Authentic practices as contexts for learning to draw conclusions from correlated data

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Drawing conclusions beyond the data

Many decisions in practical and professional situations involve drawing conclusions beyond the data at hand. One mostly combines contextual knowledge of such situations with the evidence of the data and uses a probabilistic language in making such decisions (Makar & Rubin, 2007). Comparing the data with expectations, hypotheses or statistical models can also be useful when drawing such conclusions (A. Bakker, Kent, Noss, & Hoyles, 2008) This implies that statistical inference – as defined by Makar and Rubin (2007) and Bakker et al. (2008) – is crucial in many situations, for example when monitoring dike heights, and hence deserves attention in statistics education.

Because of its relevance and lack of attention in school-level statistics education, many researchers have recently taken up the challenge of investigating types of inferential reasoning that primary and secondary school students as well as their teachers can engage with (Ben-Zvi, 2006; Pfannkuch, 2006). According to the SRTL-6 announcement, the studies presented at SRTL-5 pointed to the need of investigating the context of data and the use of evidence because it is not self-evident how to coordinate information of quantitative data with contextual knowledge as evidence in drawing valid conclusions.

In this paper proposal we focus on these two issues within the realm of statistical inference in the following way. The contexts of the data we are interested in are situations from authentic practices (refs). Our assumption is that students (grade 11, 16-17 years old) will then see the need of using particular statistical techniques such as regression. The question we intend to answer at the presentation is how students coordinate their knowledge of context and statistics in providing evidence for their conclusions about authentic problems. The authentic practices used as the sources of inspiration for the design of instruction are: the practice of sport instructors and physiotherapists, the practice of dike monitoring and calibration of measurement instruments.

Theoretical background

Apart from the recent literature on informal inferential reasoning, we also draw on activity theory and the literature on modelling. The use of authentic practices is inspired by Activity Theory (Leont'ev, 1978; Vygotskii, Rieber, & Carton, 1987). It describes society in terms of social practices as manifestations of activity which are connected to each other. Here an activity is defined as the engagement of a subject in pursuit of a certain goal or objective. The subject refers to the individual or group whose agency is chosen as the point of view in the analysis and the object refers to the 'raw material' or 'problem space' at which activity is directed and which is moulded and transformed into outcomes (Engeström, 1987).

When authentic practices are taken as the source of inspiration for design, it can be expected that students get a better view of those authentic practices and are more motivated to learn because they experience more utility of what they learn in reaching particular goals. If the unit based on authentic practices is designed well, it might give students access to a network of concepts, methods and situations of which they probably have rudimentary prior knowledge that they can build upon. As (Newmann & Wehlage, 1993, p. 10) observes, ‘A lesson gains in authenticity the more there is a connection to the larger social context within which students live’.

However, authentic practices are not immediately suitable for the implementation to educational contexts, hence adaptations are required (Prins, Bulte, Van Driel, & Pilot, 2008; Westbroek, Klaassen, Bulte, & Pilot, 2005). Moreover, an instructional unit of them has other objectives than the authentic practice: the main goal of an instructional unit is to *learn* something.

Statistical Modelling

Making sense of real-life situations often requires some form of modelling (Lesh & Zawojewski, 2007). We adopt a definition by Izsák (2004): *Mathematical modelling consists of (a) examining various attributes of a particular mathematical, physical, or social context; (b) relating a subset of those attributes through arithmetic operations, functions, or other mathematical structures; and (c) using resulting representations to solve problems.* For this study we have chosen authentic scientific practices as the basis for instructional materials designed to support students’ learning about statistical modelling (correlation and regression).

We expect that the focus on regression in such contexts will provide us with additional insight into statistical inference. For example, when monitoring dikes – crucial because almost half our country lies below sea level – one has to predict based on trends and variation when particular measures are required. In terms of the key characteristics of statistical inference as defined by Makar and Rubin (2007) and Bakker et al. (2008) such situations require inferential reasoning: using measurement data as *evidence* and *probabilistic* language, one has to *generalise* beyond the current data set to possible future situations. This prediction requires not only a statistical *model* such as regression but also contextual knowledge about variation caused by water height fluctuation and measurement error.

