PPELEM: A "Creative" Interviewing Procedure for Gaining Insights into Teacher and Student Mathematics-related Beliefs

Andrea McDonough
Australian Catholic University
<andrea.mcdonough@acu.edu.au>

Sarah Ferguson
Clairvaux Catholic school
<sferguson@ccsbelmont.catholic.edu.au>

This paper draws on two studies, one conducted by each author, where procedures for gaining insights into people's beliefs about mathematics and learning were developed or adapted for use by the researcher. In this paper we discuss the use in each study of variations of the procedure called *Pupil Perceptions of Effective Learning Environments in Mathematics* (PPELEM). The paper demonstrates the flexibility of PPELEM as a data collection tool and shows that, even with a large age difference of respondents, the procedure can be used as a prompt for both adults and primary school children and provides insights into beliefs.

Beliefs teachers hold about mathematics influence the ways in which they teach mathematics in the classroom (e.g., Thompson, 1992). Similarly, each student holds beliefs about mathematics that "directs her or his actions and subsequent learning" (Lester, 2002, p. 351). In light of the general stability of beliefs (McLeod, 1992; Pajares, 1992) and that beliefs can impact upon motivation and actions (Kloosterman, 2002; Lester, 2002;), it can be valuable for educators to research and develop an increased awareness of the beliefs held by learners and teachers of mathematics. However, gaining insights into the beliefs of teachers and students is complex. Generally researchers rely on either observation or participants self-reporting their beliefs via a traditional interview. Inferring beliefs based only on observation is difficult as it is complex to discern an "internal private belief from external behavior alone" (Solomon & Grimley, 2011, p. 694). Similarly, traditional interviews can be problematic if participants do not have fully formed beliefs about the subject in question, hold simultaneously conflicting beliefs (Thompson, 1992), or lack the reflection or articulation skills to accurately express their beliefs verbally.

In this paper we describe the use of adaptations of the procedure called *Pupil Perceptions of Effective Learning Environments in Mathematics* (PPELEM), which might be described as a "creative" (Patton, 2002, p. 394) interviewing tool. We review data from two studies, one conducted by each of the authors. Our focus is to investigate the question of whether variations of PPELEM are suitable for gathering data on the beliefs of both children and adults, and for prompting further discussion of those beliefs.

Background

The Nature of Beliefs

Beliefs are difficult to define and, indeed, Pajares (2002) stated that,

> defining beliefs is at best a game of player's choice. They travel in disguise and often under alias– attitudes, values, judgements, … perceptions, conceptions, … perspectives, repertoires of understanding, … to name but a few that can be found in the literature. (p. 309)

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Beliefs are an individual construct that, from an epistemological perspective, differs from knowledge, a primarily social construct (Op ’t Eynde, De Corte, & Verschaffel, 2002). A person’s beliefs are held in clusters or groups within a belief system (Green, 1971), with the latter composed of beliefs, both conscious and unconscious, along with hypotheses and expectations (Furinghetti & Pehkonen, 2002). The literature also suggests that espoused beliefs can often differ from practice. For example, Sullivan and Mousley (2001) argued that context could constrain beliefs becoming enacted in practice. Thompson (1992) also suggested that teachers could hold conflicting beliefs simultaneously. Op ’t Eynde et al. (2002) presented a framework of students’ mathematics-related beliefs in which they identified three dimensions. These are: beliefs about mathematics education, including the nature of mathematics, mathematics learning, and mathematics teaching in general; beliefs about the self, including self-efficacy and goal orientation; and beliefs about the social context, that is, social norms including the role and functioning of the teacher and students in their own class, and socio-mathematical norms in their class.

“Creative” Interviewing

Insights into student and teacher beliefs can be elicited in many ways. For example, Patton (2002) described a range of creative modes of inquiry for use within qualitative research including the use of “projection techniques” (p. 394) such as stories, photographs, drawings, abstract paintings or cartoons to prompt or provoke discussion. Likewise, there is evidence in the mathematics education literature that teachers and students can express their beliefs about factors related to mathematics and learning in a range of ways including questionnaires, commonly used by a range of researchers in studies on beliefs (Di Martino & Zan, 2011), and drawings (e.g., MacDonald, 2010). According to Woleck (2001), “drawing brings ideas to the surface” (p. 215) and is a particularly powerful way for young children to express meaning. MacDonald (2010) used drawings to elicit what children of 4 to 6 years understood about concepts such as heavy and light. However, she stressed the value of children talking about their drawings for more accurate interpretation by the researcher. Solomon and Grimley (2011) used a drawing task to elicit beliefs of 185 Year 5 and 6 students about mathematics and themselves as mathematics learners. This task asked students to draw “what maths or doing maths means to you” (p. 696). Solomon and Grimley found that 67 percent of students drew a metaphor for mathematics, with the responses illustrating a wide range of beliefs about the nature of mathematics. The researchers judged the drawing task as effective for use with a large group and for collecting complex and varied data.

