THE INFLUENCE OF LECTURERS PRIVILEGING DIFFERENT ASPECTS OF DERIVATIVE ON STUDENTS' CONCEPTIONS

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This paper explores the influences of university lecturers privileging of different aspects of the derivative on mechanical engineering and mathematics students developing conceptions of the derivative. The data are based on interviews with four mathematics and two physics lecturers, observations of calculus courses and students calculus course notes. The results suggest that lecturers: privilege different aspects of the derivative and types of examples; set different questions on examinations; use different textbooks; and perceive the two departments as having distinct mathematical goals and aims. These differences influence students developing conceptions of the derivative.

Research on the mathematical education of engineers is considered as an important issue. Sazhin (1998) and Maull & Berry (2000), for example, explore engineering students' understanding and conceptual development of specific concepts. Sazhin (1998) examines first and third year mechanical engineering students' understanding of some physical and mathematical concepts. He finds that engineering students learn physical concepts and concepts which are more closely related to real life experiences much easier than mathematical concepts. Maull & Berry (2000) examine first and final year mechanical engineering and mathematics undergraduates alongside postgraduate students and professional engineers. They state that "the mathematical development of engineering students is different from that of mathematics students, particularly in the way in which they give engineering meaning to certain mathematical concepts" (ibid, p.916). They note that both groups of students showed similar patterns of responses at entry, but by the final year, the groups' responses diverged. They did not, however, supply reasons for this emergent divergence and called for further research. Bingolbali & Monaghan (2004) explore this further. In a study of mechanical engineering (ME) and mathematics (M) students' conceptual development of the derivative over the first year; they find that ME students develop a proclivity for rate of change aspects of the derivative whilst M students develop a proclivity for tangent-oriented aspects. They argue that calculus practices in each department are likely to play an important role in the growth of this difference. They note that lecturers 'privilege' different aspects of derivative while teaching different departments.

Wertsch (1991, p.124) uses 'privileging' in place of 'domination' to emphasise that a mediational means may be viewed as most appropriate in a particular setting. Kendal & Stacey (2001) illustrate how students' conceptions of the derivative are strongly impacted by the aspect of the derivative privileged by their teachers. In a similar vein, Berger (1998) points out that "the social setting and values . . . may elevate one form of mental functioning over another and in this way privilege a particular form of

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mental operation such as algebraic or graphical reasoning (p.19). In examining socio-cultural values in mathematics teaching from a wider perspective, Bishop, Clarkson, Clarkson, & Seah (2000) also write that “at the institutional level we enter the political world of any organisation in which issues….engage everyone in value arguments about priorities in determining local curricula, schedules, teaching approaches, etc” (p.3). I draw on the idea of ‘privileging’ in explaining lecturers’ practices in this paper. The paper will focus on lecturers’ account of how they teach calculus to engineer and mathematics students, describe the characteristics of their observed calculus course practices, and relate them to the students’ differing conceptions of the derivative.

BACKGROUND OF THE STUDY

The study presented in this paper is a part of an ongoing project investigating ME and M students’ conceptual development of the derivative over the first year. The data for this study were collected from a large university in Turkey. A naturalistic approach to data collection was taken (Lincoln & Guba, 1985). Data were collected by a variety of means: quantitative (pre-, post- and delayed post- tests), qualitative (questionnaires and interviews) and ethnographic (observations of semester 1 calculus courses and student ‘coffee-house’ talk). The pre-, post- and delayed post- tests were applied to 50 first year ME and 32 M degree students. The tests consisted of questions regarding ‘rate of change’ and ‘tangent’ and were utilized to gain insights into: (a) how students dealt with rate of change and tangent concepts when questions were presented in graphic, algebraic and application forms and (b) if there were any differences between ME and M students’ performance in the different forms of these questions. 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 was set at the end of the first and second semesters respectively, both groups improved their performance but in different ways. Overall, ME students outperformed M students on the all forms of rate of change-oriented test items whilst M students outperformed ME students on all forms of tangent-oriented questions.

