POSSIBILITY THINKING WITH UNDERGRADUATE DISTANCE LEARNING MATHEMATICS EDUCATION STUDENTS: HOW IT IS EXPERIENCED

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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' (PT) (Grainger, Craft and Burnard, 2007). Data consist of 23 quantitative and qualitative responses from students to an on-line questionnaire. It is the analysis of the qualitative responses that are discussed in this paper. Findings suggest that such pedagogical approaches can indeed contribute to developing possibility thinking. This paper offers a descriptive categorization of how the features of the PT framework are manifested with undergraduate distance learning mathematics education students.

INTRODUCTION AND BACKGROUND

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

Grainger et al. (2007) developed a framework for identifying and analysing possibility thinking of teaching and learning. The framework was originally developed within the context of primary school children. 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	Opportunities and time for extended periods to immerse in particular activities which are frequently revisited.

Question posing	'What if' scenarios. Questioning, generating 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	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 et al. (2007).

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 & De Geest, 2010).

The CTMEE project intended to address the following research aims:

1. To find out whether, and if so, how, the features of the PT framework resonate with adult learners in a distance learning setting?
2. To find out whether experiential learning and the use of constructs in the teaching of mathematics contribute to developing possibility thinking
3. To find out whether there are any there any other pedagogical approaches within the courses that nurture possibility thinking

This paper reports on the findings to the first research aim. Findings to the second and third research aim have been reported in De Geest (forthcoming)

RESEARCH DESIGN

Data was collected via an on-line questionnaire of students on the course 'Developing Algebraic Thinking' (course code ME625; Mason, Graham and Johnston-Wilder, 2005). 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. Examples of mathematical tasks in the course are:

> It was reported that during 1992 in a certain county, although black students were only 10% of the school population, 40% of school exclusions were black. This means, it said in the report, that black students are 6 times as likely to be excluded as white. Justify, comment and construct a general method for making similar calculations from other similar data.
> (Task 9.3.4, Mason et al. 2005, p189)

And

> Write down two numbers
> Write down two numbers which total 36
> Write down two numbers with a difference of 8
> Write down two numbers with a total of 36 and a difference of 8
> (Quickie 10.1, Mason et al. 2005, page 199)

The questionnaire was developed based on the model of possibility thinking of Grainger et al. (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

This was followed by response options of 'happens often/sometimes/a few times/not at all'. To obtain exemplification 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.

The qualitative responses were analysed using a grounded theory approach such as constant comparison and were informed by the PT framework (Grainger et al., 2007). The analysis questions used were ‘what are the students experiencing in terms of the PT features?’ and ‘what triggers/influences this experience?’.

RESULTS AND ANALYSIS

The analysis provided exemplification of how features of PT, as described earlier in this paper, were manifested with the students:

Play/playfulness

Playfulness seems to take the form of exploring and experimenting. Such activities are no longer considered a waste of time. Assessment tasks where mentioned as leading to extensive exploring. Important also was mentioned that having the toolkit on how to explore from using constructs. Knowing how to get unstuck seems important so students can work through being stuck when exploring and experimenting as illustrated by the responses:

> I now keep a notebook with me so I can explore 'What if...' whenever this may occur to me.
>
> Manipulation and drawing is no longer a waste of time.
>
> On tasks for TMAs [assignments for assessment] I often ended up exploring so much that I had far too much information to answer the questions!
>
> 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 tuff and would therefore have missed out on the inner aspects.

Immersion

There were no explicit responses indicating the students had experienced opportunites and time for extended periods to immerse in particular activities which are frequently revisited. Perhaps it might be implied from the course design and the students responses about playfulness which seems to suggest students were engaging with tasks for some time.

Question posing

Students reported asking ‘what if’ questions by being required to extend and adapt tasks. They had learned ways to extend such tasks by using constructs such as *Dimensions of Possible Variation* (DoPV). They had become aware of these DoPV from being presented with tasks which had many-right-answers and/or many-right-ways to solve the tasks as illustrated by the responses:

> Being asked to extend tasks prompted this [posing questions] at first but then it started to become more natural

> If I understand an idea then I can still further my understanding by asking question like 'what if...' .