Drawings have also been used for data collection with adults. For example, Thomas, Pedersen and Finson (2001) used a drawing task to gather data about pre-service teachers’ views about themselves as science teachers. The task asked them to “Draw a picture of yourself as a science teacher at work” (p. 299). The researchers found that the task yielded valuable data about the pre-service teachers’ views of science teaching. Thomas et al. reported that the participants responded positively to the drawing task and, although they may have had initial concerns about the quality of their drawing skills, thinking about what their own classrooms would look like was good motivation for these future teachers of science. Black and Halliwell (2000) used drawing as a way for early childhood teachers to reflect on themselves as teachers. They found “the drawings helped them examine, reflectively, connections between feelings, aspirations, past experiences, relationships and events and how these shaped teacher identities” (p. 105).

Prior studies show therefore that drawings can be tools for both child and adult reflection and expression, and can provide valuable insights for researchers. In this paper we explore PPELEM, a procedure that includes the completion of a drawing, as a further possible data collection tool for use or adaptation by researchers.

Methodology

The original pencil and paper PPELEM procedure (McDonough, 2002a) was adapted for use in two separate research studies carried out by the authors to gather data regarding children's and adults' beliefs about mathematics teaching and learning. The participants ranged in age from young children to adult teachers.

McDonough (2002b) conducted 10 individual interviews with four high achieving and four low achieving children of 8 to 9 years of age (Year 3), using a total of 30 creative interviewing procedures with each child. One of those procedures was PPELEM as described in more detail below. In the second study, Ferguson (2011) researched four low achieving students in the final two years of primary school (10 to 11 years of age, Year 5/6) and their two teachers. She used data collection techniques including classroom observation, interviews, questionnaires, and PPELEM. In this paper we discuss Ferguson's use of PPELEM with the teachers. While McDonough and Ferguson each used a range of data collection techniques, we focus here on discussing the use of a PPELEM drawing as a prompt for one-to-one interview discussions and include sample data to inform the discussion of the value and flexibility of the PPELEM procedure.

The original PPELEM task (McDonough, 2002a) was designed for use with all students in a class at one time. Students are asked first to visualise and then "draw a time you were learning maths well". This is followed by completing somewhat directed written responses (transcribed for younger children) to nine questions about the what, where, when and why of the situation and helping factors.

In her later work, drawn on for this paper, McDonough (2002b) developed an interview version of PPELEM. Interviewed individually, each Year 3 child was prompted:

> I would like you to think about some different times when you have been learning maths, maybe this year, maybe last year or even earlier, maybe at school, maybe at home, or somewhere else. Please take your time and choose one time when you felt you were learning maths really well. Close your eyes and make a picture of that time in your mind. When you've got your picture I would like you to draw that time.

Once the picture was completed the child was asked: "Tell me about the time you were learning maths well (Describe the picture for me)". Using a semi-structured interviewing approach, having posed this pre-planned prompt follow-up questions were asked if necessary, keeping in mind the issue under consideration and the path of thought in the interviewee's response. As the researcher listened, she wrote key words on cards. At the end of the interview these were checked with the child as to whether they were helpful factors, with the opportunity to delete or to add. The child was then asked which was most helpful, next most helpful, least helpful etcetera with the aim of ranking the helping factors. The whole procedure was then followed with an equivalent task where the child was asked about a situation where "something was stopping you or making it hard for you to learn maths really well".

At the beginning of the two week lesson observation period in each of the two research classrooms, Ferguson (2011) administered PPELEM to the two teachers as part of the initial teacher interview. The teachers completed the teacher version of PPELEM where they were asked to "draw a picture of when you are teaching maths well". In Ferguson's pilot study of the use of the teacher version of PPELEM with 40 teachers (Ferguson, 2011) it was found that with the addition of labelling and encouraging simple "stick figure" drawings, the teachers were comfortable to complete the procedure. Ferguson emphasised to the teachers in the main study that the drawings could be simple and include labels. This was to allay any possible concerns the teachers might have had about their drawing ability. A discussion of the portrayed situation followed and formed part of the initial teacher interview. The discussion provided data regarding the teachers' beliefs that were compared to observations of their actions in the classroom.

