Nurturing Possibility Thinking (PT) in mathematics education courses through experiential learning and the use of pedagogical constructs, and beyond.

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This paper reports on the Creative Thinking in Mathematics Education Enquiry (CTMEE) at The Open University. The study investigates whether the pedagogical approaches of experiential learning and the use of pedagogical constructs in an undergraduate distance learning mathematics education course can lead to creativity seen as 'possibility thinking' (Grainger, Craft and Burnard 2007). Data consist of 23 quantitative and qualitative responses from students to an on-line questionnaire. Findings suggest that such pedagogical approaches can indeed contribute to developing possibility thinking. However, it seems the more subtle task design within such approaches is equally crucial, which is reported in this paper.

Keywords: creativity, possibility thinking, experiential learning, constructs, task design.

Introduction and background

The Centre for Mathematics Education in the Open University (OU) offers distance learning courses in mathematics education at undergraduate and postgraduate level. The pedagogical approach taken in all these courses is one of experiential learning (Kolb 1984; Dewey 1938) where students are asked to undertake mathematical tasks for themselves, reflect on this experience, try the tasks out with learners, and reflect on both experiences. The courses also use *constructs* which act as labels for experiences, such as *do-talk-record*, *generalising and specialising, conjecturing & convincing, imagining & expressing* (Pólya 1962; Mason, Burton and Stacey 1982). These pedagogical underpinnings of experiential learning and constructs are made explicit in the course materials and are referred to in research publications (Mason and De Geest 2010).

The CTMEE project intends to find out whether the aspect of experiential learning and the use of constructs in the teaching of mathematics with adult learners in distance learning could contibute to developing creative thinking in mathematics, and if so, whether there are any other pedagogical approaches within the courses that nurture possibility thinking.

Possibility thinking (PT) is described as being the essence, and at the core, of creativity (Craft 2000, 2001; Craft and Jeffrey 2003; Grainger, Craft and Burnard 2007; Craft et al. 2012; Craft, McConnon and Paige-Smith 2012). PT is about 'everyday creativity', also refered to as 'little *c* creativity' or 'what if' thinking. It is about trying out different possibilities, identifying problems and solving these (Craft 2002).

Grainger, Craft and Burnard (2007) developed a framework for identifying and analysing possibility thinking of teaching and learning. Although originally developed within the context of primary school children, the features of the

framework seem to be applicable to learning in general. One of the research questions of this study was indeed to find out whether these features would resonate with adult learners. The features of this framework for identifying an analysing PT involve:

PT feature	**What this could involve…**
Play	As a result of time for immersion, ideas incubate and questions emerge through playful encounters [with others or the tasks/concepts]. Extending of boundaries. Engagement, interest and motivation.
Immersion	Opportunites and time for extended periods to immerse in particular activities which are frequently revisited.
Question posing	'What if' and 'as if' scenarios. Questioning, genertating ideas. Questions of students treated with deep respect and interest. Making predictions, compensation, improvisation, testing.
Self determination	Ownership. To exercise agency (one is the agent in the change/activity) and autonomy (self chosen action; self directed acted; self initiated activities). Expected to take risks.
Risk taking	Challenges with no clear cut solutions. Developing courage to take risks. Contributions are valued.
Being imaginative	'As if' thinking. Being imaginative and imagining. Consider what might be, alternative world frames. Can position oneself differently and postulate reasons for this.
Making connections	(Unusual) connections between ideas and activities and between one's own and others' lives.

Table 1: Features of PT and what these could involve. Amalgamated and adapted from Grainger, Craft and Burnard (2007).

The research question addressed in this paper is: 'What pedagogical strategies in the course and task design, apart from experiential learning and reflection, foster/nurture possibility thinking?'

