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Research into pedagogical 'belief statements' held by pre-ITE students on a Mathematics Enhancement Course.

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• Introduction

This paper stems from a small-scale research project I have been undertaking with a group of pre-ITE (Initial Teacher Education) students at the University of East London (UEL) between January 2008 and July 2008. The emerging results are in their early stages of development.

In recent years, the quality of mathematics teaching has been a focus of concern. A relatively recent report (Ofsted 2005) had, as one of its main conclusions that the 'quality of teaching was the key factor influencing students' achievement.' At the time of the report I was Head of Mathematics in one of the sixth form colleges visited by the HMI survey which made up that report and I, for a change, found myself fully agreeing with Ofsted outcomes. One of the recommendations of the report was to encourage greater use of *active learning* resources of the type produced by the standards unit (2005). I had in fact been doing this, with my department, for a number of months. However, I was aware from informal discussion in my department that *beliefs* held by some teachers concerning how mathematics **should** be taught appeared to be a barrier to implementing more collaborative learning in mathematics.

Schoenfeld (1992) tells us that beliefs underpin personal thought and behaviour. Beliefs underlie reasons why we engage in certain practices and not others. However, beliefs can also become too comfortable and resistant to change (Green, 1971; Rokeach, 1960). Swan (2006) pulled much of this work together and has indicated that any attempt to develop mathematical teaching practices must attend to the beliefs of mathematics teachers and to changes in those beliefs.

After a twenty five year career teaching mathematics throughout the secondary sector I took up a post in ITE. As a programme leader of a pre-ITE Mathematics Enhancement Course (MEC), I have seen students exposed to a wide variety of teaching pedagogies which they had not previously experienced as learners. From discussion with the UEL 2007 cohort of students I was provided with anecdotal evidence that this exposure had impacted on their 'beliefs' concerning how **they** think mathematics should be taught. This paper is an attempt to place my anecdotal ideas in a more evidence based, critical framework.

The essential question to be answered in this paper is: Does participation in a pre-ITE Mathematics Enhancement Course, and hence exposure to a variety of teaching approaches, change the 'beliefs' of pre-ITE students concerning the way in which **they** think mathematics should be taught? My evidence leads me to tentatively say 'yes', but with various qualifying statements.

• The Study

As Thompson (1992) notes, most research into beliefs is interpretative and uses qualitative methods, I have attempted here to follow some of the work of Swan (2006) and have used quantitative data. My emerging results will eventually provide some insight into the relationship for a trainee mathematics teacher between prior experience of pedagogy as a learner, current experience of pre-ITE pedagogy in a transition phase from learner to teacher and future beliefs about their pedagogy as a teacher.

The cross sectional data discussed in this paper were collected as the year-1 data in part of an ongoing small-scale longitudinal study. My research method was to collect both qualitative and quantitative data from MEC students via two identical questionnaires. Then analyse their differences. (Eventually I will have data from multiple points in time, but at present I have only the two points: start of MEC cohort 2008 and end of MEC cohort 2008.)

The 2008 MEC cohort consisted of 25 students (13 male, 12 female) from very diverse backgrounds. The original idea for the study was to involve a census rather than a sample questionnaire, however due to reasons beyond my control only 22 students actually completed the questionnaire at the start of the course (7th January 2008). In addition 2 students left the course and finally 21 students completed the questionnaire at the end of the course (1st July 2008). The result of all this was that I collected only 20 of the potential 25 paired data responses to the two questionnaires.

The questionnaire consisted of 25 statements on teaching practices which the participants had to express a 'belief' in (scored 1 to 5). The 'belief statements' used to form the questions in the questionnaire are based upon statements previously used by Swann (2005) and the Standards Unit (2005).

The actual 'belief statements' used were:

Q1 I believe Learners should start with easy questions and work up to harder questions.

Q2 I believe I should tell learners which questions to tackle.

Q3 I believe I should teach the whole group all at once.

Q4 I believe I should know exactly what each maths lesson will contain.

Q5 I believe Learners learn maths through doing maths exercises.

Q6 I believe I should try to cover *everything* in a topic.

Q7 I believe I should avoid learners making mistakes by explaining things to them carefully first.

