

Using Concept Cartoons to Access Student Beliefs about Preferred Approaches to Mathematics Learning and Teaching

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Curriculum reforms in the teaching of mathematics have encouraged a move away from sole memorisation of facts to the construction of deeper levels of understanding. With this reform, teachers of mathematics are called to act as facilitators of the construction of mathematical knowledge. However, some research suggests that students believe that their teacher's role is one that would be more aligned with the transmission of knowledge. This paper reports an aspect of a small-scale pilot study that sought to illuminate the beliefs that students hold about their preferred mathematics learning environments. It also highlights the role that 'concept cartoons' played in making known these beliefs.

Researchers have used the term 'student voice' in recent years to describe a number of concepts related to education and schooling (e.g., McCallum, Hargreaves, & Gipps, 2000; Veugelers & de Kat, 2002). Student voice can encompass ideas related to the beliefs and perceptions that students might hold regarding their teachers (Pratt, 2006; Taylor, Hawera, & Young-Loveridge, 2005) to the way that curriculum is organised and taught (Alerby, 2003; Kinchin, 2004). This paper reports an aspect of a small pilot study, which drew upon the work of Kinchin (2004). The study aimed to make known the beliefs that upper-primary school students held about their preferred mathematics learning approaches, and explored the possibility of using concept cartoons (Keogh & Naylor, 1999) as a means of accessing student voice related to these preferences.

Background

There are different uses for the term 'belief' within the psychology and mathematics education research communities (Hart, 1989). Rokeach (1968) described beliefs as any simple conscious or unconscious proposition, inferred from what a person says or does. Beliefs are related to and interact with emotions and attitudes (McLeod, 1992; Rokeach, 1968). When seeking to understand children's school experiences, their articulations of beliefs are considered important (McCallum et al., 2000; Rudduck & Flutter, 2000). Rudduck and Flutter (2000) interviewed primary and secondary school students and found that students hold strong beliefs about their experiences of school and ways of improving their schooling. Beliefs may impact upon children's reactions to, or interpretations of statements, actions and products of situations involving the learning of mathematics (McDonough, 2002). They can also influence the nature of students' participation in mathematics lessons and affect the way that students learn in specific situations (Franke & Carey, 1997; Kinchin, 2004; Taylor et al., 2005).

To engage in purposeful and meaningful learning, students need to develop an understanding and appreciation of the expectations set for them by their teacher (Kinchin, 2004). Skemp (1976) warned of issues related to mismatches between the respective learning goals of students and teachers. When describing relational and instrumental understanding, Skemp proposed that a damaging mismatch occurs when students seek to understand mathematics in a relational way but the teaching is directed to understanding it instrumentally. Fewer short-term problems are evident if the opposite occurs. In recent



years, Tsai (2003), after studying Taiwanese science classrooms, referred to this type of mismatch as an 'epistemological gap'. If this mismatch of beliefs is present in the classroom, there is potential for negative emotions, primarily frustration, to manifest in the classroom setting for both teacher and student. Another product could be a lack of meaningful learning (Kinchin, 2004).

Studies have shown that students hold a range of beliefs about teachers, from viewing the teacher as a person who facilitates learning to seeing the teacher as the person who transmits facts and information for memorisation (Kinchin, 2004; Taylor et al., 2005; Tsai, 2003). For example, if a student perceives the teacher as the manager of learning, then that student is likely to respond with passivity in the mathematics lesson. In some cases, only a very small number of students view the teacher as a facilitator of learning (Pratt, 2006; Taylor et al., 2005). These students believe that the teacher's role is like that of a 'mentor' and it is thought that these students take an active role in the teaching and learning process. It would appear that most students assign a role to the teacher that implies the idea of the transmission of knowledge or manager of the learning environment (Civil & Planas, 2004; Pratt, 2006; Taylor et al., 2005). These ideas reiterate the findings of McDonough (2002) that most of the students in her case studies preferred a style of teaching where they received information from the teacher.

Franke and Carey (1997) claimed that the use of carefully selected questions could provide insights into the perceptions that students hold about mathematics. McCallum, Hargreaves and Gipps (2000) supported this claim, through research using interviews, reporting that young students have the capacity to describe a variety of learning strategies and conditions to assist them in their learning. Talking to and listening to students discuss their beliefs about the teacher's role is one way of making known the perspectives of children (McDonough, 2002; Taylor et al., 2005). Data about beliefs have been collected typically through questionnaire and interview use (McLeod, 1992).