Findings

To illustrate the type of findings that resulted from the use of different versions of PPELEM with two very different age groups, we present sample results from each study.

PPELEM with Young Students

Emily, judged by her teacher as a high achiever in mathematics, was in Year 3 at the time of the data collection but chose a school situation from Year 1 for which her description included that she "was learning minus and take away sums … I was learning maths well by using my fingers because I went five plus three and stuff like that and that was very easy". The conversation continued:

Interviewer: So what does learning maths well mean?

Emily: It means that you have to remember things, and you have to remember how to do it

Interviewer: Why was that [using fingers and counting] the most helpful thing?

Emily: Because the sums were below ten and when you use your fingers, you have ten fingers and perhaps like five, five plus three and then you put five fingers up and then you put up another three and then you go one, two, three, four, five, and then you go six, seven, eight, and so that's why it's very easy.

It appears that it was the ease of getting the answer, and therefore knowing the answer, that caused Emily to choose this situation as one in which she was learning maths well. Her fingers were a ready and appropriate tool, but it was the smallness of the numbers and their match to the tool that made the situation easy and therefore in Emily's view, a situation in which she was learning maths well.

Cara, a Year 3 student from a different school and judged by her teacher as a low achiever in mathematics, when asked to choose a situation when learning maths well, drew learning the measurement of mass in a lesson taught her teacher. Taking account of the data from the ten interviews with Cara, this mathematical focus seemed to reflect the attention she gave to measurement, particularly in her early interviews. Cara's drawing showed concrete materials to be weighed, balance scales and written work. Cara referred to three factors as most helping her to learn maths well:

1. calculators, blocks, pencil case, scissors (that is, the materials that were weighed);
2. measure; and
3. write it down.

In response to the prompt for what might be called the reverse or negative version of PPELEM, Cara was unable to think of a situation in which something was stopping her or making it hard for her to learn maths well. Instead she described a second situation in which she was learning maths well. For this second situation, a number situation, Cara ranked different helping factors as her first three:

1. think;
2. maths book with times tables; and
3. count with my fingers.

Within these responses Cara made reference to the use of materials or tools, physical mathematical activity, and cognitive mathematical activity, implying personal involvement by the child as the learner. The teacher was valued also to assist in the process of learning maths, being identified as the fourth most helpful factor in each situation.

These responses illustrate that both of these young children, one judged as a high achiever in mathematics and one as a low achiever, were able to respond to the PPELEM drawing prompt. In the discussion they were each able to explain and elaborate upon their drawing and selected situation. Insights were provided particularly into beliefs about the nature of mathematics and of mathematical learning, that is, the content area and the type of activity, both physical and mental, were specified.

PPELEM with Teachers

Ms B was a teacher of Year 5 and 6 students. Her labelled illustration of a mathematics lesson in her classroom showed students working in groups discussing, students using manipulatives, students recording their mathematical thinking and learning and the teacher was "listening, questioning, assisting and moving around". Using this illustration as a springboard for discussion, during the interview the teacher expanded on how she saw her role during mathematics lessons:

> I would spend this talking to groups or individuals making sure they're understanding the task, asking questions then finish with discussion generally work in pairs that they choose, wouldn't necessarily pull out a group to work with me.

As this study was concerned with the teaching of low-attaining students, this teacher's instructional style of attempting to talk with pairs or individual students during lessons impacted on the kind of scaffolding she was able to provide the target low-attaining students. Her drawing and subsequent comments regarding this strategy for teaching illustrated that it was a conscious and deliberate decision this teacher made about her role during mathematics lessons. In addition this was borne out by observations of the teacher during lessons.

Ms L, the other teacher in this study and also a Year 5/6 teacher, wrote "materials available at all times" on her drawing. She drew and labelled "materials" in the middle of a table with students gathered around. During subsequent observations of mathematics lessons with this teacher, it was observed that students did not use materials or representations of any kind during these lessons. Ms L explained her perception of why a student would be reluctant to use materials.

> I think what happens is she wants to do the top stuff and she doesn't want to go to concrete materials. I think she sees that as a baby thing and I think that's across the board. They think if you're telling them to get concrete materials out, that it's saying they can't do it. And I feel that that's how she is.

In another post-lesson interview Ms L said

> I think we need to go back step by step showing it pictorially as much as possible, how can I use … I want to have a look at what you sent me with the arrays to try that.

However, the next day Ms L explained why she had decided not to use grids and arrays by suggesting that using these visual representations could confuse students and in fact, may have confused her.

