UNDERGRADUATE STUDENTS' DEPARTMENTAL AFFILIATION AND CONCEPTIONS OF THE DERIVATIVE

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This paper is a byproduct of a study of first year undergraduate mechanical engineering and mathematics students' conceptions of the derivative. The results indicate that mechanical engineering students develop proclivities towards rate of change aspects of the derivative whilst mathematics students develop proclivities towards tangent aspects. In explaining the differences between the proclivities of the two groups of students, I introduce the notion of students' departmental affiliation. This is followed up by considerations regarding its genesis and implications for students' learning and participation.

THE RESEARCH

The study that this paper stems from set out to investigate first year mechanical engineering (ME) and mathematics (M) students' conceptual development of the derivative with particular reference to rate of change and tangent aspects, and examines contextual influences of the students' institutions/departments on their knowledge development. In order to investigate these issues, the study took an ethnographic approach with a quasi-grounded theory perspective. It was conducted in a large university in Turkey. Data were collected by a variety of means: quantitative (pre-, post- and delayed post- tests), qualitative (questionnaires and interviews) and ethnographic (e.g. observations of semester 1 calculus courses). The pre-, post- and delayed post- tests were applied to 50 first year ME and 32 M degree students. The tests addressed questions regarding 'rate of change' and 'tangent' and were employed to gain insights into how students dealt with rate of change and tangent concepts when questions were presented in graphic, algebraic and application forms. The pre-test was applied to all students at the beginning of the course and there was no significant difference between ME and M students' performance. In the post-test and the delayed post-test, which were applied to the students at, respectively, the end of the first and second semesters, both groups improved their performance but in different ways. Overall, ME students did better than M students on all forms of rate of change-oriented questions whilst M students did better than ME students on all forms of tangent-oriented questions.

Although these results illustrated a clear trend they did not reveal why this trend existed. To explore this further I designed two additional items and applied them after the delayed post-test. These items were given to 45 ME and 32 M students. Due to space limitations I only report on item 2 (see Figure 1) in this paper (see Bingolbali & Monaghan (2004) for further details). The remainder of this paper mainly focuses on students' responses to this item; more specifically, it presents the results from this item first, then introduces and defines the notion of students' departmental affiliation and ends up with consideration of the genesis of departmental affiliation and

implications for learning and teaching.

Item 2: Two university students from different departments are discussing the meaning of the derivative. They are trying to make sense of the concept in accordance with their departmental studies.

Ali says that "Derivative tells us how quickly and at what rate something is changing since it is related to moving object. For example, it can be drawn on to explain the relationship between the acceleration and velocity of a moving object".

Banu, however, says that "I think the derivative is a mathematical concept and it can be described as the slope of the tangent line of a graph of y against x".

a.) Which one is closer to your own derivative definition? Please explain.
b.) If you had to support just one student, which one would you support and why?

Figure 1: An item to explore reasons for rate of change and tangent orientations

RESULTS

I first outline quantitative data (percentages) and then a categorisation of students' reasons for their choices. Tables 1 shows students' responses to item 2.

	ME (n=45)		**M (n=32)**	
Item 2	Item 2a	Item 2b	Item 2a	Item 2b
Ali (A)	51	49	19	13
Banu (B)	27	49	63	78
Both (A &B)	22	2	16	3
Not Attempted (NA)	0	0	3	6

Table 1. Students' responses (percentages) to item 2

For item 2a, whilst half of the ME students (51%) found Ali's rate of changed-oriented interpretation (A) closer to their own understanding, 27% of them found Banu's tangent-oriented interpretation (B) closer to their own view. In contrast to ME students, the majority of M students (63%) found Banu's tangent-oriented interpretation was closer to their own understanding of the derivative while only 19% of them found Ali's rate of change-oriented one closer to their own interpretation. In item 2b, the preference of M students remains the same but note that ME students are equally divided, but there is still a considerable difference between the two groups: 49% of ME but 13% of M prefer Ali's rate of change argument while 78% of M and 49% of ME prefer Banu's tangent argument.