Q8 I believe Learners should mostly work on their own, consulting a neighbour from time to time.

Q9 I believe I should teach each topic from the beginning, assuming they know nothing.

Q10 I believe I need to teach each maths topic separately.

Q11 I believe Learners should use only the methods which I teach them.

Q12 I believe I should draw links between topics and move back and forth between several topics.

Q13 I believe I should follow the textbook, or worksheets, closely.

Q14 I believe I should only go through one method for doing each type of question.

Q15 I believe I should encourage learners to make mistakes and discuss mistakes.

Q16 I believe Learners should be allowed to work collaboratively in pairs or small groups.

Q17 I believe Learners should learn through discussing their ideas.

Q18 I believe I should jump between topics as the need arises.

Q19 I believe I should find out which parts learners already understand and don't teach those parts.

Q20 I believe I should teach each learner differently according to their individual needs.

Q21 I believe Learners should compare different methods for doing questions.

Q22 Even though I'll plan my lessons thoroughly, I believe I'll be constantly surprised by the ideas that come up during my lessons.

Q23 I believe I should encourage learners to work more slowly.

Q24 I believe Learners themselves should choose which questions they are to tackle.

Q25 I believe Learners should be allowed to invent their own methods.

The participants were asked to Grade these 25 statements using their currently held beliefs on how mathematics should be taught in secondary schools. The first time they filled in the questionnaire was on day-1 of the MEC and the second time they filled in the questionnaire was on the very last day of the MEC. I did not discuss the research with any of the participants between these occasions.

The participants were asked to tick one box marked on the questionnaire:

1	2	3	4	5
<input type="checkbox"/>				

The statements 1- 5 were defined on the questionnaire by:

1 = I believe this teaching practice should **almost never** be used in teaching mathematics.

2 = I believe this teaching practice should be used **occasionally** in teaching mathematics.

3 = I believe this teaching practice should be used about **half of the time** in teaching mathematics.

4 = I believe this teaching practice should be used **most of the time** in teaching mathematics.

5 = I believe this teaching practice should be used **almost always** in teaching mathematics.

In order to make the data from the grading consistent throughout the study, I identified Q1 to Q11 along with Q13 and Q14 as having a belief bias towards didactic type teaching. During data analysis I coded the data from these statements by subtracting their grades (1, 2, 3, 4 or 5) from the number six to reverse that bias. Hence during the data analysis stage the grading scale on all questions worked consistently from 1 (a didactic style of teaching) to 5 (a less didactic style of teaching or a more *active* style of teaching).

In addition I collected data on the group concerning gender, age range, the highest qualification obtained in mathematics and their 'place of origin'. For the 'place of origin' I asked for the country and continent where they received the majority of their secondary school teaching aged 11-16.

• Findings

Appendix I contains the data for the difference in responses between the two questionnaires. The individual participants are identified by a number 1-20 in the left hand column. The belief statements, listed above, are identified by the labels Q1-Q25. The data in each individual cell represents the change in participant belief concerning the individual 'belief statements' during the MEC. It is the participants grading of the statement in July 2008 minus the participants grading of the statement in January 2008. A zero represents no change in belief. A positive number represents a change towards a less didactic approach to teaching. A negative number represents a change towards a more didactic approach to teaching. The other data in the table is self explanatory.

➤ Analysis of 'overall' changes

There were 500 possible changes in belief (20 students X 25 statements) involved in this study. 240 responses (48%) were zero representing no change in beliefs. Of those

responses which represented a change in belief 160 (32%) were positive changes representing a change towards a less didactic approach to teaching and 100 (20%) were negative changes representing a change towards a more didactic approach to teaching. At this basic level the evidence leads me to tentatively state that participation in this pre-ITE Mathematics Enhancement Course, and hence exposure to a variety of teaching approaches, has changed the 'beliefs' of pre-ITE students concerning the way in which **they** think mathematics should be taught.

Overall, the beliefs of the participants appear to have changed away from didactic teaching approaches during the duration of the MEC towards less didactic teaching approaches.