> I might actually show them the other one, drawing the grid and showing them as well. So they shade in the 50 I was going to show that but I thought that might be too confusing. I think with a lot of kids the visual can confuse them more. I looked at it and thought "Oh I don't know how that's helping me" but kids are different I suppose.

The initial PPELEM drawing task indicated a dichotomy in the espoused beliefs of Ms L about the importance of materials with the absence of materials in observed lessons. It would appear this teacher held her belief about the importance of using materials in a separate "cluster" (Green, 1971) from her belief that materials are for younger children or could add to student confusion. As Thompson (1992) posited, if teachers do not examine conflicting beliefs but hold each separately, incongruity can continue. Contextual issues (Sullivan & Mousley, 2001) which may have impacted Ms L's use of materials in the classroom appeared to be her perception of the appropriateness of using materials with older students, her belief that these older students saw using materials as immature and her own familiarity with appropriate materials or representations for this mathematics content.

Discussion

The main purpose of this paper was to examine whether variations of PPELEM are suitable for gathering data on the beliefs of both children and adults, and for prompting further discussion of those beliefs. In considering these points, we first identify commonalities and differences in the PPELEM procedures used by McDonough (2002b) and Ferguson (2011).

Although PPELEM was used differently in these two studies, each PPELEM procedure was based on a set of common features:

- the seeking of insights into participant beliefs;
- a focus on mathematics learning and/or teaching;
- a focus on effective features (learning situations for children; teaching for teachers);
- the effective situation chosen solely by the research participant;
- initial recording through drawing; and
- the recording followed by a one-to-one interview.

For each variation of PPELEM the drawing was a key feature and acted as a stimulus for reflection and discussion, possibly facilitating more detailed responses than when written expression only, such as with most questionnaires, occurs. The drawings allowed formulation of ideas before speaking about them, and for young children offered a familiar form of expression. Further, in both studies and as illustrated in this paper, the interview provided the respondent with the opportunity to elaborate, explain, and add new ideas, and gave the interviewer the opportunity to seek clarification or ask follow-up questions that were stimulated by an individual response. The results from the two studies suggest therefore that PPELEM can be used successfully with some flexibility to accommodate both child and teacher respondents.

Second, we consider the suitability of PPELEM for gathering data on beliefs and for prompting discussion. Responses to PPELEM by both the children and teachers reflect attention primarily to one dimension of the framework of mathematics-related beliefs developed by Op 't Eynde et al. (2002), that is, to the dimension of beliefs about mathematics education, including the nature of mathematics, mathematics learning, and mathematics teaching in general. This is perhaps not surprising given the nature of the prompt given to each set of research participants. McDonough (2002b) found that children of 8 to 9 years of age were able to choose specific mathematics learning situations, sometimes with the drawing prompt stimulating reflection beyond the immediate experience as illustrated by Emily who chose a situation from two years prior. The interview stimulated the children to discuss the situation and to identify specific helping factors as illustrated by the responses from Emily and Cara. Ferguson (2011) found that for teachers the drawing and discussion provided the opportunity in an interview for expression of mathematics-related beliefs. These espoused beliefs were later compared to the teachers' actions in the classroom during observations.

It appears then, from the results of the two studies discussed in this paper, that there is potential value in using variations of PPELEM to gain insights into the beliefs of both children and teachers.

Conclusion

Responding to the need for the development of a broader range of instruments for conducting research on affect (Patton, 2002; Zan, Brown, Evans, & Hannula, 2006), we posit that the variations of PPELEM discussed in this paper, which each include the use of drawings, can contribute to what Patton (2002) described as the "myriad possibilities [for creative interviewing] waiting to be created or discovered" (p. 395). The purpose in using the PPELEM procedures in the McDonough (2002b) and Ferguson (2011) studies was to provoke students and teachers to articulate beliefs, rather than to infer beliefs from artefacts or observations of actions, a pitfall of some beliefs research (Lester, 2002). We suggest that the use of PPELEM communicates a respect for individuals and their sense-making, seeing both students and teachers as "active and enquiring makers of meaning" (Ernest, 1991, p. 198). As illustrated in this paper, PPELEM is a flexible tool that can be used with and provide insights into the beliefs of both teachers and students about mathematics teaching and learning. With responses emanating explicitly from the perspectives of the individuals rather than a researcher, the administration of PPELEM can contribute to research "looking in from the outside, … [focusing on] participants' conceptions of teaching and learning … [elements] essential to our objective of making teaching and learning more effective" (Flutter & Rudduck, 2004, p. 3).

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