There is, however, research that supports the use of pictorial representations as a means of accessing insights into student beliefs (Alerby, 2003; McDonough, 2002). McDonough reported on the effectiveness of the Pupil Perceptions of Effective Learning Environments in Mathematics (PPELEM) procedure as a way for teachers to access student beliefs about mathematics. Students were required to draw an experience of a time when they learned mathematics well and participate in a short interview with an adult, usually a teacher, discussing questions used to gain further insights into the student's beliefs. McDonough reported that this tool can be used to investigate student beliefs and inform teachers in their practice to better meet student learning needs. The PPELEM procedure can also act as a means for students to become more reflective about their learning.

Concept cartoons are learning and teaching tools used primarily in science education to explore scientific concepts (Keogh & Naylor, 1999). The cartoons share some common traits with those used in comic strips, but rather than being designed for humour, they aim to present to students the opportunity to interpret and understand concepts. Concept cartoons include a pictorial representation of characters in settings familiar to students along with the use of written language in speech bubbles (Keogh & Naylor, 1999; Kinchin, 2004). The familiar settings and characters give relevance to the ideas that are being presented. It is important that alternative conceptions, statements or questions pertaining to a central idea are presented within the cartoon. In most cases, alternative viewpoints are presented by characters engaging in a dialogue through the illustrator's use of speech bubbles and written language. Due to the characters' dialogue, students have the freedom to make judgements that agree or disagree with the views expressed by the characters

without feeling threatened about expressing their own opinion publicly (Kinchin, 2004). Concept cartoons are primarily intended to act as a teaching and learning tool but they have also been proven to work effectively as a cognitive and affective assessment strategy (Keogh & Naylor, 1999; Kinchin, 2004).

In response to the literature, a small pilot study was developed to inquire into the use of concept cartoons (Keogh & Naylor, 1999) as a means of accessing student beliefs about their preferred approaches when learning mathematics, illuminating the possible presence of epistemological gaps (Tsai, 2003) in mathematics classrooms.

Method

The participants in the study were 75 students completing their sixth and seventh year of primary school (Grade 5 and 6 in Victoria) who ranged in ages from 10 to 13 years. The four classroom teachers invited to participate in the study had experience ranging from four to 35 years of teaching in primary schools. The school in which the study took place was a Catholic primary school located in an outer-western suburb of Melbourne.

A questionnaire, incorporating the use of two modified concept cartoons (Keogh & Naylor, 1999), was used to gather data that described the students' and teachers' beliefs about their preferred approaches to mathematics learning and teaching. The cartoons were created drawing on ideas from research literature (Ali, 2004; Brewer & Daane, 2002; Cobb, 1994; Kinchin, 2004). These cartoons can be found in Figures 1 and 2. The dialogues in the speech bubbles could be deemed as characterisations or stereotypes of behaviourist and constructivist approaches, respectively. Such characterisations provide clarity for the students so that they could gain a picture of the differences in the approaches presented in both cartoons.

As can be seen, the dialogue in the characters' speech bubbles details actions by the teacher and the students that are aligned with either behaviourist or constructivist learning approaches. The participants were asked to complete the questionnaire by selecting the cartoon that best matched their preferred approach to learning and teaching mathematics, that is, either 'Cartoon A' or 'Cartoon B'. To limit any potential reading difficulties, the dialogue in the speech bubbles was read out loud to the participants by the researcher.

The participants were also invited to record any supporting information by completing the sentence stem "I chose this cartoon because..." A small selection of students was chosen to elaborate upon their written responses by participating in a short interview. These students were selected based primarily upon comments or statements that needed further explanation.

