with three sub-components, intended to guide teacher training in statistical inference. The conclusion highlights the importance of statistical inference as a central theme in statistics education, with significant implications for school statistics and curriculum evaluation.

Traditionally, primary school statistics have emphasised teaching descriptive statistics, focusing on foundational concepts and procedures like measuring central tendencies and basic graph interpretation (Watson et al., 2018). This aspect is particularly relevant in a Nordic context given that the basis for school statistics mainly refers to these basic statistical concepts that emphasise descriptive learning objectives (e.g. Danish ministry of education, 2019; Swedish national agency for education, 2024). However, the landscape of school statistics is evolving in a direction that seeks to introduce early exposure to the process of drawing and evaluating inferences and predictions based on contextual data applications (Burrill & Biehler, 2011; Cobb & Moore, 1997; Pfannkuch, 2005; Shaughnessy, 2019; Watson & Callingham, 2003). Integrating statistical inference into school statistics has been explored internationally within the mathematics education research community (Biehler & Pratt, 2012; Pratt

Per Blomberg
Malmö university

Blomberg, P. (2025). Preparing prospective primary school teachers in teaching informal statistical inference. *Nordic Studies in Mathematics Education*, 30 (1), 59–82.

& Ainley, 2008). This exploration underscores statistical inference as a valuable intrinsic element and a meaningful foundation for more formal treatment in later stages of schooling (Rossman, 2008). These ideas involve conceptualising, communicating and reasoning informal inferences that do not rely on abstract statistical concepts and methods typically taught at the postsecondary level (Makar & Rubin, 2009; Wild et al., 2011).

Mathematics teachers often have limited preparation in statistics, resulting in a lack of the professional knowledge necessary to teach statistical inference (Batanero, 2011; Leavy, 2010; Oliveira & Henriques, 2019). Studies conducted in a Nordic context, including those by Blomberg et al. (2022) and Landtblom and Sumpter (2021), suggest that both prospective teachers (PTs) and in-service teachers lack insight into statistical inference as a fundamental idea in teaching statistics. Further, research generally provides limited findings on how to support the development of PTs' skills in teaching inferential statistics (Ben-Zvi et al., 2018; de Vetten et al., 2019a; Groth, 2017). Additionally, the existing studies emphasize the need for further investigation into effective methods for preparing student teachers to teach (de Vetten et al., 2019b; Leavy, 2010). Responding to this gap, this paper adopts a conceptual approach to professional development (PD) for prospective and practicing teachers, as well as teacher educators, following the perspective outlined by da Ponte and Noll (2018). By focusing on advancing statistics teacher education, this study aims to address these challenges and support PTs' professional growth in teaching statistical inference. The central research question guiding this paper is:

> What design principle can assist teacher educators in preparing prospective primary school teachers to teach statistical inference?

To understand the principles underpinning teacher PD, it is crucial to consider the essential intrinsic knowledge required for planning and teaching specific content (Prediger et al., 2019). Therefore, to address the research question, this paper proposes a theoretical construct that encapsulates the design and research related to teacher PD and establishes connections with existing literature on statistics education.

Theoretical background and literature review

This section aims to elucidate elements within statistical knowledge for teaching (SKT) (Groth, 2013) and establish a theoretical foundation for the methodology employed in this paper. The introductory part lays out the theoretical constructs for designing and researching PD. The second subsection presents research insights related to inferential statistics as classroom content. In the third subsection, a PD resource in the form of statistical process theory at the teacher PD level is introduced. Finally, the fourth subsection details design elements for teacher training resources at the facilitator PD level.

Theoretical constructs for designing and researching PD

Based on Hill et al. (2008), Groth (2013) hypothesised that statistical knowledge for teaching (SKT) includes subject matter knowledge, knowledge of content and students, as well as knowledge of how to teach the content and curriculum knowledge. Among these hypothetical knowledge elements, this paper focuses particularly on knowledge of content and teaching. Specifically, it examines knowledge of statistical inference and teaching, and how this knowledge can be promoted in teacher education.

In search of a model for designing and researching PD for this research, I draw on Prediger et al. (2019), who presented a comprehensive three-level didactics framework encompassing the classroom level, the teacher PD level, and the facilitator PD level. This model, referred to as the 3T-model, is advocated for its suitability in structuring content for PTs and implementing teacher PD content with the support of resources used in PD courses and implementing teacher PD content with the support of resources used in PD courses. By applying the 3T-model in the context of this study, the focus shifts to emphasising the structuring of PD content and its realisation through PD resources. Consequently, this present study introduces an adapted design and research method for PD, which contains different layers, as illustrated in figure 1.

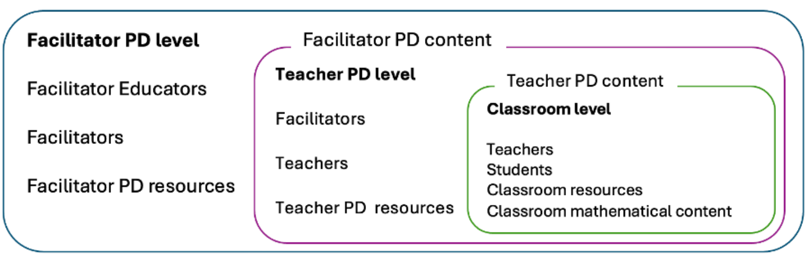

Figure 1. *The various layers of PD design and research approach adapted from Prediger et al. (2019)*

As depicted in figure 1, the design and research of PD can be conceptualised through three distinct layers: Classroom, Teacher PD, and Facilitator PD. The "first-level" activity unfolds within classroom lessons, with the "second-level" corresponding to the design and analysis of the "first-level" activity on the Teacher PD level. Lastly, the "third-level" on the Facilitator PD level aligns with the design and analysis of the "second-level" activity.

Inferential statistics as classroom content

At the classroom level, the specific content in focus in this paper is statistical inference. Among researchers, informal statistical inference (ISI) is the commonly accepted term used to describe the process of making claims or predictions beyond the given data while using the data as evidence and acknowledging the uncertainty of any generalisation (Langrall et al., 2017; Makar & Rubin, 2009). Students can initially formulate statistical questions, propose and justify conclusions and generalisations based on descriptive data, which lays the foundation for statistical investigations and the gradual introduction of more statistical concepts and processes (Bargagliotti et al., 2020; Paparistodemou & Meletiou-Mavrotheris, 2008). In contrast to formal statistical methods of conveying uncertainty, such as using confidence level, students may initially use linguistic expressions such as might, probably, likely, and unlikely (Shaughnessy, 2019). In addition, students can understand ISI holistically by integrating contextual knowledge, considering aggregated data and addressing central statistical ideas (Makar & Rubin, 2018). Acknowledging ISI as the central theme in teaching paves the way for exploring other key statistical concepts and their interconnected relationships (Lehrer & English, 2018).