Further to these findings, Table 2 (below) presents a categorisation of students' reasons for their choices in item 2. Repeated reading of students' responses produced six categories: Real life & Application, Mathematical & Scientific, Departments, Practice, Ease and Not Categorised. I first explain what these categories stand for and how I allocated students' responses to these categories. I then give examples of

students' response for each category except the last two (due to space constraint).

Real life & Application This is concerned with students' references to real life or application in explaining their preferences for the rate of change aspect.

> ME student 1: Ali's definition, because his definition is related to real life. It shows the area of application of derivative. I think that maths concepts are attractive in as much as they are applicable.

Scientific & Mathematical This category is used for the students' responses when they refer to the 'mathematicality' of the derivative for choosing the tangent aspect.

> M student 1: Banu gives the definition while Ali gives the explanation. I would support B because Banu explains it in a scientific way.

Department This is concerned with students' references to departments or being engineering and mathematics students in explaining the reasons.

> M student 2: I would say Banu because as a mathematician I can say the same. I guess what Ali says doesn't interest me.

Practice This concerns what happens in calculus courses.

> ME student 2: We are using it in that way and learning it that way'.

Ease 'Ease' here refers to what particular students reported that they found easy to solve. It particularly applies to item 1.

Not Categorised This category applies to responses in which students did not provide 'appropriate reasoning' which could be placed under the prior categories.

Based on these categories, Table 2 shows that in item2-a, 29% of ME and only 9% of M students cited 'real life and application' in explaining their preferences for Ali's rate of change oriented interpretation. 11% of ME students cited their 'department' (e.g. being engineering student) for choosing Ali's interpretation. It is noteworthy that none of those M students who went for Ali's interpretation cited 'department' for their choices. For Banu's tangent interpretation, 25% of M and 13% of ME student cited 'scientific & mathematical' in explaining their choices. 19% of M and no ME student students cited 'department' for choosing Banu's interpretation.

Categorisation of responses	ME students responses to item2				**M students responses to item2**			
	Item2-a		Item2-b		Item2-a		Item2-b	
	A 51	B 27	A 49	B 49	A 19	B 63	A 13	B 78
Real life & application	29	0	29	0	9	0	6	
Scientific &mathematical	0	13	0	29	0	25		28
Department	11	0	11	0	0	19		25
Practice	9	4	7	0	0	19		9
Ease	0	0	0	2	0	0		3
Not categorised	9	9	9	18	9	6	6	19

Table 2: **The analysis of students' written responses (percentages) to item 2**

NB: Note that some responses of the students fall under more than one category.

With respect to item2-b, for Ali's interpretation 29% of ME and 6% of M student cited 'real life & application', further 11% of ME cited 'department' and 7% of them cited 'practice' while no M students cited these categories. For Banu's interpretation, almost the same percentage of ME (29%) and M (28%) students cited 'scientific & mathematical' for their choices. It is noteworthy that 29% of ME students' reasoning concerned with the 'scientific & mathematical' category. It is also noteworthy that 25% of M students cited 'department' in explaining their choice of Banu's tangent interpretation.

Overall, it is notable that none of those ME students who went for Banu's interpretation and none of those M students who went for Ali's interpretation cited department category in explaining their choices. This is a clear indication that being from the ME department directed some ME students to choose Ali's interpretation and being from the M department directed some M students to choose Banu's one. This is also evident in the accounts of some ME and M students who contended that Ali was an engineering or physics student and Banu was a mathematics student.

BUT WHAT DO THESE FINDINGS SUGGEST?

The results show that some ME students refer to 'application', 'real life' and 'being from engineering department' for their proclivities towards the rate of change aspect while some M students refer to 'scientific (mathematical), 'abstract' and, 'being from mathematics department' for their proclivities towards the tangent aspect. I take this as evidence for the way ME and M students perceive of their departments and with the kind of features they associate their departments. The responses of the students also suggest that they identify themselves with these particular features of their departments and acknowledge membership of their departments. I posit that these responses of the ME and M students are evidence for the existence of their departmental affiliation. In other words, the responses that the ME and M students provided for their proclivities are indications that ME and M students affiliate themselves with their departments through referring to their departments' features.

