DEVELOPING ON-LINE QUESTIONNAIRES FOR MATHEMATICIANS

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In this paper I will discuss the development of an on-line questionnaire that I have designed for my dissertation research. By employing this questionnaire, I aim to gauge university mathematicians' use of Computer Algebra Systems (CAS) in undergraduate mathematics courses and to understand their thinking about the advantages and disadvantages of CAS use in university-level teaching. The development of the questionnaire is based on an interview study with mathematicians that I conducted in 2005. Thus, I integrate issues that emerged from this earlier study with concerns described in the mathematics education literature. The complexity of the questionnaire design is complicated by the fact that I am examining mathematicians in three countries, Hungary, the United Kingdom, and the United States, which requires me to consider different aspects of international comparative research and differences in cultures. I will report on the difficulties that I encountered during the design process of this questionnaire and highlight issues which researchers must pay attention to when they decide to use on-line questionnaires.

INTRODUCTION AND AIMS

Anecdotal evidence suggests that Computer Algebra Systems are becoming an integral part of university-level mathematics teaching and learning. In the past two decades, a number of studies examined various uses of CAS in classroom settings and students' learning in CAS-equipped environments in higher education. However, little attention has been paid to why and how CAS is being integrated into the university curriculum, what factors influence CAS integration, or to its sustained use in a university environment. In contrast, several school-level studies examined the integration of technology and its sustained use in schools (Hennessy, Ruthven, & Brindley, 2005). In addition, from time to time large scale studies and international comparative surveys mapped the use of technology in schools (Becker, 2000; Gonzales et al., 2004). These school-level studies demonstrate that technology is still lightly used in schools despite the heavy investment by schools and governments and that technology integration greatly depends on teachers' conceptions of technology and social/cultural factors. In my study, I aim to investigate the extent of current use of CAS, mathematicians' conceptions of CAS-assisted teaching and the influence of social and cultural factors on technology use at the university level.

DESCRIPTION OF THE RESEARCH PROJECT

For my study I chose a particular software called Computer Algebra Systems because CAS is the most widely used mathematical software in university-level mathematics. In addition, I wanted to choose a technology application that is not only a general

software but is directly related to mathematics. Building on the research conducted in schools, I posed three questions to explore CAS use and CAS integration at universities:

1. To what extent and manner are Computer Algebra Systems currently used in university mathematics departments?
2. What mathematical and pedagogic beliefs and conceptions do mathematicians hold with regard to CAS including factors influencing their professional use of CAS?
3. To what extent do nationally situated teaching traditions, frequently based on unarticulated assumptions, influence mathematicians' conceptions of and motivation for using CAS?

The first question attempts to provide an overview of the current use of CAS in universities similarly to quantitative studies conducted at the school-level. The second question examines mathematicians' conceptions revealed by school-level studies as a key factor of technology integration into the mathematics curriculum. Finally, the third question investigates the influence of teaching traditions on CAS integration. By answering these questions I aim to provide a basis for researchers to build research projects on in order to more closely investigate issues of technology integration. Furthermore, I hope that I will be able to highlight differences and similarities between findings on the use of technology at universities and at schools.

The posed questions obliged me to employ conflicting research paradigms. The *Mixed Methods* approach, backed by pragmatist philosophy as Johnson and Onwuegbuzie (2004) argue offer a plausible resolution of this conflict. Therefore, in this study, I utilize an *across-stage mixed-model research design* (Johnson & Onwuegbuzie, 2004). In accord with this design, during the past year, I conducted a qualitative study to uncover issues that can be further investigated in a quantitative investigation (phase I). I conducted exploratory interviews with 22 mathematicians at a range of universities in Hungary, the United Kingdom, and the United States. In addition, I observed classes and collected course material during my university visits. Based on the results of this investigation I have developed a quantitative study (phase II) to further examine issues which arose in the first phase.

Results of the first phase of the study support school-level findings and show that the integration of CAS into university mathematics curricula is heavily dependent on mathematicians' conceptions of CAS and CAS-assisted teaching (Lavicza, in press). In addition, the study revealed a number of personal and external factors that influence CAS integration and sustained use of CAS in university mathematics education [1].

ADVANTAGES AND LIMITATIONS OF ON-LINE QUESTIONNAIRES

The organization of emerged issues – seeking connections

The first phase of the study identified a large number of issues that would be worth further investigation but the restricted length of the questionnaire forced me to

identify and investigate the most significant issues. Over a 7-month period, I worked on the selection of these issues and piloted questionnaire items in several rounds. Finally, I developed a questionnaire that supplies data for the following clusters of variables:

- Mathematicians' personal characteristics/institutional backgrounds
- Mathematicians' current use of CAS in teaching
- Mathematicians' conceptions:
  - CAS viability in mathematics education
  - CAS self-efficacy
  - CAS Role in Mathematics Literacy
  - CAS-assisted Teaching and Learning – affordances and dilemmas

In the analysis of the data I aim to establish connections among the three clusters of variables (Figure 1).