ISI modelling as a PD resource

Viewing ISI within a holistic approach to other statistical concepts aligns with effective teaching principles emphasising key statistical ideas and their interrelations (Ben-Zvi et al., 2018). Researchers such as Lehrer and English (2018) and Makar & Rubin (2018) recognise the relationship between statistical modeling and inference as a means of helping students both express and make inferences about the contexts represented. Whether empirical data is modeled to develop a mathematical model or to conduct inferential statistics, these related processes can integrate the teaching of mathematics and statistics with regard to modelling (Bergman Ärlebäck et al., 2015). The exploration by Blomberg (2015) of the relationship between data modelling (Lehrer & Schauble, 2004) and the ISI framework (Makar & Rubin, 2009), particularly in analysing student outcomes during statistical investigation activities, suggests a unified approach between school mathematics and school statistics. This exploration, which led to developing the ISI modelling framework depicted in figure 2, involved adopting an integrative network strategy described by Prediger et al. (2008).

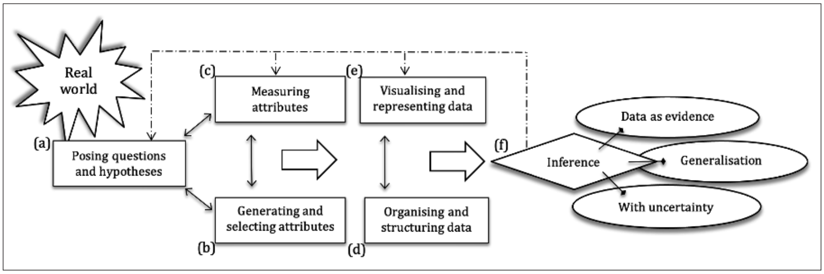

Figure 2. *Components of ISI modelling*
Note. Translated and adapted by the author from (Blomberg, 2015, p. 69).

The ISI modelling process involves key statistical elements and processes, which can be outlined as follows: (a) posing statistical questions and hypotheses within meaningful contexts, typically derived from real-world problems that underscore variability; (b) generating and selecting measurable attributes aligned with the posed questions; (c) measuring attributes to produce data characterised by variability; (d) organising and structuring the collected data; (e) visually representing the data; and (f) drawing informal inferences based on all these processes. This framework integrates explicit principles of ISI and data modelling practices, providing a structured approach to learning statistical inferences and their interconnections with other key statistical ideas (Lehrer & English, 2018; Makar & Rubin, 2018). As a statistical process theory, such a framework delineates the skills and insights that statistics education should target (Nilsson et al., 2018). In addition, it can serve as a tool to support teachers in planning and reflecting on their approach to teaching inferential statistics, thereby also functioning as a valuable teacher PD resource.

The design of teacher education resources in statistics

This section describes how the development of PTs in the context of PD related to statistical inference instruction is characterised in the current research literature. To design a specific PD activity for teaching ISI, the ISI modelling framework should be structured through appropriate activities and inputs. Here, many relevant findings of generic PD research can serve as an initial foundation, which can then be refined and adapted for ISI as the PD content (Prediger et al., 2019).

In their research review, da Ponte and Noll (2018) proposed recommendations for the design of teacher education courses in statistics, encompassing the following key points: (1) build on teachers' experiences and prior knowledge, (2) have teachers create lesson plans and questions for students, (3) have teachers examine and respond to student work, and (4) incorporate the big ideas of statistics into coursework. Furthermore, da Ponte and Noll (2018) noted an interest among researchers in integrating technology into statistics, incorporating PD into the teaching of statistics, and creating a learning environment that simulates the role of a mathematics teacher. Additionally, Heaton and Mickelson (2002) emphasised the importance of student teachers gaining experience in statistical investigations, first as students and then as teachers. This requires valuing statistical investigations as one of several possible tools for learning central concepts and big ideas of statistics in meaningful ways (Watson et al., 2018).

The co-constitution of developing big statistical ideas and acquiring skills in modelling practices justifies adopting a modelling approach for deriving inspiration in developing PD strategies (e.g. Bergman Ärlebäck et al., 2015 and Lehrer & English, 2018). Utilising a modelling perspective in designing PD involves recognising teachers' knowledge as intricate and diverse, influenced by various layers that shape their views of different teaching scenarios (Doerr & Lesh, 2003). Doerr and Lesh (2003) introduced several principles illustrating how teacher modelling processes can be elicited. Four of these principles are relevant to this study: (1) The Reality principle emphasises the importance of connecting theoretical knowledge to real-world situations within the contexts of their actual practice. This principle suggests that teachers should engage in authentic and meaningful classroom practice and student learning activities, enabling their students to apply mathematical and statistical concepts, central ideas, and strategies to real-world problems. (2) The multi-level principle highlights that teachers should simultaneously be prepared to address content knowledge, pedagogical strategies, and psychological aspects in a teaching situation. (3) The sharing principle emphasises the importance of collaborative learning and the sharing of ideas among teachers to enhance their PD. It advocates for a collaborative environment that facilitates teaching practices' reuse, replication, revision, and refinement. Finally, (4) the self-evaluation principle emphasises teachers' need to judge whether planning and assessment strategies lead to the intended learning. While this PD research underscores the effectiveness of integrating practice and content knowledge as an optimal form of teacher development, it is acknowledged that it is resource-intensive (da Ponte & Noll, 2018; Groth, 2017).

When teaching, a teacher typically guides the collective thinking of students (Carlson et al., 2019). This enacted teaching consists of carefully planned learning pathways that provide opportunities for desirable knowledge exchange (Prediger et al., 2019). A modelling approach to teaching and learning involves striking a delicate balance between effectively transferring collectively accepted "expert" knowledge (e.g. content knowledge, mathematical models and process ideas) and allowing learners to test, revise, and express their current ways of thinking (Lesh & Doerr, 2003). Rather than simply instructing PTs on specific actions or recommendations, the emphasis is on utilising a modelling approach in the selection of PD strategies to promote SKT. This approach can support PTs in becoming familiar with both the content and the overarching concepts their students are expected to learn, as well as the knowledge required to effectively teach this content. Consistent with Prediger et al. (2019), this approach emphasises a nested and dynamic view of classroom processes that enables PTs to perceive and interpret the complex aspects of teaching and learning (Lesh & Lehrer, 2003).

In summary, research findings of different approaches to teacher PD of statistics and modelling consistently recognise the importance of integrating real-world applications and fostering collaborative learning. Nevertheless, distinctions emerge in their recommendations, covering areas such as lesson planning, technology integration, multi-level, and self-assessment principles. As generic recommendations, these pieces of advice can serve as the foundation for more context-specific design principles. Utilising authentic or simulated teaching practices, such as creating lesson plans and formulating tasks for future students, appears to be a particularly suitable strategy for PD, enabling PTs to improve their knowledge for teaching ISI. Such activities can constitute reasonable complements to resource-demanding practice-integrated learning.