But what exactly is departmental affiliation? How can it be described? To describe departmental affiliation, I draw on the studies concerned with the notion of affiliation discussed in the literature. The term affiliation has been used to refer to individuals' association with or membership to an ethnicity (Lienkind, 1989), religion (Takyi & Addai, 2002), organisation (Lerner, Brush & Hisrich, 1997) and academic department (Portmann & Stick, 2003). Key to these uses is that the term 'affiliation' is used to refer to either individuals' associations with or membership of/belonging to a group or their identification with distinctive cultural patterns of this particular group. In light of the use of term in these areas, I use the term in a similar manner to describe students' departmental affiliation. For the study, I view students' departmental affiliation as 'their identification with distinctive characteristics of and

acknowledging membership of their own departments'.

GENESIS OF DEPARTMENTAL AFFILIATION

In as much as the construct 'students' departmental affiliation' emerged from students' response, it can be claimed that it exists. But where does it come from? Does the development of students' departmental affiliation occur after they embark on their studies at university? Does its development evolve over time and, if so, when is the genesis of the process of this development?

Experiencing their departments through participation in courses and activities, students come to know and interpret what their departments are all about and what is 'valued' and 'privileged' in their departments. The ways they came to interpret, perceive, and 'live' (Lave, 1988) their departments, to a certain extent, brought about their departmental affiliation. But does that mean that students' departmental affiliation can be confined to their experience at the university level? It is evident that some ME and M students come to university, to a specific department, with beliefs and perceptions regarding their departments. They make conscious decisions as to which subject they are going to study before coming to university. Interviews with some ME and M students illustrate this issue and suggest that they formed a kind of special relationship with their subject area at an early stage of their education. For instance, one ME student stated that '*this is the profession I have wanted since ...since I was 7 years old. My father is a mechanical engineer. He always made machines and drew pictures of machine pieces and I was just watching him doing it'*.

Following this and similar accounts reported in Bingolbali (submitted), I argue that students' departmental affiliation, at least for some students, cannot solely be confined to their experiences at the university level. They come to the university with a very strong established 'affiliation' to their departments. But further research is needed as to how the departmental affiliation differs from student to student and whether there is any difference between students of different departments in this sense.

IMPLICATIONS OF DEPARTMENTAL AFFILIATION

I am interested in addressing the issue of implication of departmental affiliation in terms of: (i) students' attendance in optional activities with regard to their departments and (ii) the relationship between students' departmental affiliation and their cognition. I believe that students' interpretations and perceptions of their department, which lead them to form their departmental affiliation, impact on how students locate and 'position' themselves in terms of not only what they do apart from regular courses but also which aspect of a particular concept to learn and privilege. For (i), some ME students, for instance, visited local industrial factories. Some other ME students attended the seminars and activities organised by local mechanical engineering chamber (MEC). In this connection, one ME student stated that "I am a member of MEC and I think I have obtained invaluable information

regarding engineering from this chamber". Considering that the MEC is the organisation of which generally practising engineering are members, it is hence important to note that some ME students were interested in the activities of MEC from the first year of their studies. M students could not attend any such activities because they told me that they did not have any organisations or society in their subject to attend. Some of them, however, indicated that they were helping some secondary and high school students as well as those students preparing for university entrance examinations with their mathematics and they regarded these activities as 'optional activities with regard to their department'.

For (ii), I contend that due to their departmental affiliation, students of each department position themselves according to their professional perspective and this positioning influences their proclivity towards specific forms of knowledge. It is from this perspective, I believe, that many ME students cited the applicability of the derivative concept as one of the main reason for their preferences for rate of change aspects and M students cited scientific and mathematical of derivative as one the main reason for their preferences for tangent aspects. In addition, students also referred to the features of their departments and membership of their departments in explaining their preferred forms of the knowledge. With all these in mind, I posit that it was, for many students, their departmental affiliation that impacted on their developing personal association (being an engineer or a mathematician) towards particular forms of the derivative.

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