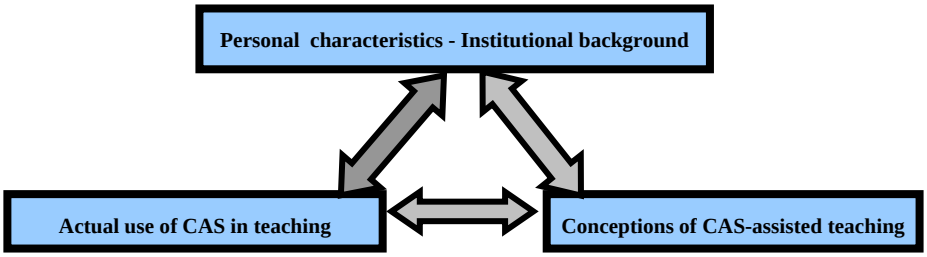

Figure 1

The 'personal characteristics and institutional background' clusters describe mathematicians' background and their work/career history. Essentially the independent variables of the study are situated in this cluster. The "actual use of CAS in teaching" cluster attempts to reveal the extent of CAS use in university-level teaching and learning. The "conceptions of CAS-assisted teaching" cluster attempts to expose mathematicians' thinking about CAS-assisted teaching. As Figure 1 shows these connections, I will examine how mathematicians with particular personal characteristics and institutional background think about CAS-assisted teaching, or how/why they use CAS in their teaching. In this way, I might be able to identify characteristics of particular mathematicians that make them likely or unlikely users of CAS-assisted teaching. Identifying such characteristics can be valuable for the development of CAS training programmes. I also seek to explore relations between conceptions of mathematicians and their actual use or non-use of CAS. This information can also result in valuable characterization of mathematicians. In addition to the three clusters, I aim to expose the reasons why mathematicians begin or avoid using CAS in their teaching practice.

International considerations

Due to the international characteristic of my study I had to consider the differences among cultures while developing my questionnaire. Osborn (2004) offers a suitable framework by establishing four equivalence criteria:

1. Conceptual equivalence – examines if concepts used in the study have any equivalent meaning in different cultures.
2. Equivalence of measurement – develops equivalent indicators for concepts.
3. Linguistic equivalence – suits the meaning of the text of the questionnaires to the particular cultures.
4. Sampling equivalence – ensures the representativeness of the sample in a particular country or culture.

On-line questionnaires

In order to develop a comprehensive study, I have to reach a sizable number of mathematicians. Due to the financial and time restraints, I decided to utilize on-line survey techniques to conduct the second phase of my study. Schonlau, Fricker, and Elliott (2001) list a number of advantages of web surveys over surveys administered on paper. On-line surveys are usually: 1) Less time consuming; 2) just as good or better than traditional surveys; 3) much cheaper to administer; 4) easier to execute. However, researchers also warn about the potential drawbacks of web-based questionnaires as 1) various technological problems might arise 2) responders may have different computer expertise causing loss of data quality 3) it is difficult to ensure data security 4) it is hard to draw a random sample 5) unlike paper questionnaires, responders are not in control of the entire questionnaire 6) response rate of web-surveys are usually lower than paper/mail surveys. For my study advantages of on-line questionnaires outweigh the disadvantages because examining mathematicians as the population of the study provides plausible resolutions for difficulties that generally arise in on-line questionnaire studies.

Sampling issues

One of the most daunting problems arose in my study when I began developing the sampling strategy that satisfies Osborn's (2004) sampling equivalence criteria. While formulating my sampling frame I decided to develop sampling that is the most representative for the selected country rather than trying to design a strategy that is applicable for the three selected countries.

The large number and great variety of higher education institutions in the US (about 4000), compared to the UK and Hungary, caused a considerable difficulty in developing the sampling frame. Finally, I was able to restricted my sample to 1478 US, 157 UK, and 52 Hungarian institutions. After estimating the population of mathematicians (35,000 in the 3 countries), I selected 3,500 mathematicians following a rigorous sampling strategy.

Issues of response rate

Besides developing an appropriate sampling frame, acquiring an acceptable response rate is the most crucial issue that contributes to the validity of the study. Most on-line and traditional survey methodology papers discuss response rate as a key issue (Cook, Heath, & Thompson, 2000; Couper, Traugott, & Lamias, 2001; Manfreda, Batagelj, & Vehovar, 2002). In spite of attempts to increase response rates with a

variety of techniques, Dillman, Tortora, and Bowker. (2001) suggest that response rates for all kinds of surveys have been declining since the early 1990's. This tendency especially accelerated due to the emergence of on-line questionnaires. People are receiving an increased number of solicitations to participate in research studies or marketing research, and they are unlikely to respond to most of these appeals. In addition, technology contributes to lowering response rate because it is fairly easy to delete e-mail solicitations from electronic mailboxes. However, the on-line survey literature offers several ideas for the enhancement of higher response rates. Authors suggest that it is important to distinguish the study from other research projects, and that researchers should make potential participants interested (Sax, Gilmartin, & Bryant, 2003). In addition, it is important to properly invite participants, act upon their requests/feedback, and remind them to fill in the questionnaires. Moreover, keeping the questionnaire reasonably short - a maximum of 20 minutes - will increase participation (Solomon, 2001). Finally, offering incentives may prove to be an effective tool to increase response rates. I am using these considerations to improve the response rate of my study.

Visual appearance

Because web-based questionnaires offer a wide range of opportunities for different visual design, this topic is extensively discussed in the research literature. Studies suggest that simple and low-graphics design has highest success rates (Couper et al., 2001).

SUMMARY

I hope that my study will be able to provide a measure to show how CAS is currently used in universities in three countries. In addition, I hope that I will be able to offer insight how mathematicians envision the use of CAS in university-level mathematics teaching and learning. Certainly, this phase of the study may not offer deep insight into the details of CAS use, however, by identifying mathematicians and institutions, details can be further investigated in the continuation of this study. In addition, using an on-line questionnaire methodology, I will be able to contribute to the methodological debates in this area.

NOTES

1. Detailed results will be found in Lavicza (in preparation).

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