Methodology and methods of design research

Cobb et al. (2017) identified two instances where educational design research aligns well with educational research, both of which resonate with the focus of this paper. Firstly, when the absence of a phenomenon limits the possibility of conducting observational studies that explore the focus of the study's interest. This paper addresses a phenomenon rarely occurring naturally in the current educational context. Specifically, the concepts of statistical inference appear unfamiliar to both PTs and active teachers in Swedish primary school settings (Blomberg et al., 2022; Landtblom & Sumpter, 2021). Secondly, design research is suitable when existing research fails to offer satisfactory guidance in pursuing more reliable findings in teaching pro-ducts, teacher PD, and system-level school development. As highlighted in the literature review of this paper, this scenario aligns with the aim of the study. Hence, educational design research with expected design outcomes, such as specified classroom content, topic-specific design principles, and a prototypical teaching-learning arrangement, seems to be an appropriate methodology for representing the PD research in this study (Bakker, 2018; Hußmann & Prediger, 2016; McKenney & Reeves, 2018). Since the main aim of this paper is to enhance the understanding of PD resources in assisting teacher educators as they prepare PTs to teach statistical inference, I turn to content-specific design research for teachers' PD. Prediger et al.'s (2019) 3T-Model for PD research and design delineates and articulates this paper's focus.

Design research context

The research team consisted of one researcher (the author of this paper) and two mathematics teacher educators. The research participants were PTs attending primary school teacher education at a Swedish university to become teachers for students aged 6–12. The participants were enrolled in a mathematics course designed for prospective primary school teachers in their second of four years of study. The course included a statistics session of three 3-hour lectures, three homework assignments, two student group work seminars, and a final presentation seminar. Four design cycles were completed, each with a new group of participants. During each design cycle, the average number of participants was 31, with a mean age of 27 years.

Data generation and method of analysis

From a researcher's perspective, each design cycle comprised three main phases: 1) analysis and exploration, 2) design and construction, and 3) eva-luation and reflection (Hußmann & Prediger, 2016; McKenney & Reeves, 2018). The first phase (analysis and exploration) aimed to specify and structure teaching and learning objectives within the context. Drawing inspiration and guidance from previous research (see Theoretical background and literature review), collaboration with teacher educators was essential for understanding practical limitations, exploring opportunities, and specifying long-term goals for student teacher development.

The second research phase, the design and construction, focused on providing theoretical conjectures and generating, selecting, and implementing preliminary teaching strategies. Data generated included videotaped teaching, student-produced written reflections using a template called CoRe (Loughran et al., 2004), videotaped presentations, slideshows from these presentations, and personal notes. The CoRe is central to the study as a mediating tool to portray PTs' pedagogical content knowledge (Bertram, 2014; Carpendale & Hume, 2019; Hume & Berry, 2011) and SKT (Groth, 2013). The CoRe template in this study consisted of eight questions (see Loughran et al., 2004), with the following two being of particular interest for the data analysis: What do you intend the students to learn about this idea, and why is it important that students know this?

During the third research phase (evaluation and reflection), emerging tentative solutions and design conjectures were evaluated by analysing the empirical findings of the PTs' outcomes. Reflection in this phase involves retrospectively considering design conjectures and observations to generate explanations for these findings. The evaluation of the student teachers' teaching plans concentrated on identifying and analysing the differences in their presentations and planning documents (using the CoRe template) across various sub-studies. The identified differences are understood to have resulted from alterations or developments in the design conjectures used throughout the different design cycles in the research. This paper presents these findings in terms of design principles, using the structure of the question recommended by van den Akker (1999). Design principles are charac-terised by a prescriptive theoretical understanding that is considered suitable as a guide for achieving a specific teaching and learning goal within a particular context (McKenney & Reeves, 2018). The design principles proposed in this paper were each motivated by an argumentative grammar inspired by Bakker (2018).

Design propositions

Before and during the first two design cycles, the entire research team planned and evaluated the design. When the first design cycle was conceived, contextual constraints were carefully considered. Notably, the mathematics teacher educators contributed valuable insights into the inherent possibilities of the initial design conjectures. Consequently, the statistics session was aligned with the study's objectives, the goals of the teacher education course, and the course's time constraints. The learning environment design employed collaborative learning and group work as a participatory structure (for more details, see Blomberg et al., 2022).

The PTs were tasked with acquiring and selecting statistical material for teaching from the internet. Subsequently, they were divided into groups to complete a CoRe outlining three big ideas for their imagined students' learning. Following this, the PTs formulated a teaching practice in statistics for their hypothetical future students. We conjectured that the research findings from the completed CoRe and the teaching plan would reveal desirable outcomes necessary for teaching statistical inference. However, the findings from the initial study indicated a lack of such knowledge. An improved strategy was developed, placing a more explicit focus on practising inferential statistics. Concepts and big ideas characteristic of statistical inference are highlighted. Consequently, the ISI modelling framework (see figure 2) was introduced as a PD resource for PTs' planning and reflection on teaching and learning inferential statistics.

The ISI modelling framework as a PD resource

This section introduces a design aimed at enriching the PD of primary school teachers in teaching inferential statistics. This design, formulated as a design principle, centres on the ISI modelling framework as a resource for teachers during the planning and reflection stage. Three key pieces of advice at the teacher PD level accompany this design principle, each reinforced with theoretical underpinnings. Subsequently, the design principle is substantiated with empirical arguments along with its distinguishing characte-ristics. These empirical arguments, derived from a reflective analysis of experiences gained throughout the design cycles, are presented explicitly.

Table 1. *Planned teaching practices categorised by stated statistical big ideas, from Blomberg et al. (2022)*

Category	Frequency	Example of PTs' stated statistical big ideas
Data	10	"How to measure and compare data – To be able to formulate a question to be able to find out a specific matter", "With the help of statistics, you can find out various questions", "Statistics is a collection ... – Collection is an important process; it is important for students to get an understanding of who to ask or what to look for"
Analysis	9	"Interpret – reading the diagram", "The bars represent data – To be able to create bar charts after collected data", "Analyse – comparison of the data presented in the diagrams"
Critical	1	"Statistics can be misused and misunderstood - All available statistics should not be trusted. It is important to be critical of sources"
Communication/ Making inference	0	
Other topic	9	"Stress – We think that students should learn that stress can be both positive and negative depending on how you deal with it", "Risks with an increased use of the Internet", "Values – We want our students to gain knowledge about the Convention on the Rights of the Child"

Findings from the first design cycle

After the first design cycle, an analysis of PTs' planned teaching practises revealed an emphasis on organising and visualising data, interpreting and reading charts, and being statistically critical as classroom content to teach (Blomberg et al., 2022). Table 1 presents the distribution of planned teaching practices categorised by stated statistical big ideas.