This change is not a *strong* change and it is not consistent throughout the statements. Some statements have much more change than others and some statements even have relatively strong negative changes. For example Q10 (I believe I need to teach each maths topic separately), Q18 (I believe I should jump between topics as the need arises) and Q19 (I believe I should find out which parts learners already understand and don't teach those parts) exhibited strong positive change for half the group. These may be beliefs that are easily changed in the context of being a learner. While Q1 (I believe Learners should start with easy questions and work up to harder questions), Q5 (I believe Learners learn maths through doing maths exercises) and Q22 (Even though I'll plan my lessons thoroughly, I believe I'll be constantly surprised by the ideas that come up during my lessons) exhibited very little change. Many of these beliefs were already at the top end of my scale and therefore difficult to exhibit more positive change. It was interesting that Q6 (I believe I should try to cover *everything* in a topic) exhibited a negative change in 50% of the group. This is causing me to return to my interpretations of which statements display belief bias towards didactic or non-didactic type teaching.

➤ **Analysis of possible changes due to 'age'**

Due entirely to the age make up of the participants I analysed the data by splitting the group up into two subgroups (under 30 and over 30). The 13 participants in the under 30 group had a mean positive total change of 2.9 and a standard deviation of 8.64. The 7 participants in the over 30 group had a mean positive total change of 4.4 and a standard deviation of 5.59.

It was not possible to identify a strong correlation of age to belief change. However, in this particular group the older participants did exhibit more positive change with less variation within that change.

➤ **Analysis of possible changes due to 'gender'**

Males in the group had a mean positive total change of 5.6 which was much higher than the females in the group who had a mean positive total change of only 1.3. In addition the males in the group had a much higher standard deviation concerning this change than the females 9.07 as opposed to 5.38. The males demonstrated a higher level of positive change in beliefs away from didactic teaching but at the same time also had more variation within that change.

Four statements show wide variation in belief change between males and females in the group. Q2 (I believe I should tell learners which questions to tackle) had a mean +0.8 change for males but -0.3 for females while Q24 (I believe Learners themselves should choose which questions they are to tackle) had a mean +0.9 change for males but -0.1

for females. Here males have shown a much stronger move away from didactic beliefs for statements Q2 and Q24 than females. Q12 (I believe I should draw links between topics and move back and forth between several topics) had a mean -0.4 change for males but +0.7 for females while Q23 (I believe I should encourage learners to work more slowly) had a mean 0.0 change for males but +1.0 for females. Here females have shown a much stronger move away from didactic beliefs for statements Q12 and Q23 than males.

There does appear to be *some* gender difference in belief change but this requires more investigation before passing general comments.

➤ **Analysis of possible changes due to 'place of origin'**

There were 7 participants of African origin in the group, 2 participants of Asian origin in the group and 11 participants of European origin in the group. Ignoring the 2 participants of Asian origin as I considered their sub-group too small, I compared the African sub-group with the European sub-group. Their means were very similar +3.1 and +3.5 and it was not possible to identify a strong correlation of 'place of origin' to belief change.

Hidden within this 'place of origin' analysis I found two statements which show wide variation in belief change between Africans and Europeans in the group. Q2 (I believe I should tell learners which questions to tackle) had a mean -0.6 change for Africans but +0.5 for Europeans. Here Europeans have shown a much stronger move away from didactic beliefs for statements Q2 than Africans. Q23 (I believe I should encourage learners to work more slowly) had a mean +1.3 change for Africans but +0.1 for Europeans. Here Africans have shown a much stronger move away from didactic beliefs for statements Q23 than Europeans. Females made up 29% of the African group but 55% of the European group; so this variation in belief changes for these statements may be due to a gender effect rather than a 'place of origin' effect.

➤ **Analysis of possible changes due to 'qualifications in mathematics'**

The participants can be split into two groups by their highest qualification in mathematics. Seven participants had a level 2 qualification (GCSE, 'O' level or equivalent) as their highest qualification in mathematics before embarking on the MEC, they displayed a mean total change in beliefs of +5.3. Thirteen participants had a level 3 qualification (AS, 'A' level or equivalent) as their highest qualification in mathematics before embarking on the MEC, they displayed a mean total change in beliefs of +2.5.

There does appear to be some variation in belief change between these two groups but this requires more investigation before passing more generalised comments.

