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TWG05: Probability and statistics education

Introduction to the papers of TWG05: Probability and statistics education

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Overview

The working group gathered 30 participants from 15 countries. 22 papers and 4 posters were accepted.

The first session started with an ice-breaker activity. Firstly, the participants were asked to introduce themselves to a neighbor they had never met before. In a second time, each participant had to briefly present her/his colleague: her/his name, occupation, country and expectations about the working group. The cross-presentations made it possible to identify 3 main expectations. First researchers who attended TWG5 sought after constructive feedback on their work. Then they hoped to widen their point of view: gather new ideas, get informed of new trends, get to know better research works from other countries. The third main expectation was about networking: meet nice and smart people and develop possible collaborations.

The team of co-leaders had organized papers into 5 groups on 5 different topics. A session was devoted to each group and this session was managed and chaired by one of the co-leaders.

Teacher education (Aisling Leavy)

This session explored a broad spectrum of research in teacher education pertaining to statistics. The presentation by Artego, Diaz-Levicoy and Batanero reported on a study of the competence of 140 Chilean primary school students levels in reading pictograms. Frischemeier and Biehler reported on the development of statistical literacy and thinking in a statistics course for elementary preservice teachers. Negotiating the content and the teaching of statistics during teachers' professional development was the focus of the presentation by Bakogianni. The research reported by Gokce and Kazak examined middle school mathematics teachers' pedagogical content knowledge in relation to statistical reasoning. Afeltra, Mellone, Romano & Tortora reported on the results of a study designed to support teachers' interpretative abilities and use of errors as a didactic resource.

Discussion focused on the following guiding questions: What are the important understandings that teachers/students need to develop? What experiences can we provide to promote and develop teacher understanding? What considerations should we take into account when designing tasks to assess statistical understandings? In what ways might current knowledge frameworks limit/support the identification of teacher knowledge?

When discussing the important understandings and knowledge that teachers need to develop, there was acknowledgement of the limited experiences of pre-service teachers in statistics and the limited space it receives in teacher education courses. The greater recognition in teacher education of the dual role of content knowledge and pedagogical content knowledge was welcomed. In moving forward there was the recommendation of the need to support teachers in developing awareness of

the features of good tasks so they can design and modify their own tasks to ensure maximal learning benefit for children. When discussing the considerations that need to be taken into account when designing tasks to assess understandings/knowledge, there was agreement that it is difficult to assess teacher knowledge when we are not entirely sure what knowledge is important in order to teach statistics. Thus, there is the need for more research that elaborates what it is that teachers need to know in order to teach effectively in their classrooms. Finally, when discussing the ways in which we can promote and develop teacher understanding, there was discussion around the importance of acknowledging what makes statistics unique (from mathematics). Consensus was also reached on the importance of task design is drawing attention to conceptual understanding, on the usefulness of focusing on children's responses (both errors/misconceptions and correct responses) and on the use of collaborative feedback is useful in revising understandings about teaching and learning statistics.

Informal statistical inference (Caterina Primi)

Recently several researches effort are made to understand the informal ideas relating to statistics inference (ISI) as it is seen as having a potential to help build fundamental concepts that underlie formal statistic inference. Indeed, students can show complex ideas regarding statistical concepts (such as distribution, sampling) that can be seen as “precursor notions” of regular statistical concepts.

Four papers were presented on this topic. Leavy explores the informal inferential reasoning of primary students (5-6 years old). In Büscher's paper students' patterns of thought and the processes of their conventionalization are reconstructed in a qualitative study with students of grade 7 (12-14 years old). De Vetten shows the importance of preparing primary school teachers for teaching ISI, identifies learning goals for the teachers, and reports on an intervention study focusing on these learning goals. McLean's paper reports on students' modelling activities involving resampling process of bootstrapping.

In the final discussion emerged the importance of informal inferential reasoning in particularly how it should be promoted at every level (from early years upwards) as it is the beginning of access to a statistical cultural. Additionally, the group agree that Informal inference has an important socio-political contribution and may represent the first exposure to prediction and data-based inference. For this reason, the group has identified the need for national curricula and policy bodies to promote an emphasis on informal inference at the school level. As future directions, the group has identified the critical role of task design, language and technology in accessing understandings of inference, and finally the research of evidence of whether and how informal statistical inference improves the transition to formal statistical inference.