It is notable that statistical inference is missing and that about a third of the teaching practices highlighted contextual issues separately from statistical big ideas and content as learning objectives. Thus, it was concluded that PD activities centred on statistical literacy and content knowledge were insufficient to support PTs in planning for ISI teaching. In our design, we conjectured that implementing the ISI modelling framework into PD practice could induce a more holistic, coherent, and precise view of big ideas in PTs' planned teaching practices.

The design principle – ISI modelling as a PD resource

If you intend to introduce PTs to the application of ISI modelling in planning a teaching practice for informal statistical inference, consider the following steps:

a Arrange a statistical modelling activity for the PTs to reflect on with the support of the ISI modelling framework because modelling inferential reasoning and stimulating discussion that enables reflection around student-centred classroom activities have the potential to both develop PTs' content knowledge and teaching abilities (Bargagliotti et al., 2020; da Ponte & Noll, 2018; Doerr & Lesh, 2003; Heaton & Mickelson, 2002; Leavy, 2010).

b Invite PTs to reflect on the distinctions between inferential and descriptive statistical questions, as understanding the conceptual meaning of a mathematical object involves recognising critical differences in the characteristics of related learning objects (Runesson, 2006). This includes descriptive and inferential statistical questions (Paparistodemou & Meletiou-Mavrotheris, 2008; Shaughnessy, 2019) and other types of questions that arise during the statistical investigation process (Arnold & Franklin, 2021).

c Provide PTs with selected segments of expert knowledge on big ideas related to ISI teaching practices, utilising resources such as published research articles and conference presentations. This approach aligns with recommendations to furnish PTs with guidelines and resources for practising the teaching of statistics and acquiring content-specific teaching knowledge (Groth, 2013; Makar & Fielding-Wells, 2011; da Ponte & Noll, 2018).

Backing argument

By introducing an investigative statistical activity and utilising ISI modelling as a PD resource for reflection, the PTs were provided with the opportunity to comprehend the diversity of big ideas in statistics. However, the evaluation of the second cycle revealed that, by the end of the course, PTs continued to grapple with recently encountered statistical concepts and ideas that extend beyond descriptive statistics. Table 2, made by group A during the second design cycle, exemplifies a typical teaching practice demonstrating a relatively limited perspective on big statistical ideas.

Table 2. *A teaching practice regarding statistics from a presentation by PTs (author's translation)*

Work area in statistics and charts - year 4	Objectives for the work area:	
	Connection to central content	Lesson objectives
Introduce various types of charts and how they are read. How to collect data for descriptive statistics and how this can then be presented in different ways. Create a chart related to the collected data.	Tables and charts to describe survey results, both with and without digital tools. Interpretation of data in tables and diagrams.	Learn about the different types of charts available and how they can be used to present various kinds of statistics.

In this example (see figures 3 and 4), the learning goals were limited to descriptive statistics, which involved constructing and interpreting tables and charts through student-led statistical surveys. Using statistical investigation as a teaching strategy may indicate knowledge of content and teaching (Groth, 2013). Nevertheless, it proved challenging for PTs to integrate ideas related to ISQ and ISI when incorporating them as classroom content into their teaching plan. Like Group A, the planned teaching practices for all groups in design cycle 2 lacked emphasis on ISI. This shortage in conceptual understanding, particularly regarding inferential statistical ideas beyond descriptive statistics, may explain the PTs' difficulties in planning and reflecting on the teaching of inferential statistics.

The evaluation and reflection phases across design cycles 1–3 revealed that while the ISI modelling framework is valuable, it may not be sufficient. Instead, ISI modelling was conjectured to be a necessary PD resource when accompanied by a specialised content knowledge of the big ideas emphasised in the framework. An improved design strategy involved delivering lectures on ISI modelling as an approach to conducting inferential statistics. The introduction of this design principle to PTs was guided by the aforementioned advice. This approach combined

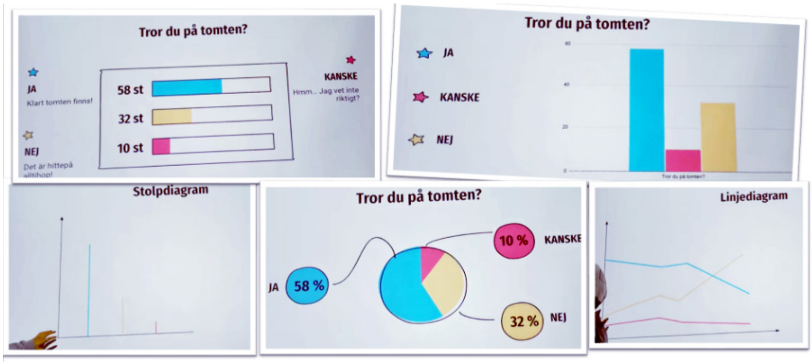

Figure 3. *PowerPoint slides entitled "Do you believe in Santa?" containing tables and charts to teach from a presentation by PTs (author's translation)*

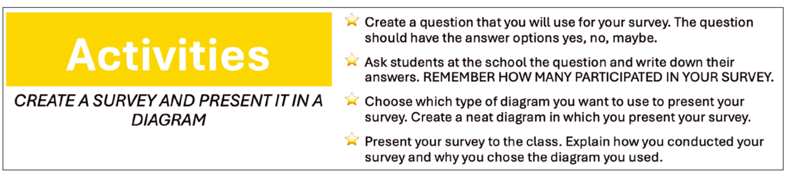

Figure 4. *PowerPoint slide containing teaching instructions from a presentation by PTs (author's translation)*

lectures on both descriptive and inferential statistical aspects with collaborative investigation activities during the lessons. Additionally, relevant sections of an academic article by Makar and Rubin (2009) were provided, outlining the characteristics of ISI and offering examples of teaching methods for ISI.

In contrast to the excerpt from the second design cycle, figures 5 and 6 illustrate two completed CoRes from the fourth cycle, reflecting a more developed understanding of teaching practices for inferential statistics proposed by the PTs. These two examples of teaching practices suggest that the conjectured design principles enhanced PD related to reflective ISI outcomes. Analysing all groups' planned teaching practices from the fourth cycle revealed an improved coherent and precise view of big statistical ideas. An evaluation of the completed CoRes revealed progress from an unsatisfactory level in all groups' SKT outcomes related to ISI in cycles 1 and 2, to more than half of the groups achieving an SKT level where ISI was either initially or partially applied by cycle 4. Furthermore, the completed CoRes of PTs demonstrated a significantly richer and more accurate application of statistical concepts and ideas compared to the teaching practices observed in previous cycles.