Interestingly only one statement Q6 (I believe I should try to cover *everything* in a topic) exhibited large differences between the two groups. The level 2 students had a mean change of +0.3 whilst the level 3 students had a mean change of -0.9. Here level 2 participants have shown a much stronger move away from didactic beliefs for statement Q6 than level 3 participants.

• Conclusions

We know there is evidence that many teachers begin their careers with previously constructed, often naive, theories about teaching (Powell 1992). In fact Harel (1994) notes, reflecting comments made by Thompson (1992), that: "teachers' beliefs of what mathematics is and, in particular, how it should be taught are tacitly formed by the way they are taught mathematics in their precollege and college mathematics education" (p115). I am still in the process of confirming these ideas with my research and measuring if these beliefs and hence future teaching pedagogies change during pre-ITE or ITE, but I have seen measurable change.

This paper demonstrates that I do appear to have some evidence to indicate that participation in a pre-ITE MEC, and hence exposure to a variety of teaching approaches, does change the 'beliefs' of pre-ITE students concerning the way in which **they** think mathematics should be taught. In addition this paper indicates that there is a need for further research in this area.

The research in this paper is limited by the size of my participation group of 20 MEC students. This is a very small number to generalise from and therefore any conclusions I arrive at can only really be applied within the context of this small group of individuals.

The belief changes observed in my study need not be a function of the teaching on the MEC course and I am fully aware that the students may have been giving me answers they felt I wanted. There is a need for further research in this particular area. However, anecdotal evidence leads me to feel that the *active* teaching styles used on the MEC are positively contributing to the development of the identity of mathematics teachers.

Even if the belief changes observed in my study turn out to be a function of the teaching on the MEC course, I am fully aware that the students may not turn these beliefs into action and simply teach mathematics as they are encouraged to teach it by their mentors in schools. Having discussed these issues with ex-MEC students from the 2007 cohort who have recently completed their PGCE in 2008 I feel there is anecdotal evidence that this is happening. Again there is a need for further research in this area.

Enhancement Courses are very important in today's ITE landscape. These courses and the ITE pre-learning which take place on them, as part of becoming a teacher, are an under-researched area. The whole area of *subject knowledge* has recently attracted political interest and it is important that as a profession we take the lead in figuring out which professional knowledge, and just as importantly which pedagogy, matters most for the effective teaching of mathematics. It is hoped that if this paper does nothing else it will stimulate dialogue in this area.

The main impact of this paper, hopefully, is on future pedagogical approaches on pre-ITE courses particularly concerning how the teaching of mathematics *subject knowledge* is best approached. Of course it appears obvious that if you want teachers to teach in a less didactic way then their own learning of mathematics should be facilitated in a less didactic way. However, if it really was that easy there

would be less didactic teaching of mathematics taking place and less need for Ofsted reports concerning the quality of mathematics teaching (eg. Ofsted 2006).

As practitioners in ITE and pre-ITE it is difficult to influence the way that mathematics is taught to our students prior to their arrival on our courses. However, we do have an influence over the way that mathematics **is** taught on our ITE and pre-ITE courses.

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- **Appendix I: The difference in responses between the two questionnaires**

The individual students are identified by a number 1-20 in left hand column. The statements Q1-Q25 are listed elsewhere in the paper. The data in each individual cell represents the change in student belief concerning the 'belief statements' during the MEC in 2008. It is the students grading of the statement in July 2008 minus the students grading of the statement in January 2008. A zero represents no change in belief. A positive number represents a change towards a less didactic approach to teaching. A negative number represents a change towards a more didactic approach to teaching. The other data is self explanatory.

