Inferentialism – a social pragmatic perspective on conceptual teaching and understanding in mathematics

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In the symposium, we will discuss the perspective that *Inferentialism* (Brandom, 1994; 2000) offers on conceptual teaching and understanding in mathematics. Brandom criticizes the representationalist way to view knowledge as mental (object-like) representations, which are assumed to be more or less correct representations of objects in an extern reality (Bakhurst, 2011). A representationalist view implies a "topic-by-topic approach" for teaching in which concepts and calculation procedures are taught atomistically. It implies the idea of knowledge growth as a linear enterprise where teachers must initially define some basic concepts in order to be able to gradually introduce additional elements. It is also assumed that once students have learned the definitions and procedures, they will be able to solve mathematical tasks by applying what they have learned (Bakker & Derry, 2011). Our hypothesis is that teaching and understanding of mathematics benefit from reconceptualizing knowledge as inferentialist; instead of considering conceptual understanding to be fundamentally keyed on mental states of representations, it is proposed that knowledge is primitively an ability, the ability to navigate in the *web of reasons* (Brandom, 2000; Bakhurst, 2011).

Inferentialism demonstrates that grasping a concept is an activity that involves commitment to the inferences implicit in its use in a practice of giving and asking for reasons (Bakker & Derry, 2011).

> To grasp or understand [...] a concept is to have practical mastery over the inferences it is involved in – to know, in the practical sense of being able to distinguish, what follows from the applicability of a concept, and what it follows from. (Brandom, 2000, p. 48)

Brandom illustrates this inferentialist perspective on conceptual understanding by comparing the human responsiveness to the responsiveness of a thermostat. Brandom (2000, p. 162) asks:

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> What is the knower able to *do* that [...] the thermostat cannot? After all they may respond differentially to *just* the same range of stimuli [...]

Brandom's answer to this is that, in contrast to the thermostat, the knower is not only responsive to external stimuli. The knower, the concept user, is responsive to reasons, the knower is moved by its ability to search for reasons and follow reasons:

> The knower has the practical know-how to situate that response in a network of inferential relations – to tell what follows from something being [...] cold, what would be evidence for it, what would be incompatible with it, and so on. (Brandom, 2000, p. 162).

Humans understand why they turn on the heating, whereas the thermostat does not. Following this line of reason, Bakker and Derry (2011) point out the significance for education. In education, students are not supposed to only show right reactions on certain stimuli. Instead, they are supposed to know reasons, to understand what they are doing, and become intelligent concept users.

Privileging Inferentialism over Representationalism does not diminish the importance of representation, because evidently "there is an important representational dimension to concept use" (Brandom, 2000, p. 28). However, the meaning of representations is not pre-given. Representations gain their meaning in their role in reasoning. Representations, as is the case with concepts in general, should be distinguished and understood precisely by their inferential articulation, that is, in terms of the conditions under which one is justified in using the concepts and aware of the consequences of accepting them.

Conceptual holism becomes a direct consequence of conceptualizing the conceptual on behalf of reasoning:

> [...] grasping a concept involves mastering the properties of inferential moves that connect it to many other concepts: those whose applicability follows from the applicability of the concept in question, those from whose applicability the applicability of the target concept follows, those whose applicability precludes or is precluded by it. (Brandom, 1994, p. 89).

Brandom (1994) introduces the term "web of reasons" as a metaphor of this holistic view of understanding. Webs of reasons are social in nature. Responsiveness to reasons allows our actions and claims to be constrained by norms or rules rather than simply by nature. On this account, webs of reasons are cast in the social *game of giving and asking for reasons* (GoGAR) (Bakhurst, 2011) where a move in GoGAR "can justify other moves, be justified by still others, and that closes off or precludes still other moves" (Brandom, 2000, p. 162).

By accounting for how students contribute to the game of giving and asking for reasons, we are not only provided an instrument by which we can account for students' conceptual understanding in light of having practical mastery over the inferences constitutive for the web of reasons (Bransen, 2002). We are also provided an instrument by which we can discern individual differences in how students participate in and contribute to mathematical reasoning in the classroom.

Research projects

In the symposium, we will present and discuss three research projects that use Inferentialism as theoretical frame for conceptualizing learning and teaching mathematics. Per Nilsson presents a project, which aims at characterizing qualities in teaching mathematics for understanding by giving account of the inferences explicit or implicit in the social game of giving and asking for reasons. The project presented by Maike Schindler focuses on collaborative communication in students' inquiry-based group work. The analysis illustrates how meaning making occurs in collaborative communication, in which students show joint efforts in their meaning making. In the third presentation, Abdel Seidou connects GoGAR to experimentation-based teaching of the statistic concept *correlation*.