Research design

Data was collected via an on-line questionnaire of students on the course 'Developing Algebraic Thinking' (ME625). This is a third level undergraduate distance learning course that can count towards Graduate Diploma in Mathematics Education and/or a BSc (Honours) Mathematics and its Learning . The course is open to everyone, though it is intended particularly for students working or aspiring to work in mathematics education. It integrates development of the core ideas of algebra with relevant pedagogical constructs and principles and aims to extend awareness of how people learn and use algebra. The questionnaire was developed based on the model of possibility thinking of Grainger, Craft and Burnard (2007). It consisted of statements which respondents were asked how these fitted with their experiences first within the context of experiential learning (part 1), then in the context of the use of constructs (part 2), with response options 'happens often/sometimes/a few times/not at all'. For example, to find out whether the students had experienced the feature of the PT

framework of risk taking as a result of experiential learning in the course, the statement read:

> Trying out tasks for myself, reflecting and trying the tasks with others in ME625…
>
> - Prompt me to take risks in my thinking and my practice

followed by response options of 'happens often/sometimes/a few times/not at all'. To obtain examplification of their experiences, respondents were invited to describe a particular incident of how/when this happened. It is the analysis of these qualitative responses that are discussed in this paper.

All 120 students registered on the course were invited to take part in the study shortly after the due date of the final assessment but before they received their results. Twenty-seven responses were received, of which twenty-three were useable (four did not go past the consent part of the questionnaire). All had completed the questions relating to experiential learning (part 1), and 17 completed both sections. Twelve respondents provided 39 exemplifications of their experiences. Responses varied in length from short statements to more elaborate responses. Several responses mentioned specific tasks, or specific constructs.

Analysis method

The qualitative responses were analysed using a grounded theory approach such as constant comparison and were informed by the PT framework (Grainger, Craft and Burnard 2007). Categorisations were cross-checked with elements of the course design that is documented in the course materials. The analysis question used was 'what caused this shift in engagement, in learning, in change?'

Results and analysis

Analysis of the data suggests the following pedagogical elements in the course design, apart from experiential learning and reflection, nurture features of possibility thinking to happen:

The special role of constructs

Mason, main author of the ME625 course explains the pedagogical use of constructs as based on psychological insights into how people change their behaviour (Mason 2002, 1999; Mason and De Geest 2010). He argues that constructs can act as labels for recognising past actions and offer possibilities coming to mind when responding to something happening. However the qualitative data from this study offers some deeper insights into what this actually involves, and how it can nurture PT. Features of the PT framework and how

Toolbox

Pedagogical constructs are described as being a toolbox, as helping to get unstuck, as offering ways to 'know' how to go about exploring and experimenting and build resilience in that process. Having a toolbox seems to nurture PT by supporting the PT features of risk taking, play (playing with the mathematical problem through exploring and experimenting) and immersion (becoming resilient to keep going):

> Constructs prompt me to start from a different angle if stuck.

> The constructs have made it possible for me to explore the inner aspects of tasks. I was able to work through being stuck most of the time by using the course constructs. Previously I would have stopped as soon as the going gets tough and would therefore have missed out on the inner aspects.

Language to communicate

Several respondents also reported that constructs allowed them to express and communicate their thinking by using the wording of the constructs. This seems to support the PT features of making connections (between their own and their students' lives/thinking) and being imaginative (position oneself differently and communicate reasons for this). For example:

> I'm now more able to argue a case at work [using constructs] about why students might be bored and disengaged in traditional maths lessons.
>
> Helpful knowing I can pass on these techniques [of constructs]

The role of assessment tasks

Responses mentioned that the assessment tasks pushed the students into being challenged and coaxed them out of their comfort zone nurturing PT by supporting the PT features of risk taking (challenges, developing courage to take risks, to move out of the comfort zone), play (extending boundaries) . The assessment tasks require students to write about the process of doing the mathematics tasks in the course, they require to adapt and expand the tasks and try these out with learners, and it requires the students to write about this process using the constructs used in the course to account for what happened and how it influenced their thinking and planning. Hence the foci for development of awareness within the course are continued in the assessment tasks. The assessment tasks are written as a continuation of the pedagogical approaches taken in the course of experiential learning, reflection and using constructs and are not, as often is mentioned a barrier, alien to what is happening in the rest of the learning.