Self determination (autonomy and agency)

Self determination, directed action and self chosen action in the forms of autonomy and agency seems to be very present with the students. Many responses mentioned experiencing ownership of ideas, of learning and of feeling valued. Experiential learning and reflection stimulated students to develop their own conjectures about theories of learning and of mathematics learning based on new and old experiences. This is aided by the tasks with their focus on many-right-answers and many-right-ways to solve the problem: they seem to validate and respect own ways of thinking and at same time offer new ideas and approaches. The requirement for adapting and extending task, the stimulus to create own examples and been given a toolbox of constructs and frameworks to do so, means students are in charge of their own learning. They report feeling interested, focussed and motivated as a result and as illustrated by the responses:

> Being told something is 'correct' or 'incorrect' is not always helpful. In fact, for me, it is usually rarely helpful. More helpful and important is the reasoning, which make something valid or invalid. Experiential learning has the advantage that it does not force a view. On the contrary, one discovers through experience the dimensions of variation of a problem and its associated range of permissible change. This means that there is an element of real ownership associated with ideas.

> Lots of ideas which I was able to construct my own tasks from.

> 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?

> If you create your own examples or expand one that is given you are taking charge of learning and that makes you more interested and focused.

Risk taking

Students report feeling comfortable with taking risks, indeed one response read ‘no fear of failure’. Taking risks meant a change in teaching practice by moving from

using textbooks to investigative mathematics, using an approach of experiential learning in the classroom. Taking risks also happens within the students' own learning of mathematics by moving out of their comfort zone and challenging themselves by doing mathematics tasks which they consider beyond 'their level'. Important seems to be the ability to know how to get unstuck which can be achieved by using course constructs and frameworks. It was also mentioned that the impact the tasks had on the student's own motivation, encouraged to take more risks in classroom. It is not clear what that motivation is. The course and task design's emphasis on many-right-answers/many-right-ways contributes to the students feeling that their thinking and ideas are valid and valued. This could give a sense of feeling safe. The requirements of the assessment tasks push the student out of their comfort zone as illustrated by the responses::

> I have been encouraged and required to think and work in new ways, without fear of failure.
>
> Seeing the impact of the tasks on my own motivation encouraged me to "take more risks" in the classroom
>
> When I was stuck I used different constructs to get unstuck
>
> Using techniques from constructs and frameworks to get you out of stuck situations
>
> Having constructs at hand I feel capable of dealing with problematic situations.

Being imaginative

Students reported feeling imaginative as having new and different experiences of and approaches to learning mathematics. The 'low entry high ceiling tasks, the many-right-answers/many-right-ways design and the requirement for developing own examples and adapting tasks all seem to stimulate being imaginative. Experiential learning and reflection makes students become aware of their own learning and on working on developing a (new) structure of thinking. Making connections between mathematical ideas as a result of the task design leads to solving problems in more than one way as illustrated by the responses:

> Experiencing the connection between different concepts allowed me to solve a problem in various ways and also to prompt learners to seek alternative ways of solving a problem.
>
> The experiential approach to learning actually allows for all sorts of approaches to be tried. 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. From the experience of the process and the actual results obtained you can make further, more informed, choices.

Making connections

Students made connections with other areas of mathematics, other mathematical approaches, and with becoming aware of own learning. Working on imagery seems

to offer a way to connect abstract ideas. The emphasis in the course and task design of that there is not one right way or right answer, but many, seems lead students to being able to empathize with differing ways of learning of other people. Reflection lets students become aware of their own learning, of their assumptions about learning and the role of their own past experiences and make connections between these. These are then challenged as a result of having to do the tasks themselves, and having to adapt and then try out the tasks with learners. Several respondents reported a change in their teaching as a result, and in particular and change in their questioning. Another aspect of development concerns being able to express and talk about learning and pedagogies by using constructs and frameworks as vocabulary as illustrated by the responses:

> I was looking at it with fresh eyes. I could see how other might approach it. I could develop the question, adapt for different learners.
>
> By learning mathematics in new ways I have become more aware of what works for my learners.
>
> Throughout the book our preconceived ideas are challenged
>
> Returning regularly to the construct showed me how the way I learn relied on what I previous knew and the way I had previously tackled similar problems. Also showed me why less experienced learners may struggle to make these connects.

DISCUSSION AND CONCLUSION

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 would have a positive story to tell. It is also not clear what the implications are of the timing of the research, that is the students were invited to take part in the study shortly after the due date of the final assessment but before they received the results.

The intentions of the study as reported in this paper were to find out whether the features of PT (Grainger et al., 2007) which was developed in a classroom setting with primary aged school children would resonate with the experiences of adult learners, in a distance learning setting, in the context of mathematics education learning. It seems that these students experienced the features of PT, although there was not sufficient data to get insights into what the feature of immersion would entail in this setting.

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