GROUP B Group members: Four prospective teachers.

Theme: Inferential statistics - Children's use of media	**Big idea 1: Statistical investigations starts from statistical questions.**	**Big idea 2: Statistical sampling.**	**Big idea 3: Statistical inference means making uncertain statements or predictions in addition to available data.**
What do you intend the students to learn about this idea?	Statistical questions involve obtaining information based on a specific question. Statistical questions are about getting information based on a specific request. These questions are derived from the chosen topic, which gives a clearer outcome for the investigation. A statistical question should be measurable and relevant to the area under investigation. An example of a good question for a study on children's internet usage is, "How many hours per day do children of different ages use their mobile phones?" Another example is, "How many hours per day do you use your phone?"	It is important for students to know which sample is relevant for the statistical investigation, how statistical sampling can be used to make generalisations, and gain knowledge about what it is to be able to make a sample.	Statistics involves generalisations, acknowledging that there is a certain uncertainty in the results. Students should also be able to express the uncertainty verbally. Generalisation means understanding that the statistical questions have been answered by a statistical sample of individuals, that the result could have been different if we had chosen a different sample, but that one can still say something general about the entire population even if not everyone was surveyed. Important concepts to learn: - Probable - Likely
Why is it important that students know this?	By mastering the meaning of statistical questions, students can later understand how to collect information and data to conduct statistical investigations.	To gain knowledge about the significance of statistical sampling for the result. And as a fundamental prerequisite for making generalisations/ predictions, etc.	We believe that since they encounter statistics daily, they need to acquire knowledge about how confident statements one can make based on statistics.
Which teaching methods will you use and for what particular reason have you chosen these particular methods?	The students will begin by looking at charts. Students will consider what questions have been posed in the charts they observe. They will start by providing examples of statistical questions. After students have shared their thoughts and ideas, the class will together compile a summary of what characterises statistical questions. Provide examples of questions that are statistical questions and those that are not. Let the students determine if the question is a statistical question or not. Students will contemplate descriptive questions and inferential questions.	What is a statistical sample? How can the sample affect the result of a survey? Which sample is the one that has responded to the survey? Is it a good sample for getting a correct answer? Students will participate in a survey and then compile the results. They will compare it with a survey on the same subject conducted by students in Stockholm. Students will consider why the surveys may look different.	Students will reflect on the differences and similarities between Stockholm's results and their own. In pairs, students will then predict what the students in the other class will get. What is most likely and probable for the result in that class? After the other class has conducted the same survey, students will reflect together on why the results turned out the way they did. What differences and similarities could we see with Stockholm, what differences and similarities did we have with the other class? Do we see any correlation? Why do we think that is? Inferential questions: What can we interpret from the material?

Figure 5. *A CoRe on inferential statistics, produced collectively by Group B (author's translation)*

Next, I will present an excerpt from the verbal presentation of Group C. This example aims to illustrate how expert knowledge from an article can inspire PTs in their planning work. It highlights the various types of questions that teachers should consider. One of the four PTs in Group C begins the presentation by providing the background for their proposed teaching activity, as outlined in figure 6.

PT 1: What we took from Mark [referring to Makar] in 2009 is that we teachers should create engaging mathematical problems that are connected to reality [... and] the importance of asking a driving question. A driving question gives our students a clear goal of where their statistical investigation should land.

After reviewing Big idea 1, PT 2 introduces Big idea 2, as shown in figure 6.

GROUP C Group members: PT 1, PT2, PT3 and PT4

Theme: Inferential statistics	**Big idea 1: Statistical investigations starts from statistical questions.**	**Big idea 2: Statistical inference involves displaying and representing data.**	**Big idea 3: Statistical inference means making uncertain statements or predictions in addition to available data.**
What do you intend the students to learn about this idea?	The questions must include differentiation of data. Not just one answer, but several data that show different answers, including options and value.	The students should learn that it is important to be able to represent their data in an adequate way in order to be able to convince and conduct mathematical reasoning that contributes to a greater knowledge of statistics.	Students should learn that they can make smaller samples that can provide predictions beyond the available data. Random sampling is an important approach to learn when moving from descriptive statistics to inferential statistics.
Why is it important that students know this?	Because it is one of the components [needed] to understand [the subject of] statistics and be able to compile data.	It is important because it primarily gives the data a visual support that students will need to use in their future professions, especially when they need to produce or compile various data that are important for its operations.	Students need to know how predictions can be made from descriptive data and that it is important to discuss statistical uncertainty around this approach.
Which teaching methods will you use and for what particular reason have you chosen these particular methods?	Ask students questions about what statistics mean, examples of statistical questions discussed in EPA, show films about statistics.	Create different diagrams and use various programs such as Excel, and evaluate how clearly the data is presented in this type of representation. Also, understand how to interpret various data based on different diagrams.	Problems that the whole class discusses and solves together. The reason for this is that students present their solutions to the statistical question and simultaneously discuss with the rest of the class about data as evidence, generalisation, and uncertainty.

Figure 6. *A CoRe on inferential statistics, produced collectively by Group C (author's translation)*

PT 2: By using a reality-based problem, we, as teachers, can create more extensive discussions about what a statistical question is and how we use statistics. And our idea is that the students should consider which questions are relevant to the problem. And we believe it is easier to formulate these statistical questions and discuss their relevance if it is a real-world problem.

This example suggests that these PTs recognise the importance of problem context in teaching statistical investigations. Identifying various types of questions that arise in statistical investigations and distinguishing between statistical and mathematical questions may indicate a specialised form of statistical knowledge (Groth, 2013). Furthermore, this specialised knowledge influences both the teachers' content knowledge and their approach to teaching statistics.

Concluding remarks after the fourth design cycle

The thoughtful design modifications made before the fourth design cycle likely contributed to improving PTs' collective knowledge of content and teaching to a satisfactory level for achieving the intended impact. The empirical examples discussed above suggest that the academic paper enhanced PD in relation to content knowledge and teaching practices for reflective ISI outcomes, particularly in terms of posing inferential statistical questions and their connection to making informal inferences.

Figure 7 encapsulates the design principles and PD resources specification across this study's three PD design and research approach layers.

