

Problematic Topics in First-Year Mathematics: Lecturer and Student Views—A Review Paper

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Abstract: *In this paper we report on the outcomes of two surveys carried out in higher education institutions of Ireland; one of students attending first-year undergraduate non-specialist mathematics modules and another of their lecturers. The surveys aimed to identify the topics that these students found difficult, whether they had most difficulty with the concepts or procedures involved in the topics, and the resources they used to overcome these difficulties. In this paper we focus on the mathematical concepts and procedures that students found most difficult. While there was agreement between students and lecturers on certain problematic topics, this was not uniform across all topics, and students rated their conceptual understanding higher than their ability to do questions, in contrast to lecturers' opinions.*

Keywords: higher education

I. INTRODUCTION

It is generally agreed that students have problems transitioning from mathematics at secondary level to mathematics in higher education and that significant numbers of students have not mastered the basic mathematical skills required for first-year undergraduate mathematics modules [1–3]. A number of studies have identified particular topics that prove problematic for students [4–7]. However, from the research carried out to date, it is not clear if students have difficulties with both the concepts and procedures involved. Additionally there is little evidence to suggest that students can identify these problems themselves and hence seek to redress them. As part of a larger project on the development of technology-enhanced formative assessment resources to support teaching and learning in first-year undergraduate nonspecialist mathematics modules, lecturers and students in higher education institutions (HEIs) in Ireland were surveyed. The purpose of the surveys was twofold: to identify mathematical topics, concepts and procedures that are problematic for first-year undergraduate students in HEIs; and to determine the resources currently in use by students, those recommended by lecturers to help overcome these difficulties and suggestions for new resources. This paper presents findings from the former; the latter will be discussed in a subsequent paper [8]. The research questions addressed in this paper are:

1. What topics do students attending first-year service mathematics modules deem to be problematic?
2. Is it the concept or the procedure related to the topic that students identify as causing the most difficulty?
3. What concepts and procedures do lecturers identify as problematic for their first-year service mathematics students?

II. BACKGROUND

This project focuses on the period of transition from secondary to higher education and the requirement for students to have an understanding of basic mathematical concepts and procedures in order to succeed in first-year undergraduate mathematics modules. The literature that follows examines transition and mathematical understanding in this context, after providing a brief overview of the Irish higher education system.

Mathematics during transition to higher education

Clark and Lovric [10] identified the transition to mathematics in higher education as a ‘rite of passage’ where students move from one set of practices and beliefs formed at secondary to a new set in higher education. Guedet [11] identified the difference in teaching methods between secondary and higher education as being partly responsible for students’ difficulties in transitioning, suggesting that appropriate online resources may be helpful in developing students’ autonomy during this transition. As a result of the widening of access to higher education [2, 12, 13] the range of

mathematical abilities demonstrated by incoming first-year undergraduate students has increased. This, coupled with the difficulties associated with the transition to mathematics in higher education, has resulted in many students being inadequately prepared for mathematics. A number of studies in the UK [2,14] and in Australia [4,13,15] found that students in first-year undergraduate programmes demonstrated a lack of understanding of some of the basic mathematical concepts required. Tariq [16] conducted a study of 326 first-year biosciences students' mathematical ability from seven different institutions in the UK and found that students were better at mathematical calculations than word problems, suggesting that they lacked conceptual understanding of mathematics

Mathematical understanding

Students' conceptual understanding and procedural skills were assessed in a study undertaken by Engelbrecht, Harding and Potgieter [17] in the University of Pretoria in South Africa. They found that students did not perform better in procedural problems over conceptual ones and they were more confident in their ability to do conceptual rather than procedural problems. The authors suggested that this may be attributed to a new approach that had been taken for the teaching of this course where conceptual thinking was cultivated. However, in a further study, Engelbrecht, Bergsten and Kagesten [18] found that engineering students often attempted to solve conceptual problems using procedural techniques. Mahir [19] examined students (n = 62) who had just completed first-year Calculus courses in Turkey on their conceptual and procedural knowledge of integration and concurred with Engelbrecht et al. [18] that students who possessed adequate conceptual knowledge could also perform the procedures. Similarly, Mahir [19] found that most students did not possess a conceptual understanding of integration and were inclined to use routine manipulations and procedures rather than a conceptual approach to solving integration problems.

III. METHODOLOGY

Two surveys were carried out at the start of this project: one of students attending first-year undergraduate mathematics modules in the four HEIs involved and the other of lecturers teaching first-year undergraduate mathematics in all of the HEIs on the island of Ireland. The questions were developed by the nine members of the project team in the four HEIs.1 The mathematical topics selected were all on the OL LC curriculum and were mostly on the first-year undergraduate curriculum in the four HEIs involved and are similar to those used by Dalby et al. [4]. The questionnaire was piloted on different groups of students, the results analyzed and the questionnaire adjusted accordingly. The final questionnaire had 46 Likert item questions followed by seven open-ended questions, of which two are relevant to this paper.

IV. CONCLUSION

In this paper we examined and compared the responses to surveys completed separately by students and lecturers. In general, students were optimistic about their ability to complete question types that they were likely to have encountered in first-year undergraduate mathematics modules. Students who had taken OL mathematics at LC were less optimistic than those who had taken HL. Similar results were found in Australia [4–6], Spain [7] and the UK [16]. However, it has been shown that in some cultures and countries there are cultural differences in university students' confidence in their educational ability [28]. In answer to the first research question we found that the most problematic topics identified by students were integration, differentiation, functions, logs and limits. The second research question aimed to identify whether students considered the concept or procedure of the topic caused them difficulty. Students rated their ability to Understand higher than their ability to Do the question types and considered the methods of calculus caused them more problems than the ideas In this paper we examined and compared the responses to surveys completed separately by students and lecturers. In general, students were optimistic about their ability to complete question types that they were likely to have encountered in first-year undergraduate mathematics modules. Students who had taken OL mathematics at LC were less optimistic than those who had taken HL. Similar results were found in Australia [4–6], Spain [7] and the UK [16]. However, it has been shown that in some cultures and countries there are cultural differences in university students' confidence in their educational ability [28]. In answer to the first research question we found that the most problematic topics identified by students were integration, differentiation, functions, logs and limits. The second research question aimed to identify whether students considered the concept or procedure of

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