COMPUTER ALGEBRA RELATED CONCEPTIONS AND MOTIVATIONS OF UNIVERSITY MATHEMATICS LECTURERS AN INTERNATIONAL STUDY

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As a consequence of sizable investments in technology, Computer Algebra Systems are becoming more accessible and widely used in mathematics teaching and learning in universities. However, little is known about the factors influencing the integration of technology at the university-level. To better understand the affect of technology incorporation on mathematics education a number of school-level studies have focused on the relationships between teachers' conceptions of mathematics, mathematics teaching, and technology as well as on various social and cultural factors. My study investigates the relationships of these factors at the university-level paying particular attention to cultural elements by taking an international comparative approach.

INTRODUCTION AND AIMS

Mathematical understanding and computer proficiency are vital ingredients not only in the education of future scientists, engineers, and teachers but also for the economic well-being of any nation. However, universities in most developed countries report that their students are mathematically ill-prepared for their studies. A number of studies have attempted to tackle this problem by examining teaching, learning, and teacher preparation at the pre-university level. Nevertheless, university-level mathematics departments, the principal suppliers of mathematics teaching for other departments, are seldom studied. Mathematical software packages, which are increasingly being integrated into university classrooms, provide further didactic and research challenges. My research aims to investigate the integration of a significant example of a computational tool – Computer Algebra Systems (CAS) – into university mathematics teaching. It will focus on developing a model of university teachers' CAS-related didactic beliefs in relation to their manner of CAS integration into teaching. This model will assist in the better understanding of present CAS-enhanced teaching practices and will contribute to the development of a warranted pedagogy for CAS use. More specifically, I will examine

- the extent to and manner in which CAS are currently used in university mathematics departments;
- the pedagogic and mathematical beliefs and conceptions university mathematics lecturers hold with regard to CAS including factors influencing their professional use of CAS;
- the extent to which nationally situated teaching traditions, frequently based on unarticulated assumptions, influence lecturers' conceptions of and

motivation for using CAS.

CONTEXT

University mathematics departments are under twofold pressure – to facilitate the mathematical development of their own specialist students and, at the same time, provide the means by which the mathematical needs of students specializing in other subject areas can be addressed (Thomas & Holton, 2003). In addition, adding to the complexity of these tasks – new computer-based mathematical tools have revolutionized some areas of the subject creating both cognitive and pedagogic dilemmas for practitioners (Wong, 2003). Furthermore, universities, in response to the encouragement of governmental agencies, are spending large sums of money on the integration of technology into their teaching of mathematics which is frequently viewed as a means of reducing teaching costs, particularly in respect of service courses designed for science and engineering students (Thomas & Holton, 2003). However, at the earlier school level, evidence has now accumulated that, despite the variety of expectations and the generally wide accessibility of ICT, the predicted explosion in the integration of technology use in schools has not taken place (Kaput, 1992). Indeed, studies have shown that high access to ICT does not always result in high use of these applications (Cuban, Kirkpatrick, & Peck, 2001). There have been many projects attempting to enhance our understanding of the learning opportunities afforded by ICT (Lagrange, Artigue, Laborde, & Trouche, 2003), but there have been no comprehensive studies that overview ICT use especially at the university level. Therefore, there is an apparent need for a study that outlines the extent of ICT use in university mathematics teaching and investigates factors influencing the integration and efficacy of technology applications in that area.

RATIONALE

Computer Algebra Systems, which combine capabilities for symbolic, numeric and graphic computation, have a distinguished position among ICT applications because of their general applicability in a variety of mathematics topics, and thus their potential to become a powerful instrument in students' mathematical toolkit. Noss and Hoyles' (2003) characterization of mathematical software packages also illustrates CAS' prominent role. They distinguish between two forms of mathematics education software – programmable microworlds and expressive tools. In general, the former support teaching and learning of specific courses while the latter may provide tools for use beyond the scope of particular courses. Software like CAS, developed as powerful computational and visualization tools for mathematicians, but later adopted for instructional purposes, falls into the latter category. It is argued that achieving proficiency in the use of such complex mathematical packages may influence students' future studies and professional work as CAS remains a powerful computational instrument for solving emerging mathematical problems (Artigue, 2005). Thus, theorised findings from the examination of such an exemplary mathematical tool at the university level could also be applicable to other technology applications and at different educational levels.

At the school level, technology integration is influenced greatly by teachers' conceptions, beliefs, attitudes, and motivations (Kendal & Stacey, 2001; Ruthven, Hennessy, & Brindley, 2004). Furthermore, international comparative studies on secondary school teaching have also demonstrated that teachers' didactical beliefs and conceptions of the subject, as well as the characteristics of their classrooms and their relation to technology, are heavily affected by teaching traditions and geographic locations (Andrews & Hatch, 2000; Beaton & Robitaille, 1999) However, little is known about such influences on university teachers' pedagogical integration of ICT, and there is no study that examines the influence of teaching traditions at the university level. Hence, I aim to examine CAS related and mathematical conceptions – paying particular attention to influencing factors of teaching traditions - of university lecturers in order to better understand trends of CAS integration in university level teaching. For my investigation, I adopt Thomson's (1992) inclusive notion in which conceptions include a "notion of belief system … viewed a more general mental structure, encompassing beliefs, meanings, concepts, propositions, rules, mental images, preferences, and the like" (Thompson, 1992, p. 130). In addition to the investigation of teachers' conceptions, I will examine what external factors influence the integration of CAS into teaching, because a recent British study suggests, at the secondary school level, that ICT integration is informed by a combination of mathematics departments' cultural values and governmental policies (Hennessy, Ruthven, & Brindley, 2005). However, possibly due to the professional autonomy of university teachers internal factors are the overwhelming influence in higher education.