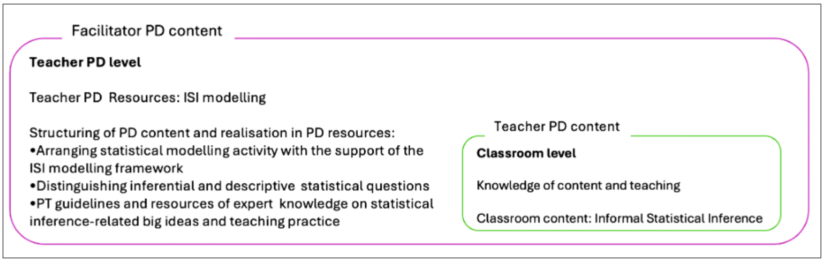

Figure 7. *Specified design principles and PD resources at a PD design and research approach layer*

Insights gathered from design cycles 1–3 indicate that PTs generally perceive ISI as a somewhat unfamiliar concept and find certain aspects of it challenging. These findings suggest that PTs, as learners at the teacher PD level, need adequate time to understand and engage with ideas of inferential statistics, which is crucial for effectively conceptualising and teaching statistical investigations, including ISI. Moreover, the study highlights the importance of ISI modelling as a valuable statistical process theory for planning a teaching practice aimed at novice students learning statistical inference. However, it is essential to recognise that this PD resource does not operate in isolation. When combined with specific design principles at the teacher PD level, as illustrated in figure 7, ISI modelling can become a practical PD resource, offering PTs content-specific teaching strategies for ISI.

Discussion

This study is motivated by the growing emphasis on enhancing students' informal inferential reasoning through the development of statistics curricula and teacher education (Ben-Zvi et al., 2018; de Vetten et al., 2019a; Groth, 2017; Makar & Rubin, 2018). The paper presents insights from a PD design and research study that incorporates ISI modelling, a statistical process theory, as a supportive resource for PTs. The research question investigates how to effectively support the development of PTs' knowledge in teaching inferential statistics. The study's answer to the research question, articulated through design principles (van den Akker, 1999) and bridging theory and practice (Bakker, 2018), provides concrete guidance for PD facilitators supporting the development of prospective primary school teachers' SKT. The findings highlight the potential of the ISI modelling framework and the identified design principles to assist teacher educators in preparing PTs for statistics teaching, including ISI.

The relevance and significance of the findings in this paper offer valuable guidance for statistics teacher education and provide ideas for designing PD programs focused on teaching inferential statistics in primary schools. While these findings are of general interest for international research (da Ponte & Noll, 2018; de Vetten et al., 2019b; Groth, 2013; Leavy, 2010), they are particularly relevant in the Nordic context, where there is a strong emphasis on descriptive statistical objectives in both schools and teacher education (Blomberg et al., 2022; Danish Ministry of Education, 2019; Landtblom & Sumpter, 2021; Swedish National Agency for Education, 2024). PD spanning several weeks has been recommended to cover both content knowledge of statistics and pedagogical strategies for teaching statistics (Groth, 2017). However, the statistics education research community has highlighted the challenge of integrating time-intensive teaching practices into PD programs, particularly within constrained timeframes (da Ponte & Noll, 2018). Instead of providing idea-listic recommendations, this paper offers practical findings that facilitate knowledge exchange, thereby effectively preparing primary PTs to teach statistical inference.

In qualitative educational design research, the applicability of findings is expected to be limited to the specific content domain and the unique institutional context in which the study is undertaken (Cobb et al., 2009). This reduced generalisability is consistent with the present study, in which teacher education specifically developed local forms of collective knowledge and pedagogical practice. However, the strength of qualitative approaches lies not in their ability to provide broad, context-free findings, but in their capacity to offer cumulative wisdom (Petocz et al., 2018). These approaches aim for generalisation by presenting findings from specific cases that contribute to broader models (Bakker, 2018). As such, this paper provides examples of the category *knowledge of content and teaching* within the SKT framework proposed by Groth (2013).

By adopting a generalisability perspective on the models discussed, this paper contributes to understanding the utility and adaptability of the 3T Model described by Prediger et al. (2019) and its connection to the hypothetical SKT framework outlined by Groth (2013). Applying the simplified form of the 3T Model, where teachers act as learners and facilitators serve as teacher educators within PD contexts, proved beneficial in addressing the complex realities of teaching, design, and research in teacher PD settings. Emphasising the structuring of PD content and its implementation through resources, the proposed simplified 3T Model is valuable. Additionally, applying ISI modelling – through the transformation of data modelling (Lehrer & Schauble, 2004) and ISI (Makar & Rubin, 2009) from the classroom to the PD level – enhances our understanding of statistics teaching strategies for teacher PD. Moreover, there are notable overlaps between mathematics and statistics teaching practices, particularly in modelling (Lehrer & English, 2018). ISI modelling can serve as a resource that improves our comprehension of investigative situations, whether the aim is to develop mathematical models (Lesh & Doerr, 2003) or to deepen knowledge of statistical inference (Makar & Rubin, 2009). Thus, the ISI modelling approach can act as a unifying mathematical process theory, bridging school mathematics and school statistics in the context of modelling.

PD courses that align with actual teaching practices in statistics (da Ponte & Noll, 2018; Leavy, 2010) resonate with the model and modelling approach proposed by Lesh and Doerr (2003). This approach emphasises classroom-based PD activities, transforming PT experiences into valuable learning opportunities. This paper investigates the structuring of PD content and its implementation through didactical resources at the PD level, focusing on one face of the three-level didactic tetrahedron (the 3T Model) proposed by Prediger et al. (2019). This focus, coupled with the study's specific context, highlights the need for future research to apply, refine, and validate the design principle in various contexts. Further research on PD involving PTs and their planned teaching practices for teaching ISI would be advantageous. Such studies could provide deeper insights into the complexity of teaching statistics and the development of SKT.

Conclusion

This paper underscores the effectiveness of well-designed PD activities, guided by pragmatic design principles, in preparing PTs for teaching ISI within time-constrained and content-rich statistics sessions. The implications are particularly relevant for traditional teacher education programs aiming to incorporate statistical inference into existing PD courses. Implementing ISI modelling, as proposed in this paper, offers PTs a valuable PD resource for planning teaching practices that integrate key elements and big ideas of inferential statistics. This PD tool acts as a catalyst, encouraging PTs to identify and connect essential big ideas, a crucial component of teachers' SKT.

At the curriculum level, this paper consistently emphasises the crucial integration of statistical inference across all educational levels. The holistic approach adopted, centred around essential statistical ideas, aligns with the impactful principle of teaching through investigative activities. In contrast to a strategy that isolates individual statistical content, focusing on ISI as a central theme allows statistical concepts and procedures to emerge organically as students engage with key ideas. As demonstrated, measures of centre, tables, and charts develop in response to the overarching goal of understanding ISI. Prioritising statistical inference as the central big idea, framed within the ISI modelling framework, has the potential to prompt a re-evaluation and restructuring of the entire statistical curriculum.

Acknowledgement

I am grateful to the two teacher educators and the PTs who generously participated in this study. Additionally, I thank my two supervisors for their supportive feedback throughout the research and writing process and the anonymous referees for their valuable suggestions during the revision process. This work was supported by the Swedish Research Council [2019-04419].