RESEARCH METHODS

The data presented in this paper were obtained: (1) through semi-structured interviews with four mathematics and two physics lecturers and (2) from the observations of calculus courses and students’ calculus courses notes. Lecturers interviewed were those who taught in a department other than their own. One of the mathematics lecturers (L1) was teaching calculus in engineering department and another one (L2) was teaching the same course in this own department. The other two mathematics lecturers (L3&L4) had taught mathematics in engineering departments in previous years. Two physics lecturers were selected to find out how they taught engineering and mathematics department and their reports were considered to provide insight into how these departments were perceived from the outside. One of the physics lecturers (L5) had taught physics in both engineering and mathematics

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departments. The other lecturer (L6) taught physics in the engineering and biology but not in the mathematics department.

Lecturers were asked: (1) if they teach engineering and mathematics students in a different way, (2) if they set different types of questions in examinations, and (3) if they use different textbooks for different departments. Since the interviews were semi-structured, there was scope to pursue directions raised by the lecturers. Lecturers' responses to the interview questions were transcribed and analyzed. Analysis consisted of repeated rereading of transcripts and noting/categorizing statements which appeared to shed light on lecturers' perceptions of ME and M students and their mathematical needs.

An observation schedule was employed to follow lecturer and students' activities in each ME and M calculus classroom and also record the duration of the time spent on each activity. These observations were compared with students' notes. My intention was to gain insights into which aspects of the derivative were privileged in each department. Examination questions were also looked at to find out what kinds of questions were privileged in examinations.

RESULTS

The results are presented in four sections. First, excerpts from lecturers' interviews regarding the way they teach engineering and mathematics departments, and the results of an analysis of calculus courses observation and students' notes are presented. Second, lecturers' reports about the types of questions they set in examinations for different departments and an analysis of the questions set in calculus examinations are described. Third, lecturers' reports on the textbooks used in different departments are presented. Finally, lecturers' views of their teaching in different departments are given with specific reference to departmental goals and aims.

Lecturers privileging particular aspects and examples

All six lecturers point out that whilst teaching in different departments they focus on different aspects of a topic. They indicate that this difference particularly occurs in delivering specific aspects of the concepts and relevant examples. In the following excerpts mathematics lecturers are responding to whether they teach mathematics and engineering students in different ways:

> L1 Well of course, in engineering departments it is more application-oriented.... I give examples regarding objects in motion with regard to time, pressure, and so forth... That is why, I focus on rate of change aspects with engineering students. But in our department we focus more on concepts rather than on application aspects, for example, tangent aspect.

Other lecturers also make similar comments. For example, in the M calculus course, L2 spent more time on tangent than on rate of change and when asked why, he states:

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L2 If they were physics department students, lots of examples regarding physical meanings of the derivative would be given. But in mathematics department the derivative as a concept is prioritised. For maths students to see just how it can be applied is enough.

As for what happens in calculus courses, lecturers' privileging of derivative were established by observation of their lessons and students' course notes. The analysis of observations and students' notes (see, table 1) shows that ME students were taught more application (rate of change) aspects of the derivative while M students were taught more theoretical or tangent-oriented aspects. The results further reveal that although a similar number of theorems were given in both departments (23 to ME and 20 to M), proofs of 85 % of the theorems were provided in M but only 43 % in ME department.

	Rate of change		**Tangent**	
	ME	M	ME	M
Duration examples	≈133 minutes (9 examples)	≈11 minutes (no examples)	≈10 minutes (no examples)	≈85 minutes (7 examples)

Table 1: The general analysis of ME and M calculus course' observations and student notes

Lecturers setting different questions in examinations

When asked if they reflect this difference with regard to concepts and examples in examination questions as well, all lecturers state that they set different questions in examinations for different departments. Some excerpts are given below:

L1 Mathematics students would be specialists in this area…they need to know this job's reason and logic. That is why you can ask them theorems in their examinations. This is their job. You can ask them some definitions as well. Nevertheless if you do this in engineering departments, it would not do anything good to them but get them bored.

The other mathematics lecturers also state that they set theorems in mathematics calculus examinations but not in engineering calculus ones. They indicate that they set application problems for ME examinations. Physics lecturers also make similar remarks.

