

# Agency as a tool in design research collaborations

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*The aim in this paper is to shed light on interactional aspects of researcher and practitioner collaboration in design research in mathematics education. Symbolic interactionism is used to gain understanding of interactional aspects as it has potential to take both individual and social aspects of the interaction into account. Aims and agencies are in focus of the retrospective analysis of the collaboration between two researchers and two practitioners as they collaborate to develop instructional design. The analysis shows how referring to authoritative disciplines as the mathematics community influence agency and therefore has great potential to influence how the negotiation of meaning progresses and participants act. I argue that agency could be viewed as an indirect tool that has the potential to direct the collaboration when designing tasks based on what aim different actors put in the foreground.*

*Keywords: Collaboration, agency, interaction, design research.*

## **Introduction**

Collaboration is at the core of design research in mathematics education. A key characteristic is that it is research conducted with researchers and practitioners in real-world settings (Plomp, 2013). This collaboration is often between one or more researchers and practicing teachers. It is essential that this team collectively has the competence to develop the design, conduct the lessons, and perform the retrospective analysis (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). This means that we have different actors in the activity, each with its interpretation of the aim and purpose, as well as of the actual activity and the mathematics involved. Since each actor has a specific set of competences and a vital role to play in the collaboration to develop the design, the question is how their differences influence the discussions during meetings and by extension the design? McClain (2011) explores this interplay of differences in the classroom interaction between students who performed the resulting tasks and the teacher who orchestrated the discussions. She views it as interplay between the students' contribution, the task and what she calls the proactive role of the teacher. One key aspect of the interplay is where the authority over the topic, the agency, lies. Agency is thought of as a capacity to act in social interaction. She emphasizes that it is important for students' learning that agency shifts between different actors in the activity.

The discussion in this paper focuses on the developing phases of design research. How does this shifting of agency that McClain (2011) identifies in the design research classroom appear in the development of tasks in between lessons? The aim of this paper is to further understand how the aim and agency fluctuate between the participants and its influence on how the negotiation develops as researchers and teachers collaborate to develop instructional design. Results could be viewed as a contribution to the mathematics design research methodology discourse of how collaboration between researchers and practitioners can support the design process.

## Previous research

Design research in mathematics education is described as a research design that is interventionist; iterative; process, utility and theory oriented; and has involvement of practitioners (Plomp, 2013). The idea is to develop tasks and activities, test them in real classrooms, evaluate the outcomes and then revise the design in an iterative process involving practitioners from the field. All in all, the research design enables the team to pursue multiple goals in the same project. The aim is to understand the processes involved in utilizing the developed tasks, design usable material for users in real life context and lastly to contribute to theory building. Plomp (2013) calls it the twofold yield of design research, producing both research-based intervention and knowledge about interventions in the form of theory.

Beside the global aims of design research, an intention to develop theories and instructional designs, there are local aims as well. The instructional design has an aim, an intention to stimulate learning, in form of a hypothesised learning process and goal for the subjects (Cobb et al., 2003). The so-called Hypothetical learning trajectory (HLT) is defined by Simon (1995) as follows:

The hypothetical learning trajectory is made up of three components: the learning goal that defines the direction, the learning activities, and the hypothetical learning process – a prediction of how the students' thinking and understanding will evolve in the context of the learning activities. (p. 136)

Cobb (1999) argues that the learning goal of a HLT should be from a group perspective rather than an individual one. Simon (1995) amongst others talk about a prediction of individual learning processes and thinking whereas Cobb (1999) call this line of thinking highly idealized at best. Instead, he proposes a focus on collective mathematical development in the classroom community. A HLT then consists of an “envisioned sequence of classroom mathematical practices together with conjectures about the means of supporting their evolution from prior practices” (p. 9).

Global and local aims are both individual interpretations as well as objects for the research team to negotiate. In this paper, it is assumed that this process is that of a social interaction within the team and interaction is described with the theoretical background of symbolic interactionism (Blumer, 1986). It proposes that humans act according to the meaning that objects have to them and that the meaning of objects arise out of social interaction. This is an interpretative process where humans constantly interpret others actions and the meanings they indicate before acting themselves (Blumer, 1986). It means that participants of the research team interact according to how they interpret the local aim of the design as well as their own global aims and interpretations of the mathematics in question. Voigt (1994) calls this the negotiation of meaning in the mathematics education context. It is a negotiation because the actors contribute to a discussion based on their interpretation of what is being discussed and at the same time re-evaluate their own understanding, thus creating a negotiation of what is viewed as the community's meaning of the objects.