References

Akker, J. van den (1999). Principles and methods of development research. In J. van den Akker, R. M. Branch, K. Gustafson, N. Nieveen & T. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 1–14). Springer. https://doi.org/10.1007/978-94-011-4255-7_1

Arnold, P. & Franklin, C. (2021). What makes a good statistical question? *Journal of Statistics and Data Science Education*, 29 (1), 122–130. https://doi.org/10.1080/26939169.2021.1877582

Bakker, A. (2018). *Design research in education: a practical guide for early career researchers*. Routledge. https://doi.org/10.4324/9780203701010

Batanero, C. (2011). Measuring levels of statistical pedagogical content knowledge. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching statistics in school mathematics – challenges for teaching and teacher education: a joint ICMI/IASE study* (pp. 295–298). Springer. https://doi.org/10.1007/978-94-007-1131-0

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S. et al. (2020). *Pre-K-12 guidelines for assessment and instruction in statistics education II (GAISE II). A framework for statistics and data science education*. A. S. Association. https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf

Ben-Zvi, D., Gravemeijer, K. & Ainley, J. (2018). Design of statistics learning environments. In D. Ben-Zvi, K. Makar & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 473–502). Springer. https://doi.org/10.1007/978-3-319-66195-7_16

Bergman Ärlebäck, J., Blomberg, P. & Nilsson, P. (2015). An instructional design perspective on data-modelling for learning statistics and modelling. I O. Helenius, A. Engström, T. Meaney, P. Nilsson, E. Norén et al. (Eds.), *Proceedings of MADIF 9* (pp. 37–46). SMDF.

Bertram, A. (2014). CoRes and PaP-eRs as a strategy for helping beginning primary teachers develop their pedagogical content knowledge. *Educación Química*, 25 (3), 292–303. https://doi.org/10.1016/S0187-893X(14)70545-2

Biehler, R. & Pratt, D. (2012). Research on the reasoning, teaching and learning of probability and uncertainty. *ZDM*, 44, 819–823. https://doi.org/10.1007/s11858-012-0468-0

Blomberg, P. (2015). *Informell statistisk inferens i modelleringssituationer – en studie om utveckling av ett ramverk för att analysera hur elever uttrycker inferenser* [Informal statistical inference in modeling situations – a study of developing a framework for analysing how students express inferences]. [Licentiate dissertation]. Linnaeus University.https://lnu.diva-portal.org/smash/get/diva2:843625/FULLTEXT02.pdf

Blomberg, P., Högström, P. & Liljekvist, Y. (2022, 2–7 February). *Learning opportunities for pre-service teachers to develop pedagogical content knowledge for statistical inference*. Twelfth Congress of the European Society for Research in Mathematics Education (CERME12). https://hal.science/hal-03751811/file/TWG05_06_Blomberg%20.pdf

Burrill, G. & Biehler, R. (2011). Fundamental statistical ideas in the school curriculum and in training teachers. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching statistics in school mathematics-challenges for teaching and teacher education* (pp. 57–69). Springer. https://doi.org/10.1007/978-94-007-1131-0_10

Carlson, J., Daehler, K. R., Alonzo, A. C., Barendsen, E., Berry, A. et al. (2019). The refined consensus model of pedagogical content knowledge in science education. In A. Hume, R. Cooper & A. Borowski (Eds.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 77–94). Springer. https://doi.org/10.1007/978-981-13-5898-2_2

Carpendale, J. & Hume, A. (2019). Investigating practising science teachers' pPCK and ePCK development as a result of collaborative CoRe design. In A. Hume, R. Cooper & A. Borowski (Eds.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 225–252). Springer. https://doi.org/10.1007/978-981-13-5898-2_10

Cobb, G. W., & Moore, D. S. (1997). Mathematics, statistics, and teaching. *The American Mathematical Monthly*, 104 (9), 801–823. https://doi.org/10.2307/2975286

Cobb, P., Jackson, K. & Dunlap Charpe, C. (2017). Conducting design studies to investigate and support mathematics students' and teachers' learning. In J. Cai (Ed.), *Compendium for research in mathematics education* (pp. 208–233). NCTM.

Cobb, P., Zhao, Q. & Dean, C. (2009). Conducting design experiments to support teachers' learning: a reflection from the field. *Journal of the Learning Sciences*, 18 (2), 165–199. https://doi.org/10.1080/10508400902797933

Danish Ministry of Education (2019). *Matematik fælles mål 2019*. Børne- og undervisningsministeriet. https://emu.dk/sites/default/files/2020-09/GSK_F%C3%A6llesM%C3%A5l_Matematik.pdf

Doerr, H. M. & Lesh, R. A. (2003). A modeling perspective on teacher development. In R. A. Lesh & H. M. Doerr (Eds.), *Beyond constructivism: models and modeling perspectives on mathematics problem solving, learning, and teaching* (pp. 125–140). Lawrence Erlbaum.

Groth, R. E. (2017). Developing statistical knowledge for teaching during designbased research. *Statistics Education Research Journal*, 16 (2), 376–396. https://doi.org/10.52041/serj.v16i2.197

Groth, R. E. (2013). Characterizing key developmental understandings and pedagogically powerful ideas within a statistical knowledge for teaching framework. *Mathematical Thinking and Learning*, 15 (2), 121–145. https://doi.org/10.1080/10986065.2013.770718

Heaton, R. M. & Mickelson, W. T. (2002). The learning and teaching of statistical investigation in teaching and teacher education. *Journal of Mathematics Teacher Education*, 5 (1), 35–59. https://doi.org/10.1023/A:1013886730487

Hill, H. C., Ball, D. L. & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education*, 39 (4), 372–400. https://doi.org/10.5951/jresematheduc.39.4.0372

Hume, A. & Berry, A. (2011). Constructing CoRes – a strategy for building PCK in pre-service science teacher education. *Research in Science Education*, 41 (3), 341–355. https://doi.org/10.1007/s11165-010-9168-3

Hußmann, S. & Prediger, S. (2016). Specifying and structuring mathematical topics: a four-level approach for combining formal, semantic, concrete, and empirical levels exemplified for exponential growth. *J Math Didakt*, 37 (1), 33–67. https://doi.org/10.1007/s13138-016-0102-8

Langrall, C. W., Makar, K., Nilsson, P. & Shaughnessy, J. M. (2017). Teaching and learning probability and statistics: an integrated perspective. In J. Cai (Ed.), *Compendium for research in mathematics education* (pp. 490–525). NCTM.