The issues described do not usually transcend national boundaries. Adopting an international research perspective, however, enables researchers to better understand local phenomena through comparison with other systems (Clarke, 2003). Also, internationally conducted research facilitates researchers and practitioners learning from each other (English, 2002). Moreover, the recent surge in international comparative research, at least at school level, has undoubtedly contributed to our understanding of issues in mathematics education. Therefore, my research will investigate how teaching traditions have influenced CAS enhanced teaching practices, adding to international comparative studies at the university level.

Much of the intellectual need of this study, however, rest on the commitment to develop a model for university lecturers' CAS-related didactic beliefs in relation to their manner of their CAS integration. Particular sets of beliefs about Computer Algebra Systems are manifested in specific ways in the classroom. Furthermore, as teaching deeply influenced by traditions a comparative study highlights this influence on teachers' beliefs (Stigler & Hiebert, 1999). Thus, by examining these beliefs we can illustrate how cultural scripts generated and maintained by teachers affect students' understanding of concepts. Thus, the study will create a model, a typology of beliefs and actions, to understand these manifestations and to find how a particular type produces its effects on students' learning in relation to the teachers' objectives. The motive behind my specific research design is to tease out the thinking behind the different ways of working manifested in the sorts of activity that teachers employ in classrooms, and to devise a typology for them so as to be able to contribute to the development of a warranted pedagogy for CAS use, sensitive to particular teaching traditions. The study's implications for teaching, research, and policy will derive both from this model and from the factual information about CAS use at universities.

RESEARCH DESIGN

School-level studies investigating teachers' conceptions of mathematics, its teaching, and technology employ either qualitative or quantitative approaches depending on their proposed research questions. Findings of these studies complement the breadth and depth of each other. In addition, researchers often draw from or clarify results of studies conducted with another research paradigm. However, my proposed research aims necessitate taking both qualitative and quantitative approaches. Therefore, in my study, I exploit a mixed method approach utilizing an *across-stage mixed-model design* (Johnson & Onwuegbuzie, 2004). Therefore, the design of the study involves two distinct but related phases. The first phase is currently underway following Grounded Theory methodology (Glaser & Strauss, 1967). It takes the form of a qualitative study intended to expose key factors in connection with CAS integration and comparative research. After piloting the instruments in England and Hungary, I conducted semi-structured exploratory interviews, observed classes, and collected course materials in selected universities in Hungary, UK and US. Currently, I am analyzing this data set following the analytic and coding techniques of Grounded Theory (Strauss & Corbin, 1998), using the qualitative software package HyperResearch.

Drawing on results of analyses of these data, I will construct a questionnaire, which will address, in a variety of ways, the issues uncovered during the first phase of the project. The questionnaire will incorporate the questionnaire design of Andrews and Hatch (2000) and include a selection of open and closed items concerning lecturers' beliefs about and experience of CAS. The analyses will vary according to the nature of the items concerned. Closed items are likely to be subjected to factor analyses and multidimensional scaling while open items will be examined by qualitative techniques and HyperResearch software. The final questionnaire will be distributed electronically, in Hungary, UK, and US, in early 2006 after revision according to a pilot study and consideration of cultural and language related issues. The preliminary sampling indicates, utilizing the 30 percent response rate estimation of Laughbaum's (1999) hand held technology study in the US, that distributing 3000 questionnaires to lecturers will most likely yield the desired 800-1000 responses essential for statistical validity. For sampling, I will employ official lists of universities and multi-stage sampling methods considering various characteristics of universities, departments, and lecturers. Nonetheless, sampling methods and the questionnaire design will be explicitly developed following the detailed data analysis from the first phase of the study.

CONCLUSION

With my study, I aim to provide a comprehensive overview for researchers about the current state of CAS use in universities and by this I hope to assist in the coordination research projects and research priorities. Furthermore, I hope that my model will add to the development of a warranted pedagogy of CAS and in general ICT use in various levels of mathematics teaching. In addition, mathematics lecturers may also benefit from this study by becoming more conscious about issues of CAS and integrating findings into their practices. In sum, results of this study will contribute to the understanding of CAS potential and actual use in several ways. It will

- provide a measure of CAS use at a large number of universities,
- allow insight into academics' understanding of and thinking about CAS and their relationship to teaching/cultural traditions and identify characteristics of effective practice in respect of CAS use.

Therefore, it will enable researchers and practitioners to

- pinpoint directions for improvements and limits of CAS applicability,
- assist in the possible development of CAS training workshops,
- align research into local practices with international trends,
- test and validate an international comparative research instrument.

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