As global and local aims and the design itself are negotiated, participants position themselves through their contribution to the negotiation. Burr (2003) talks of the capacity to take up positions for one's own purposes and that agency lies in responsive actions in interaction. In the mathematics classroom context, McClain, Zhao, Visnovska, and Bowen (2011) defines agency as “authority over

both the mathematics being taught and the sequencing and presentation of that content” (p. 63). Combined, they frame the agency concept for this paper. As the participants of a research team interact in the development of the design, they act according to their interpretations and their positioning in a community, for example as a representative for the mathematical community, and act with the authority of that discipline. It is also possible for one to act according to different agencies as fits one’s purposes, also known as the dance of agency (Pickering, 1995). As the negotiation progress, agency shift between the participants and within them. Shifting agency enables the participants to contribute in different ways and from multiple perspectives, for example as mathematicians, practitioners or researchers. The result is an effect on the design of the HLT in line with different actors’ fluctuating aims and their agency to contribute according to those aims.

## **Method**

The data used here is generated from video recordings of a small-scale teaching experiment involving probability with students from year 5 and 6 in a Swedish elementary school. The aim of the task was for the students to become able to discuss matters of relative frequency data and the law of large numbers in a probability context. Relative frequency is a way of analysing data from repeated random events, such as flipping a coin, where the number of observations of each outcome is divided by the total number of events. The law of large numbers then states that as the sample size increases, the likelihood of a difference between the relative frequency and the actual probability of the event decrease. Thus, can the relative frequency be used as a measure of probability. The research team consisted of the author of this paper, a senior researcher (here called Paul) and two teachers (here called Karen and Tilly). The whole process was initiated by the two teachers who felt that they needed inspiration and experience in teaching probability, which they had never done before. The balance of numbers provided a sense of balance between researchers and teachers, which later has been recognized by Stephan (2015) to be an important factor to highlight teachers’ unique knowledge in design research collaborations. The work was organized as such that after an introductory meeting, the two researchers drafted a design proposal in line with the requested topic. That design was further developed by a discussion within the team, which was video recorded, and then initiated by one of the teachers in the classroom. Minor adjustments were carried out between the two teachers’ lessons and major changes of the lesson sequence were carried out after both teachers had used each lesson plan. A total of 5 lessons were designed although one of the teachers divided the last lesson into two because of time management issues.

### **The activity and hypothetical learning trajectory**

The task design originated from a teaching experiment by Brousseau, Brousseau, and Warfield (2001), where the students were asked to investigate a chance event with an unknown sample space. The aim was to introduce basic principles of the Law of large numbers from probability as well as a frequency perspective on probability theory. We used an opaque soda bottle containing an unknown amount of small coloured balls (neither the students nor the teachers knew the content of the bottles) during the first lesson. When the bottle was turned over, the colour of one ball was revealed while remaining inside the bottle. Thus, creating a constant but unknown sample space. The activity was presented as a race in the first lesson with three contestants on a six-step track. As one of the three

colours were observed on a bottle turn, that colour advanced one step down the track. The students were asked to guess which colour would first get six observations during each race. Based on the topics discussed by the students in the first lessons, the following three lessons made use of a transparent bottle with a visible sample space. Here the students were asked to discuss chance, random variation, sample space, sampling and the law of large numbers. The importance of the sample space was highlighted in the second lesson because of ideas discussed in the first lesson. The students got to return to the opaque bottle in the last lesson(s) and again, in an organized manner, investigate the unknown sample space from the first lesson with the use of the law of large numbers. By producing a large enough sample, they could reason about the sample space in the opaque bottle by translating the relative frequency of each outcome into the probability of that outcome. Overall, one class needed a total of five lessons and the other class six lessons, to reach an agreement about the unknown sample space in the opaque bottle.

### **Method of analysis**

The analysis of the transcript in the forthcoming section is inspired by retrospective analysis from the design research methodology. It is based on open inquiry and constant comparison (Glaser & Strauss, 1967) where you retrospectively analyse and compare small instances of data from the whole set with one another to gain insights into the processes (Gravemeijer & Cobb, 2013). Trustworthy accounts of possible meanings can be developed by immersing oneself in the social setting, using participant observation, alongside systematic coding of data in retrospective analysis (Cobb, Stephan, McClain, & Gravemeijer, 2001). Instances of active contribution to the negotiation, utterances by the teachers or researchers, are coded with in-vivo codes. These instances are then compared to each other to find differences and similarities in their actions as they indicate the participant's interpretations, aims and agency. When looking at longer sequences, patterns are sought after, especially how participants' aims and agency influence the development of the negotiation. Short excerpts used for constant comparisons are presented in the text and expanded upon. Tied to those excerpts are expansions on the continuing interactions not shown in the transcripts due to space limitations.