Probability and sampling (Sibel Kazak)

Four papers were presented and discussed in the subtheme of probability and sampling. The paper by Paparistodemou, Meletiou-Mavrotheris and Vasou report on young students' ideas of randomness and expressions of probability of an event when designing their own games with the use of Scratch software. Silvestre and Sanchez examine high school students' reasoning while engaging with the idea of sampling distribution and the estimations of likelihood of outcomes in repeated random sampling by using Fathom software. Elicer and Carrasco explore the use of a

sequence of tasks designed based on the framework of didactical engineering to introduce conditional probability as a decision-making tool. Eichler, Vogel and Böcherer-Linder describe and compare the use of different visualization tools, such as unit square, tree diagram and 2x2 table for visualizing Bayesian situations that involve conditional probability and Bayes' rule. In the general discussion based on these papers the following issues were raised:

- Use of 'uncertainty' term instead of 'probability' to emphasize the link between probability and statistics and informal inferential reasoning.
- Current trend in teaching probability topics in higher grade levels in school mathematics curricula in different countries.
- Mismatch between emergence of probabilistic ideas in young students and how the school mathematics curricula are designed. Lack of focus on subjective probability in school.
- Role of representations in conditional probability situations and in decision-making. It was noted that there is no ultimate representation but variety of choices for different purposes.
- The need for attending to cognitive and non-cognitive components of learning both for teachers and for students of all ages (elementary through to college level).
- How to design tasks or activities in game-based environments like Scratch that will foster the development of statistical/probabilistic reasoning. By over stipulating the environment we may lose the affordances that the environment provides (i.e. openness, creativity).
- Use of technology in task-design and challenges in implementating such tasks in classrooms.
- Research (future directions): More research on ways of thinking about what children can do and more focus on philosophical perspectives in research are needed.

Technology (Daniel Frischemeier)

This session explored in what ways technology can promote and develop statistical reasoning. In detail we got to know about the use of different technology tools like educational software, spreadsheets, online platforms (for distance learning), response tools, and programming tools in statistics education. Overall we have five papers in the session on technology.

Parzysz reports on the use of spreadsheets to teach probability and introduces learning environments for French High school students to learn about the binomial distribution with spreadsheet software like Excel and discusses the potential and limitations of using spreadsheets when simulating random experiments and when shifting from discrete to continuous distributions. Serpe and Frassia present teaching examples to enhance the discussion on the meaning and interpretation of probability for higher secondary school students in Italy. In detail Serpe and Frassia show ways to implement programming for simulating chance experiments and introduce specific tasks (e.g., airplane task). In the article of Tacoma, Drijvers and Boon the reader gets to know about the potential of feedback devices and response tools in statistics education. Their research aims how students' models can be used to generate feedback in an online course on statistical sampling. The paper of van Dijke-Droogers, Drijvers and Tolboom describes a study which investigates ways to enhance grade 8 students' statistical literacy through within-class differentiation. The study is framed in a design-based research project and interventions like Digital Mathematics Environments and digital tools are used. Finally, Meletiou-Mavrotheris,

Paparistodemou and Bayes describe an online course about statistical methods for post-graduate education majors and point out prospects and considerations of distance education.

Two fundamental issues have arisen in the discussion at the end of the session regarding the learning and teaching with technology in statistics education: design issues (task design and design of learning environments) and also the role of technology in teacher education. Regarding the first aspect “design issues” two fundamental questions have arisen in the discussion process of the whole TWG5: How to support learners in their use of technology? How to concentrate on the content rather than on technical issues of the tool? Regarding the second aspect “technology in teacher education”, the group agreed that teachers need a solid technological knowledge (technological pedagogical content knowledge, TPACK) to be able to implement and orchestrate technology in statistics classrooms successfully. As future directions in the field of technology in statistics education the group has identified the potential of web-based applications, mobile devices and online learning systems for the learning and teaching of statistics.

Varia (Corinne Hahn)

Five papers were gathered in a “varia” group as they covered issues that were not directly related to other subthemes. Arteaga and colleagues describe a large study carried out in Chile with 6th and 7th grades students. The aim of this study was to explore students’ competencies in reading pictograms. They report that the highest level they called “critical interpretation” is rarely reached by students. Gea and colleagues analyse correlation and regression problem situation in Spanish textbooks. Amazingly they report that there were very few problems with context. Trakulphadetkrai presents a qualitative study carried out with undergraduate students, with the aim of exploring how students learn statistical concepts through enactive story writing. Gonzales and Chitmun describe a socially open-ended problem in a sport related context and present the results of an exploratory study on the impact of one of these problems. Chiesi and Primi investigate how students’ attitudes changes during an introductory statistics course and discuss educational implications.

The general discussion at the end of this session focussed on the question of task design. We raised many questions, among which the following three have been particularly prominent:

- Can a problem be “real” or simply realistic or meaningful?
- What could be the most appropriate task for the statistic classroom: didactical situation, project work, inquiry-based activity, open problem?
- What is the role and impact of tools?

Conclusion

In this working group, we challenged current frameworks and perspectives on statistics education research and some important issues emerged from the discussions. The participants agreed that we need to know more about:

- uncertainty in IIR,
- theoretical frameworks / philosophical frameworks for research purposes,
- childrens’ naive conceptions and how to build on them.