Methods

Because the design of instructional materials is an important part of the research, we have chosen design experiments as the main method (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Cobb, McClain, & Gravemeijer, 2003). A core research instrument is the ‘hypothetical learning trajectory’ (A Bakker, 2004), which is the link between educational theory and the teaching experiment; it consists of conjectures about students’ prior knowledge, the final learning goal and a series of learning.

First literature was reviewed and researchers and teachers approached to find a suitable first authentic practice. This led to two possibilities, which were tested with two students to enable a choice for which one to use. In the educational version of the authentic practice students do a small experiment as an introduction to modelling to experience the steps needed. This small experiment must evoke the motive for statistical modelling.

In the second phase the students will work on the problem of dike height monitoring and prediction to learn statistical modelling in a more formal way. Technical tools like TI-Nspire and Excel will be used for performing and understanding the method of least squares and regression. We intend to focus our presentation on this second phase to investigate how students do rely on and use evidence in making arguments. In the last phase, based on the authentic practice of instrument calibration, the students can apply what they have learned in a new context.

The first teaching experiment runs from December 2008 to January 2009, the second from January to February. The first author is teaching in the first experiment and observing in the second.

To monitor students' learning processes, their contributions will be observed and recorded (audio and video). Data collection further includes student work, interviews, questionnaires and tests. In the analyses, the observations will be compared with the predictions from the HLT, which will lead to a revision of the materials and improvement of the theoretical and empirical foundations.

We expect that our experiences in the two teaching experiments will also provide us with material to discuss other themes of the conference: the role of context and tools in IIR, but also a series of instructional activities that were designed to support students' inferential reasoning about and beyond correlated data.

Literature

Bakker, A. (2004). *Design research in statistics education: On symbolizing and computer tools.* Utrecht, the netherlands: CD-Bèta Press.

Bakker, A., Kent, P., Noss, R., & Hoyles, C. (2008). *Using technology-enhanced boundary objects to develop techno-mathematical literacies in manufacturing industry.* Paper presented at the International Conference of the Learning Sciences Utrecht.

Ben-Zvi, D. (2006). *Scaffolding students' informal inference and argumentation.* Paper presented at the ICOTS-7, Auckland.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher, 32*(1), 9-13.

Cobb, P., McClain, K., & Gravemeijer, K. (2003). Learning about Statistical Covariation. *Cognition and Instruction, 21*(1), 1.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.

Izsak, A. (2004). Students' Coordination of Knowledge When Learning to Model Physical Situations. *Cognition and Instruction, 22*(1), 81-128.

Leont'ev, A. N. (1978). *Activity, consciousness, and personality*. Englewood Cliffs, N.J.: Prentice-Hall.

Lesh, R., & Zawojewski, J. (2007). Problem solving and modeling. In *Second handbook of research on mathematics teaching and learning a project of the National Council of Teachers of Mathematics* (pp. 763-804). Charlotte, NC: Information Age Publishing.

Makar, K., & Rubin, A. (2007). *Beyond the bar graph: Teaching informal statistical inference in primary school.* Paper presented at the SRTL-5, Warwick.

Newmann, F. M., & Wehlage, G. G. (1993). Five standards of authentic instruction. *Educational Leadership, 50*(7), 8.

Pfannkuch, M. (2006). *Informal Inferential Reasoning* Paper presented at the ICOTS-7, Auckland.

Prins, G. T., Bulte, A., Van Driel, J. H., & Pilot, A. (2008). Selection of authentic modelling practices as contexts for chemistry education. *International Journal of Science Education.*

Vygotskii, L. S., Rieber, R. W., & Carton, A. S. (1987). *The collected works of L.S. Vygotsky*. New York: Plenum Press.
Westbroek, H. B., Klaassen, K., Bulte, A., & Pilot, A. (2005). Characteristics of meaningful chemistry education. *Research And the Quality of Science Education*.