### **Results**

The excerpts from the transcripts presented here are all from a meeting with the two researchers and the two teachers between Karen's first lesson and Tilly's first. The purpose was to engage in a mini-cycle to evaluate the initial design and revise it before Tilly used it in her classroom. One of the researchers, the author of this paper, was present during Karen's lesson and the discussion utilized their experiences as a main source of data to analyse. In the first episode, the two teachers discuss Karen's experience during the first lesson. She had asked the students to reflect on the notions statistics, chance and probability at the beginning of the lesson and then proceeded to carry out the design outlined here in an earlier section. Notice how the focus shifts from being about implicit aspects of the activity to being about students connecting knowledge.

Karen:           What fascinated me was that their engagement induced the use of the concepts that we highlighted and reconnected to what we did at the beginning. Statistics, chance and probability, well, that Kim said "This is what I think! Statistics is what

we're doing, and the balls drop by chance but you may still calculate the probability". He started...

Tilly: He added that, you didn't guide him?

Karen: No, he was like "This is what I think, I figured out this with statistics". So, it kind of extracted their knowledge.

Tilly: They latched on on the correct incident somehow.

Karen: Exactly, and they could use the concepts to describe it, what we had done.

Tilly: Mm

Karen acts with an interest in the activity as an eliciting factor for student's development of concepts. Tilly indicates that she is interested in how Karen carried out the activity in the classroom and both act as if their main aim is to further develop the task. Tilly then subtly indicates that she has shifted her focus towards the students' learning process in the second utterance. She acts as if her interpretation of the aim has shifted towards the global aim of contributing to theory on students learning processes. The negotiation takes off in another direction, initially being about gaining understanding of the design aspect towards being about understanding aspects of learning. The global aim of understanding the students' learning in respect of making connections as well as developing language is pursued long after this extract ends. The following episode picks up this chain of events a bit further into the meeting. Karen admits that the development of the lesson had made her unsure of how she interpreted the three concepts statistics, chance and probability. We start off with her reading her own notes from what she found out from a dictionary after the lesson. Note from where Karen and Paul finds authority for their claims and questions.

Karen: "Not be able to calculate in advance. Statistics, summarization of information, nah, Probability, the chances of getting" for example blue.

Paul: So what it becomes, Heads or Tails, aren't known in advance. Is that what you mean?

Tilly: Why did you pose that question like that? What were you thinking? Since you do this professionally... Why did you ask that question?

Paul: Well, because I thought the sentence was incomplete. "we calculate in advance", I just wanted to emphasise ... what is it we can't calculate in advance?

Tilly: Aaa, okay

The initial statement was copied from a dictionary and Karen acts as if she trusts and places the authority within that community. At least in the case of chance and probability, she relies on the dictionary and achieves agency with the use of it. The group's prior negotiation of meaning of statistics makes her less confident in the case of statistics, she indicates that she gives primacy to the group's interpretation. Paul questions this authority altogether. Tilly seems to pick up on Paul's questioning and probes the nature of Paul's agency; is he acting from a mathematics education researcher perspective, or a mathematical community perspective or something else? Paul continues by acting as if there are better interpretations of these concepts by questioning the wordings. He

later on continues to negotiate the meaning of these concepts by means of examples and more mathematically precise definitions and thereby achieves agency by referring to the mathematical community. This exchange impacts the negotiation towards being even more focused on language. It also becomes apparent that Paul's agency influences how Karen and Tilly use technical terms in the remainder of the session. Paul's aims and agencies remain in focus as they are given more space and remain unquestioned as the work progress. The following episode is from the later parts of the meeting. It shows the impact of Karen's and Tilly's interaction in the first episode regarding the topic but also how Paul is left as an authority. Notice how Paul remains unopposed even though his claims and sentences are incomplete just as Karen's were in the previous episode.

Paul: My question about statistics springs from that fact that statistics is a rather large subject... A large topic so to speak

Karen: Mm

Paul: And I think that the curriculum sort of... Even in our ... our curriculum contains what this student is saying about the ratings of a TV-show. That you compare... often just think about observations, or we usually say frequencies, frequency tables and so on, so you limit the whole field of statistics to what one might call data collection, frequencies and such.