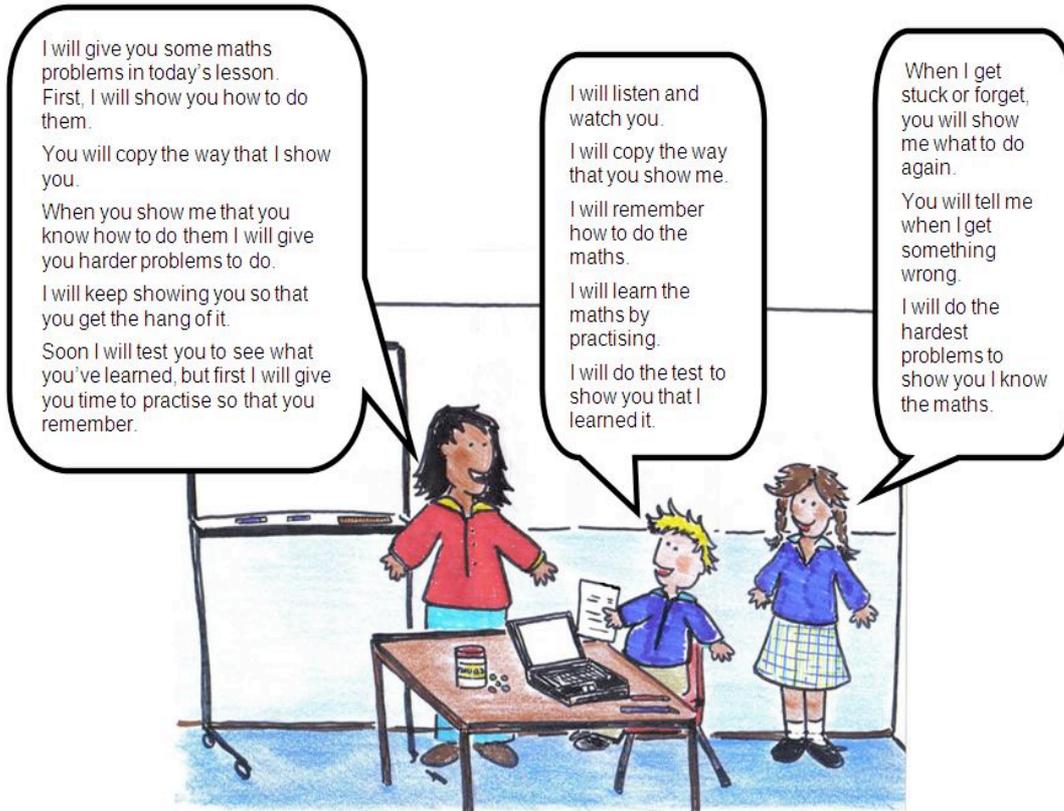


Figure 1. The concept cartoon (Cartoon A) that depicts a behaviourist approach to learning

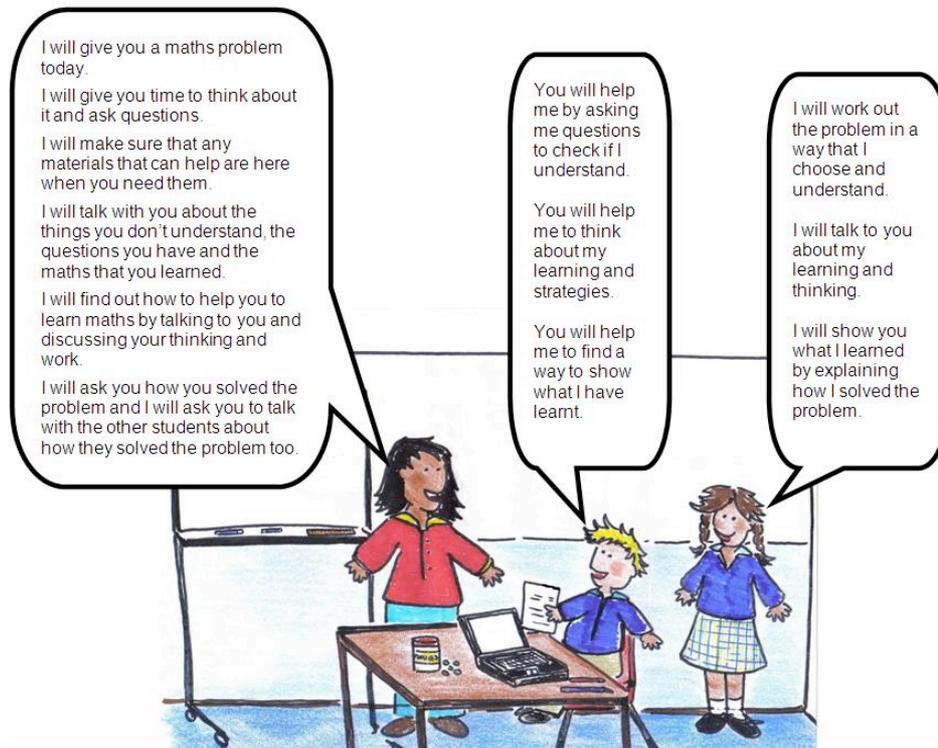


Figure 2. The concept cartoon (Cartoon B) that depicts a constructivist approach to learning.