		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
1	Female	0	-1	-2	0	0	1	-1	-1	1	0	-1	2	0	1	0	1	1
2	Male	0	0	0	1	-2	1	1	1	1	1	2	1	0	-1	-1	0	0
3	Female	1	1	0	0	0	1	0	0	0	1	0	-1	1	0	1	0	0
4	Male	-1	-2	0	1	0	0	0	0	0	-1	-1	0	0	1	0	0	0
5	Male	0	0	0	0	-2	-1	-2	-1	-1	0	-1	0	1	-1	1	0	1
6	Male	1	1	0	0	0	0	1	0	0	1	0	0	0	0	-1	0	0
7	Male	0	0	1	0	0	1	0	0	-2	2	0	2	0	0	0	0	0
8	Male	0	0	-4	0	0	-4	0	-4	0	0	0	0	0	0	4	0	0
9	Male	1	2	-1	1	0	-1	0	0	0	0	-1	1	0	0	0	2	2
10	Female	0	2	-1	1	0	0	1	-2	0	0	1	0	1	1	0	0	2
11	Female	1	0	-1	1	0	1	0	0	1	2	0	0	0	-1	-1	1	0
12	Female	0	1	0	0	0	-1	0	-1	-3	0	-1	0	0	0	0	0	1
13	Male	0	-2	0	0	0	-2	1	0	1	1	0	1	0	0	-1	0	0
14	Male	1	-1	1	-1	0	-1	1	0	-1	0	0	2	-1	0	1	1	1
15	Female	0	2	0	1	1	2	1	0	1	1	1	-1	1	1	2	1	1
16	Male	0	-1	1	0	0	-1	1	0	0	0	-1	0	-1	-2	-1	1	-1
17	Female	0	0	-2	0	1	0	0	0	1	0	1	-2	0	0	0	1	-1
18	Female	0	0	-1	0	0	-3	-2	0	-1	4	0	-3	2	1	-1	0	-1
19	Female	0	1	-1	0	0	-2	2	0	0	1	1	-1	1	0	0	0	0
20	Female	0	2	0	0	0	-1	0	1	-2	1	0	2	0	0	0	1	1
	Mean	0.2	0.3	-0.5	0.3	-0.1	-0.5	0.2	-0.4	-0.2	0.7	0.0	0.2	0.3	0.0	0.2	0.5	0.4
	St.dev.	0.52	1.25	1.19	0.55	0.72	1.50	1.01	1.09	1.15	1.08	0.86	1.35	0.72	0.79	1.23	0.60	0.88

• Appendix I....continued.

	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Total Q1-Q25	Highest Qualification in maths.	Age Range	Educated majority of time in which COUNTRY between 11 and 16	Educated majority of time in which CONTINENT between 11 and 16
1	1	1	0	-1	2	1	1	1	7	level 2	21-30	UK	Europe
2	0	1	-1	0	0	-1	0	1	5	level 3	21-30	UK	Europe
3	0	0	3	2	-1	2	3	1	15	level 2	31-40	Ghana	Africa
4	1	1	0	0	0	0	0	0	-1	level 2	41-50	Ghana	Africa
5	0	0	0	-1	0	1	1	-1	-6	level 3	21-30	UK	Europe
6	0	1	0	-1	0	1	0	1	5	level 2	21-30	UK	Europe
7	1	0	0	0	0	3	0	0	8	level 2	31-40	Somalia	Africa
8	0	0	0	0	0	4	0	0	-4	level 3	21-30	Ghana	Africa
9	1	-1	1	-1	0	0	1	1	8	level 3	21-30	UK	Europe
10	0	-1	0	2	0	0	1	2	10	level 3	21-30	Northern Ireland	Europe
11	0	1	1	-1	0	0	1	-1	5	level 3	41-50	Bulgaria	Europe
12	0	1	0	0	0	0	-1	-2	-6	level 3	21-30	Romania	Europe
13	2	-1	1	1	0	1	-1	-1	1	level 3	31-40	Algeria	Africa
14	1	0	1	-1	1	1	-2	-1	3	level 2	31-40	Nigeria	Africa
15	2	1	1	1	1	0	2	0	23	level 3	21-30	UK	Europe
16	-1	2	-1	1	-1	0	0	-1	-6	level 3	21-30	UK	Europe
17	1	1	-1	0	0	-2	1	1	0	level 2	31-40	Nigeria	Africa
18	0	1	1	-2	0	-1	-1	0	-7	level 3	21-30	Poland	Europe
19	1	-2	0	-1	2	0	2	0	4	level 3	21-30	Sri Lanka	Asia
20	2	-2	0	0	0	0	0	0	5	level 3	21-30	South Korea	Asia
	0.6	0.2	0.3	-0.1	0.2	0.5	0.4	0.1	3.5				
	0.82	1.11	0.92	1.07	0.77	1.36	1.19	1.00	7.58				

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