> On one of the tasks in a TMA I was able to push myself further to explore a trigonometry problem.
>
> On tasks for TMAs I often ended up exploring so much that I had far too much information to answer the questions!

The importance of knowing about getting stuck and unstuck

Several respondents mentioned the importance of being able to get unstuck, and that this helped them in engaging with experimenting and exploring, with risk taking, supporting the PT features of play (experimenting and exploring), risk taking (develop courage to take risk because of knowing you can get unstuck) and self-determination (expected to take risks). Techniques of getting unstuck are: using other approaches informed by using different constructs, helping them focus attention (a construct itself) on another approach, another way in. Perhaps equally important is the portraying of being stuck as a good thing, and something to be expected when doing mathematics:

> Getting stuck on a task for a while is excellent, for it provides an opportunity to experience the creative side of mathematical thinking. (Mason, Graham and Johnson-Wilder 2005 p xi).

Students reported:

> When I was stuck I used different constructs to get unstuck
>
> Using techniques to get you out of stuck situations [makes me feel innovative in my approaches]
>
> Prompt me to start from a different angle if stuck

In the handbook, there are no specific entries for getting unstuck, although there are hints on the importance of conjecturing and dealing and not getting caught up with flawed conjectures:

> "Remember that all first articulations are likely to be flawed, sometimes seriously. They are best treated as conjectures, for their status is temporary and conjectural. By saying conjectures out loud, and even making a brief note of them, you separate yourself somewhat from them, so you can look at them more dispassionately. By externalizing them, using your notebook, they can be pinned down long enough to test tem, and perhaps modify or even reject them in favour of a new version." (Mason, Graham and Johnson-Wilder 2005 p24).

The role of choice

The course has elements of choice at all levels: the choice of engaging with tasks (they are not expected to do all), choice on how to do the tasks. There is choice in the assessment tasks in that they can decide with tasks to report on, which learners to work with, which constructs to use. Throughout the course, the approach is there are many right answers; many right ways and they are equally valid.

This engrained choice-ness seems to contribute strongly to a sense of ownership, and agency, supporting the PT feature of self-determination. It contributes to being willing and able to take risks:

> This is because the approach requires you to start with what you perceive to be important and, through a collection of smaller tasks, assess the appropriateness of your choice.
>
> That I can decide what is the best way for me and that by doing this I can encourage my learners to find the best way for them.
>
> I could see that the tasks I encountered and took on were very much up to me; how did I extend them? What resources worked for me?
>
> In the end the learner arrive at statement like this is 'correct' or this is 'incorrect' but with his/her experience and expertise. I feel that this make learning a more rewarding process which in turn encourages learner to learn.

The course materials make the importance of choice-ness clear:

> "Instead of asking learners to do a lot of exercises, to 'do what they are told' it can change learners' attitudes considerably if they are invited to make choices for themselves. "(Mason, Graham and Johnson-Wilder 2005 p238).
>
> "If mathematics lessons continue to restrict the possibility of making sensible and informed choices, then some learners are likely to make the only choice they can: not to participate, and to make things difficult for others." (Mason, Graham and Johnson-Wilder 2005 p276).

Discussion

This is a small case study specific to one course in mathematics education of the Open University and is thus limited in scope and range. It involves self-reporting and this may not be entirely reliable. It is also likely that respondents willing to spend about 20

minutes answering a questionnaire might be biased to be positive about their experiences as a student on the course and have positive experiences to report. Findings suggest that pedagogical approaches of experiential learning and the use of pedagogical constructs can indeed contribute to developing possibility thinking. However, it seems the more subtle task design within such approaches is equally crucial.

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