Results

All names used within this report are pseudonyms. The data that relate to student preferences according to classroom membership and insights from a number of interviews are reported here. Three of the teachers, Ms Ruzic, Mr Brook and Ms Gallo, believed that their preferred approaches to teaching were aligned with those practices depicted in Cartoon B (constructivist approach). However one teacher, Ms Costa, stated that there was a place for the practices represented in both cartoons. Ms Costa explained that the practices described in Cartoon A were similar to ones that she employed at the beginning and end of a unit about a particular mathematics topic. Ms Costa continued her explanation by reporting that the practices depicted in Cartoon B were ones that were used during the unit of work. The data that relate to the student preferences according to their classroom grade are in Table 1.

Table 1

Frequency of Student Preferences for Learning Environments by Classroom (n=75)

Cartoon type	Ms Ruzic	Mr Brook	Ms Gallo	Ms Costa	Total
Behaviourist (<i>Cartoon A</i>)	10	10	3	2	25
Constructivist (<i>Cartoon B</i>)	10	8	13	10	41
Combination (<i>Cartoon A & B</i>)	0	0	0	9	9

These data show that all students were able to choose a cartoon that described their preferences. There appears to be a near equal spread of preferences by students in the classrooms of Ms Ruzic and Mr Brook. Nearly half ($\approx 50\text{--}55\%$) of the students in these two grades showed a preference for a learning approach that matched the one chosen by their classroom teacher. The preferences of the students in Ms Gallo's classroom appear to be most aligned with those of their teacher. Approximately four-fifths of students ($\approx 81\%$) in this class chose the approach that mirrors the preference of Ms Gallo. The only students who chose a combination of the cartoons were students in Ms Costa's grade. Nearly two-fifths ($\approx 43\%$) of the students in this classroom showed a preference for learning that combined aspects of the behaviourist and constructivist approaches. The greatest discrepancies between beliefs held by the teachers and students appear to be present in the classrooms of Ms Ruzic, Mr Brook and Ms Costa.

The space for written explanations on the concept cartoon questionnaire provided opportunities for the students to elaborate on their choice of cartoon. A number of themes emerged from the written explanations of the students who chose Cartoon A (behaviourist classroom). The most common theme pertained to the importance of the teacher showing and modelling procedures. For example, during an interview, Demi, a Grade 6 student in Ms Ruzic's class, revealed beliefs about the role that she has assigned to her teacher:

It's her job to show me exactly what to do. I like seeing the way to do it and seeing all of the steps. Sometimes she doesn't do that, though.

Other emerging themes in the students' responses concerned the 'need for the teacher to show the 'right' way of doing the mathematics', 'time to remember what had been taught in lessons through revision', and 'tests as a means of providing feedback on performance'.

Mikey, a Grade 6 student taught by Mr Brook, participated in an interview. When asked to discuss his written explanation, Mikey said

I wrote that down because it is important to understand by real learning. Real learning is learning that I understand for myself...I don't see copying the teacher as real learning...that's just remembering. If I understand it, I don't need to remember it. I get it...it makes sense. You need to make sense of maths.

Analyses of the written responses from the students who chose Cartoon B (constructivist classroom) revealed some interesting themes. The most frequent themes included the 'importance of discussion with peers', 'exploring and using self-constructed strategies', the 'value of working with other students to compare solutions and strategy uses', the 'importance of using questions in learning', the 'place of mistakes or errors when learning' and the 'need to understand the mathematics being taught'. In many cases, more than one theme was recorded by these students.

Madison, a Grade 5 student taught by Ms Costa, chose a combination of cartoons. In a follow-up interview, Madison elaborated upon her written explanation by saying

I like it when Ms Costa shows me how to do the sums step-by-step and when she keeps showing me. When I get it, I like to see how someone else does it so I learn a different way.

The written responses from students who chose a combination of cartoons revealed fewer themes than those questionnaires completed by students choosing Cartoon A and considerably less than the questionnaires completed by those who chose Cartoon B. The themes of 'opportunities to learn other solution strategies after being shown procedures by the teacher' and 'opportunities for students to make their own decisions about use of materials' featured in the responses from these students.