L3 You have to ask theoretical questions to maths students anyway. Questions are all applications in engineering, but 40% theoretical and 60% application in maths department.

The analysis of ME and M departments' mid-term and final calculus courses reveal that lecturers reinforce the difference in their teaching in examinations questions. One rate of change and no tangent question was set in the ME mid-term examination while one tangent and no rate of change question in the M final examination. M students were asked to prove two theorems in both their mid-term and final examinations but engineering students were not asked to prove a theorem.

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Lecturers privileging different textbooks

Both mathematics and physics lecturers point out that they make use of different textbooks or privilege different parts of the same textbook for different departments. When asked if they use different textbooks for different departments, lecturers report:

L3 Of course, the books that we give our mathematics department students include more theoretical stuff and include theorems and proofs. But in engineering departments, books are more real life or application-oriented ones.

L1 The books I use in engineering department are generally application-oriented ones…. But in our department I would use those books which include more theorems and proofs…

Lecturers' awareness of distinct departmental goals and aims

Both mathematics and physics lecturers put forward that while teaching in different departments, they make amendments in their instructions and prioritise different aspects of a particular concept. They view the two departments as having distinct mathematical and physical goals and aims. For instance when asked if they teach students' according to their departmental goals or why they teach in different ways, lecturers state:

L1 They demand from us some stuff. It is like we use mathematics here and there, we want our students to know this and that so that they can be successful in the coming years' modules

L3 The starting point and main aim is where maths and engineering students make use of maths. Maths students need to know everything but engineering students only need to know the parts which are useful for them.

L2 explains the aim of M calculus as:

"It is how to have students comprehend theoretical thinking. I mean how to attain a theoretical thought. And to get them know what proof methods are and how to carry out them. We try to make students comprehend this in the maths department".

Physics lecturers also articulate similar remarks regarding engineering and mathematics departments:

L6 Topics are presented so that they are useful for department's job… are close to these departments features. And I think this is the right thing. You need to give topics in accordance with each department's feature so that they are useful to students.

DISCUSSION

All lecturers interviewed state that they privilege different aspects of a specific concept whilst teaching in different departments (though not in these words). In the case of derivative concept, as table 1 shows the ME students' calculus course privileged rate of change or application aspects whilst the M students' calculus

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course privileged tangent aspects and theorem-proof aspects. Given students' developing conceptions, it is likely that calculus practices in each department have played a crucial role in the emergence of the different tendencies in these two groups of students' performances. It is reasonable to infer that each particular privileging fosters or affords development in certain directions and constrains it in others (Greeno, 1998). In parallel with what they privilege in their lessons, the results also show that lecturers' privileging is manifest in both the examination questions that they set for different departments and textbooks they use for teaching.

The crucial question here is: why do lecturers privilege different aspects of the same topic or concept in different departments? It is clear from lecturers' interviews that lecturers are quite aware of this particular privileging and do it deliberately. The common reasons for why they carry out their practices in different ways are attributed to: distinct departmental goals, aims (L2, L3), departmental features (L5,L6), departmental demands (L1), and usefulness for student (L3, L6). It is thus reasonable to infer that lecturers perceive the two departments as having distinct mathematical or physical aims and carry out and amend their practices accordingly.

It can be posited that lecturers perceive that different institutions or departments attribute particular 'values' (Bishop et al., 2000) to particular forms of knowledge. This perception has to do not only with lecturers' experience of teaching in particular departments but also the way departments historically and culturally are perceived. This accumulated "repertoire of experiences, images" (Schön, 1983, p.60) and perception of each department lead lecturers as "professional practitioner" (ibid.) to carry out their practices accordingly. It is, then, rational that different departments' students' developing conceptions are affected by practices to which they are being exposed.

To sum up, lecturers carry out their practices in accordance with the departmental perspectives and privilege institutionally-valued aspects and students' conceptions develop in parallel with this perspective. Therefore research into students' conceptions of subjects at the university level should pay attention to students' departmental differences.

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