Landtblom, K. & Sumpter, L. (2021). Teachers and prospective teachers' conceptions about averages. *Journal of Adult Learning, Knowledge and Innovation*, 4 (1), 1–8. https://doi.org/10.1556/2059.03.2019.02

Leavy, A. M. (2010). The challenge of preparing preservice teachers to teach informal inferential reasoning. *Statistics Education Research Journal*, 9 (1), 46–67. https://doi.org/10.52041/serj.v9i1.387

Lehrer, R. & English, L. (2018). Introducing children to modeling variability. In D. Ben-Zvi, K. Makar & G. J. (Eds.), *International handbook of research in statistics education* (pp. 229–260). Springer. https://doi.org/10.1007/978-3-319-66195-7_7

Lehrer, R. & Schauble, L. (2004). Modeling natural variation through distribution. *American Educational Research Journal*, 41 (3), 635–679. https://doi.org/10.3102/00028312041003635

Lesh, R. & Lehrer, R. (2003). Models and modeling perspectives on the development of students and teachers. *Mathematical Thinking and Learning*, 5 (2-3), 109–129. https://doi.org/10.1080/10986065.2003.9679996

Lesh, R. A. & Doerr, H. M. (2003). In what ways does a models and modeling perspective move beyond constructivism? In R. A. Lesh & H. M. Doerr (Eds.), *Beyond constructivism: models and modeling perspectives on mathematics problem solving, learning, and teaching* (pp. 519–556). Lawrence Erlbaum.

Loughran, J., Mulhall, P. & Berry, A. (2004). In search of pedagogical content knowledge in science: developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, 41 (4), 370–391. https://doi.org/10.1002/tea.20007

Makar, K. & Fielding-Wells, J. (2011). Teaching teachers to teach statistical investigations. In C. Batanero, G. Burrill & C. Reading (Eds.), *Teaching statistics in school mathematics – challenges for teaching and teacher education: a joint ICMI/IASE study* (pp. 347–358). Springer. https://doi.org/10.1007/978-94-007-1131-0_33

Makar, K. & Rubin, A. (2009). A framework for thinking about informal statistical inference. *Statistics Education Research Journal*, 8 (1), 82–105. https://doi.org/10.52041/serj.v8i1.457

Makar, K. & Rubin, A. (2018). Learning about statistical inference. In D. Ben-Zvi, K. Makar & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 261–294). Springer. https://doi.org/10.1007/978-3-319-66195-7_8

McKenney, S. & Reeves, T. C. (2018). *Conducting educational design research* (2nd ed.). Routledge. https://doi.org/10.4324/9781315105642

Nilsson, P., Schindler, M. & Bakker, A. (2018). The nature and use of theories in statistics education. In D. Ben-Zvi, K. Makar & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 359–386). Springer. https://doi.org/10.1007/978-3-319-66195-7_11

Oliveira, H. & Henriques, A. (2019). Teachers' perspectives about statistical reasoning: opportunities and challenges for its development. In G. Burrill & D. Ben-Zvi (Eds.), *Topics and trends in current statistics education research: international perspectives* (pp. 309–328). Springer. https://doi.org/10.1007/978-3-030-03472-6_14

Paparistodemou, E. & Meletiou-Mavrotheris, M. (2008). Developing young students' informal inference skills in data analysis. *Statistics Education Research Journal*, 7 (2), 83–106. https://doi.org/10.52041/serj.v7i2.471

Petocz, P., Reid, A. & Gal, I. (2018). Statistics education research. In D. Ben-Zvi, K. Makar & G. J. (Eds.), *International handbook of research in statistics education* (pp. 71–98). Springer. https://doi.org/10.1007/978-3-319-66195-7

Pfannkuch, M. (2005). Probability and statistical Inference: How can teachers enable learners to make the connection? In G. A. Jones (Ed.), *Exploring probability in school: challenges for teaching and learning* (pp. 267–294). Springer. https://doi.org/10.1007/0-387-24530-8_12

Ponte, J. P. da & Noll, J. (2018). Building capacity in statistics teacher education. In D. Ben-Zvi, K. Makar & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 433–456). Springer. https://doi.org/10.1007/978-3-319-66195-7_14

Pratt, D. & Ainley, J. (2008). Introducing the special issue on informal inferential reasoning. *Statistics Education Research Journal*, 7 (2), 3–4. https://doi.org/10.52041/serj.v7i2.466

Prediger, S., Bikner-Ahsbahs, A. & Arzarello, F. (2008). Networking strategies and methods for connecting theoretical approaches: first steps towards a conceptual framework. *ZDM*, 40 (2), 165–178. https://doi.org/10.1007/s11858-008-0086-z

Prediger, S., Roesken-Winter, B. & Leuders, T. (2019). Which research can support PD facilitators? Strategies for content-related PD research in the Three-tetrahedron model. *Journal of Mathematics Teacher Education*, 22 (4), 407–425. https://doi.org/10.1007/s10857-019-09434-3

Rossman, A. J. (2008). Reasoning about informal statistical inference: one statistician's view. *Statistics Education Research Journal*, 7 (2), 5–19. https://doi.org/10.52041/serj.v7i2.467

Runesson, U. (2006). What is it possible to learn? On variation as a necessary condition for learning. *Scandinavian Journal of Educational Research*, 50 (4), 397–410. https://doi.org/10.1080/00313830600823753

Shaughnessy, J. M. (2019, 5–10 may). *The Big Ideas in the statistics education of our students: Which ones are the biggest*? XV Inter-American Conference on Mathematics Education. https://conferencia.ciaem-redumate.org/index.php/xvciaem/xv/paper/viewFile/1091/603

Swedish National Agency for Education (2024). C*urriculum for compulsory school, preschool class and school-age educare – Lgr22*. Skolverket. https://www.skolverket.se/publikationer?id=12435

Vetten, A. de, Schoonenboom, J., Keijzer, R. & Oers, B. van (2019a). Pre-service primary school teachers' knowledge of informal statistical inference. *Journal of Mathematics Teacher Education*, 22(6), 639–661. https://doi.org/10.1007/s10857-018-9403-9

Vetten, A. de, Schoonenboom, J., Keijzer, R. & Oers, B. van (2019b). Pre-service teachers and informal statistical inference: exploring their reasoning during a growing samples activity. In G. Burrill & D. Ben-Zvi (Eds.), *Topics and trends in current statistics education research: international perspectives* (pp. 199–224). Springer. https://doi.org/10.1007/978-3-030-03472-6_9

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., 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. https://doi.org/10.1007/978-3-319-66195-7_4

Wild, C. J., Pfannkuch, M., Regan, M. & Horton, N. J. (2011). Towards more accessible conceptions of statistical inference. *Journal of the Royal Statistical Society Series A: Statistics in Society*, 174 (2), 247–295. https://doi.org/10.1111/j.1467-985X.2010.00678.x

Per Blomberg

Per Blomberg, PhD in Mathematics with a specialization in mathematics didactics, is a Lecturer at Malmö University, Sweden. His research centers on the didactics of statistics and modeling, with a particular focus on the teaching and learning of inferential statistics in compulsory education. He is also dedicated to advancing teacher education through educational design research.

per.blomberg@mau.se