Discussion

One of the aims of this study was to gain information about the potential use of concept cartoons (Keogh & Naylor, 1999) to inquire into student beliefs. The concept cartoons acted as an assessment tool that allowed access into student beliefs about their preferred learning environments. This study confirms findings from other studies that visual imagery, as used in the concept cartoons, can be an engaging and useful way of assessing student affect (Alerby, 2003; Kinchin, 2004; McDonough, 2002). These cartoons provided an opportunity for students to reflect upon their preferences when learning mathematics and make these known to others.

Anecdotal data reveal that overall the students responded positively to the use of the cartoons in the questionnaire. However, the use of the term 'cartoon' was misleading for some students (Keogh & Naylor, 1999). Some students made this known by commenting that they were expecting to see characters that resembled those seen in a popular television program. Researchers and teachers will need to be mindful of discussions about the term 'cartoon' when using concept cartoons with students.

The inclusion of a written explanation proved to be important. Further insights were accessed via opportunities to elaborate further on choices. Each student was also able to provide reasons for their choice of cartoon, although the degree to which they were able to articulate these thoughts varied from student to student.

The findings from this study suggest that, not surprisingly, the presence of 'epistemological gaps' extends beyond science learning and teaching (Tsai, 2003) to mathematics classrooms in upper-primary school settings. The presence of this type of mismatch in beliefs was most evident in three of the four classrooms involved in the study. It must be acknowledged here that it is not known to what extent the teachers' practices were actually aligned with their stated or actual beliefs because this was not the focus of

the study. Despite this, the data do suggest that approximately one-third of students involved in the study could be at risk of not fully understanding the mathematics that is being taught, their participation in mathematics lessons may be limited or negative emotions towards mathematics may be experienced by these students (Kinchin, 2004; Pratt, 2006; Taylor et al., 2005).

The data collected via the questionnaire confirm that students do hold beliefs about the way that they learn and the teacher role (Civil & Planas, 2004; Pratt, 2006; Taylor et al., 2005). It could be argued that through their written responses, the students demonstrated understanding of characteristics that define behaviourist and constructivist approaches. The findings also support the idea that within the one classroom, the beliefs that students hold can be varied (Franke & Carey, 1997) and as learners, students have the capacity to describe strategies and conditions that best support their learning (McCallum et al., 2000) when given the opportunity.

A challenge for teachers lies in supporting students to come to an understanding and appreciation of the expectations of practices within the mathematics classroom. Careful consideration must occur to ensure that teachers are not just transmitting information about these expectations but providing opportunities for students to reflect upon and understand these expectations and 'ways of working'. The joint-construction of sociomathematical norms (Yackel & Cobb, 1996) by the teacher and students could be an opportunity to make explicit the expectations of learning and teaching behaviours. If the teacher's role is to facilitate the construction of mathematical knowledge and to support higher-order thinking, teachers need to make explicit the reasons for their actions in mathematics lessons. In one way, this might make clearer the expectations of the learning actions for the students, thus leading to the possible reduction in any 'epistemological gaps' (Tsai, 2003) or mismatches in beliefs (Skemp, 1976).

This study has important implications for the classroom, especially when it comes to developing understanding and meaningful participation in mathematics by all students. If current education reforms in mathematics education tend to be moving away from the reception and memorization of knowledge to the construction of deeper levels of meaning and understanding (Ali, 2004; Brewer & Daane, 2002; Cobb, 1994; Kinchin, 2004), then attention needs to be paid to knowing more about the preferences of students with whom teachers work and making efforts to minimise the possible presence of epistemological gaps in mathematics classrooms.

Conclusion

This study was designed to gain insights into the beliefs of upper-primary school students about their preferred approaches to mathematics learning. It had a second important aim, which was to test the effectiveness of using concept cartoons to gain these insights. The findings highlight the important need of accessing student beliefs about their preferred approaches to learning mathematics because students and teachers may not always share a common set of beliefs about these approaches. Even though reforms are moving away from procedurally orientated classrooms, it would appear that many students prefer behaviourist approaches when learning mathematics. The concept cartoons have provided a way of accessing information about student learning preferences. These cartoons, used primarily in science education, have proven to be a purposeful assessment tool and a useful way of accessing 'student voice'.

For the future, possible research ideas concerning concept cartoons include extending their use as a potential pedagogical tool in mathematics. The concept cartoons could be

studied as a stimulus that teachers use to initiate classroom inquiries where students formulate mathematical arguments as responses to the characters, confirming or challenging information contained within the cartoon. Concept cartoons warrant further research and application in mathematics classrooms.

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