Tilly: Mm

Paul: What do you think, we could think about beginning to establish this type of concepts like... What is the frequency of blue? What is the frequency... How many observations of blue? How many observations of red? So, you insert this type of technical terms to become more precise. Specify a little bit more. That is, I imagine, a part of learning, that you learn to... You use a language and start to become a little bit more precise.

Paul acts as if he wants to shift focus to the local aim of the activity. He offers an alternative, or additional, learning goal in students developing their language through the activity. He pushes his agenda by referring to the authoritative mathematical community and therefore achieving agency. Both Karen and Tilly accept Paul's agency and leave his claims unopposed and instead adjust their use of language after the episode to fit Paul's. Paul's agency also results in a shift of focus in the following interaction. The continuing negotiation still involves interpretations of language but also aspects of the design and how language development can be anticipated and sequenced in a HLT.

To sum up the analysis, I exemplify how rearranging the aims of the activity, placing the aim of understanding students' learning in the foreground instead of the aim to develop the design, can have huge impacts on the course of the developmental process. Karen's and Tilly's interaction in the first extract refocused much of the remaining discussion towards negotiating the meaning of language use and development. An example of the dance of agency in designing educational activities has also been offered. Especially how some agency has higher authority and thus also more impact on the negotiation process.

## **Discussion**

Shifts of agency emerged in the presented episodes. Karen and Tilly both seemed to mostly rely on personal agencies in their actions, trusting in their professional experience in teaching for learning and language development. Paul on the other hand was perceived to rely on agency achieved from highly regarded disciplines as the mathematics and mathematics education research communities when he contributes with examples and language. It corresponds with results from when Pickering (1995) studied mathematicians in their work. He saw that mathematicians often relied on their personal agency as they created initial ideas but “surrendered” to that of the discipline, as they needed to resort to following standard procedures of (for example) proofs. Similar phenomenon was observed in the episodes. Karen and Tilly relied on their personal agency until Paul referred to the mathematics community; Karen and Tilly then surrendered to the formalized language of the discipline to a greater extent. Further on it resulted in worksheets handed to the students using this formalized language and thus re-evaluating the HLT in light of formal use of concepts. I suggest that it emphasizes how the dance of agency (Pickering, 1995) is a principle to regard in collaboration between researchers and practitioners as it has the potential to be an indirect tool to guide the negotiation process in different directions.

Shifts in aims emerged in the data. Karen initially acts in line with the global aim of developing aspects of the design but soon shifts to align with Tilly to negotiate the meaning of student’s language development. Paul later uses the mathematics community to achieve agency to shift focus towards developing the design once again. Blumer (1986) argues that not only individual aims should be regarded but also that of the group. When multiple actors interact over a period of time a joint action is formed. It is a social construct that extends from being merely the sum of all actions, for example it also has its own aim that is negotiated by its participants. One might look at Karen’s, Tilly’s and Paul’s shifts in aims as attempts to negotiate what aim should be in focus or in the foreground while the others remain in the background. It becomes apparent in the topics discussed that the negotiation of aims for the joint action has impact. In the extended data, patterns emerge of how shifts in the joint aim redirect the following interaction until it was renegotiated. The result was an added activity in the HLT that was meant to challenge students’ ideas of chance. Reasons for why the participants chose to contribute in this way did not emerge from the existing data but one could speculate whether it has something to do with the respective role of the actors, being from a tradition of research or education. It presents a way forward to further advance our insight in the collaboration between researchers and practitioners in design research in mathematics education.

## **Implications**

As Stephan (2015) highlights the importance of working with small groups of teachers instead of just one in design research collaborations, the dance of agency is yet another tool to create purposeful design research collaborations. In the case of Paul, agency is used to steer the negotiation of meaning towards more mathematically aligned use of vocabulary. In another setting, it is possible to rely on shifting agencies to empower teachers in the collaboration by placing it in the domain of mathematics teachers. There is also the possibility to put focus on the research agenda when discussions tend to steer away. One could also consider the interpretation that it has the potential to

shift the power relations, creating an (even bigger?) imbalance between participants, making participants less likely to make substantial contributions to the development of the task. The conclusion is that conscious achievement of agency can be used as a tool for researchers in design research collaborations to manoeuvre the discussion and shape the HLT to fulfil different aims.

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