Mathematics, teaching and understanding – analysing the game of giving and asking for reasons in a classroom mathematical practice

(Per Nilsson)

Recent mathematics education reforms call for the instantiation of mathematics classroom environments where students have opportunities to develop their understandings in communicative and interactive classrooms (Staples, 2007 Hufferd-Ackles, Fuson & Sherin, 2004). This paper reports on how analytical constructs of Inferentialism (Brandom, 2000) can be used to account for teaching mathematics for understanding in whole-class discussion, which is based on students' group work.

In Inferentialism, conceptual meaning is tightly connected to patterns and norms of interaction. To give meaning to and to understand a concept is to account for how the concept is inferentially endorsed and used in the interactive game of giving and asking for reasons (Brandom, 2000).

Aim of study

The aim of the present paper is to characterize qualities in teaching mathematics for understanding by giving account of the inferences explicit or implicit in the social game of giving and asking for reasons.

Method

The data analysed in this study was gathered from a grade 6 (12–13 years old) classroom in Sweden. The episode that is analysed follows from group-work in which the students was discussing the task in figure 1.

How big part of the figure is dark? Write down two different fractions.

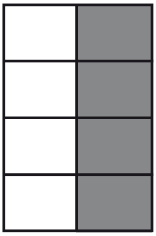

Figure 1. *The task*

The teacher of the class led the whole-class discussion. Moved by the game of giving and asking for reasons, the class develops inferential patterns related to the mathematical idea of *equivalent fractions*.

Collaborative meaning–making in inquiry–based learning: implications from Inferentialism

(Maike Schindler)

Inquiry-based learning (IBL) has generated much interest in mathematics education research (e.g. Pehkonen, 1997; Maaß & Artigue, 2013; Artigue & Blomhøj, 2013). With the project *Meaning–making in collaborative communication* (M2C2) I contribute to these efforts.

Based on Inferentialism (Brandom, 1994, 2000; Bakker & Derry, 2011) as background theory, I developed an analytical framework, which serves to evaluate group communication in mathematics according to the specific requirements in IBL practices: Collaborative communication, in which students make joint efforts in approaching problems and sharing ideas, is the focus of this study (Schindler, 2015).

In this paper, I present how the framework was used for analyzing collaborative meaning–making in an empirical study with students in upper secondary school; in a project, which addressed mathematically interested students from a Swedish gymnasium. In so-called *kreativa matteträffar*, which took place at the university, the students worked cooperatively on mathematical problems that were based on the ideas of Realistic mathematics education (RME, e.g. Gravemeijer & Bakker, 2006) and IBL.

The data analysis focuses on their collaborative meaning–making activities, in which they inquire and negotiate the mathematical content. I will present what factors contribute to students' collaborative meaning–making in IBL.

Aim of study and research questions

The present paper focuses on the questions: How does meaning–making occur in students' collaborative communication in IBL group work? What factors contribute to collaborative meaning–making in IBL?

Developing a local instruction theory for the learning of correlation in statistics – results and implications of a pilot study

(Abdel Seidou)

The present paper is a part of a larger project aiming at developing a Local instructional theory (LIT) (Gravemeijer, 2004) for the learning of statistical correlations. In this paper, we report on the results and implications of a pilot study.

The construction of the LIT builds on a *content dimension*, related to products and processes associated with statistical correlation; a *teaching dimension*, stressing collaborative teaching and students' experimentation with data and a *knowledge and learning perspective*, connected to the theory of Inferentialism and, particularly, to the *game of giving and asking for reason* (GoGAR) (Brandom, 1994; 2000).

Presentation and future research

During the symposium, we first present the results and implications of the pilot study indicating how discursive and organizational aspects of the task formulation and the activity setup affect how the concept of correlation come into

Figure 2. *Local instructional theory*

play in the GoGAR. For instance, the formulation of the task's question: "*how* sure are you?" prompted students to a numerical answer without further elaboration, resulting in GoGAR poor of content related to correlation. Second, we set forth the set-up of the next step of the project. Based on the lessons learnt from the pilot study, the next step is to develop and conduct an empirical study based on the general principles of Design Experiment in educational research (Cobb, et al., 2003).

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