

UNDERGRADUATE MATHEMATICS TEACHING PROJECT

A METHODOLOGICAL REPORT OF WORK-IN-PROGRESS

Barbara Jaworski University of Oxford

Elena Nardi University of East Anglia

Stephen Hegedus University of Oxford

The Undergraduate Mathematics Teaching Project¹ (UMTP) is a one-year study aiming to characterise, and identify issues related to, mathematics teaching in undergraduate tutorials. It builds on earlier research into mathematics learning in undergraduate tutorials and involves a research collaboration between mathematics educators and mathematicians. From participant observation, semi-structured interviewing, and group discussion, it develops a set of qualitative data which is analysed through repeated critical scrutiny to distil characteristics and issues of the teaching experienced which might be seen as germane to a wider variety of settings. Here we discuss the methods of data collection and of the currently ongoing data analysis.

The broad aim of the Undergraduate Mathematics Teaching Project (UMTP) is to explore, in a collaboration between mathematics educators and university mathematics teachers, current thinking and practices in mathematics teaching at first year undergraduate level. It seeks to elicit relationships between the enacted teaching, the mathematics being taught, the aims and objectives for students' learning, and the perceptions of those teaching (the tutors) and those observing (the researchers). It will begin to provide a knowledge base on which to make decisions affecting practice in university teaching and illuminate an under-explored area of influence on mathematics teaching more widely.

¹ This project is funded by the Economic and Social Research Council (ESRC) Award Number R000222688.

The research develops from two previous studies. The first explored undergraduates' mathematical learning difficulties in first year tutorials (Nardi, 1996) – in particular students' appreciation of abstraction and formalism. The second study followed from the first: data, in the form of transcripts of tutor-student dialogues, and analyses were presented to the tutors (whose tutorials were observed in the first study) to explore their related thinking and reactions (Nardi, 1998). Both studies provided strong evidence of the potential of tutorials as a source of rich data, allowing insights into learning and teaching.

Theoretical perspectives

The research is embedded in a growing theoretical area which focuses on the development of knowledge in advanced mathematics, and the difficulties students face in dealing with mathematical abstraction. The work in the area of Advanced Mathematical Thinking (e.g. Tall, 1991) is highly relevant and the work of Nardi, quoted above, fits into this tradition. The current study seeks to relate these theoretical perspectives to issues in teaching.

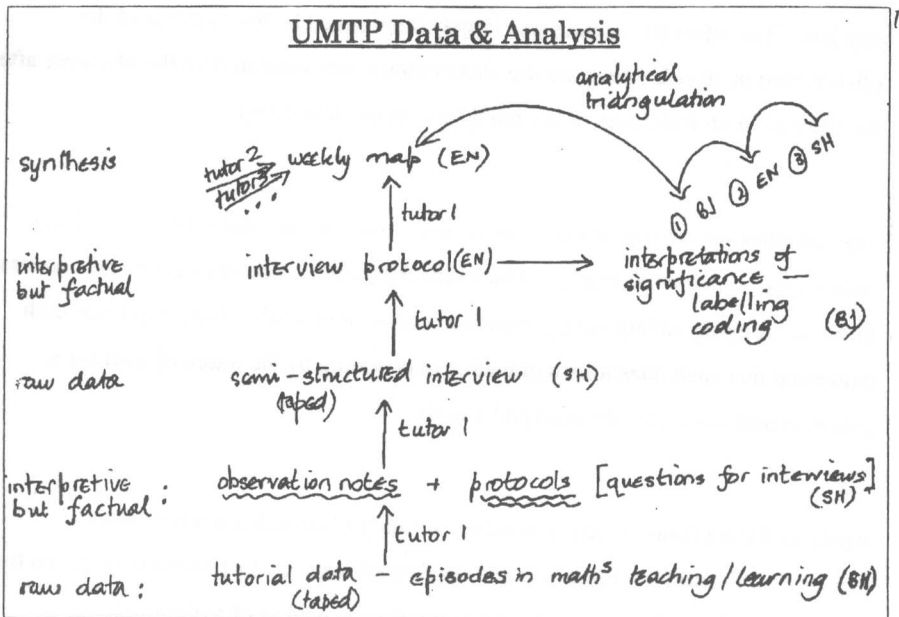
There is an extensive, curriculum-based, literature in this area, mainly in North America, which seeks to relate undergraduate learning to methods of teaching. For example, alternative approaches to calculus (e.g. Ferrini-Mundy & Graham, 1991), linear algebra (e.g. Carducci, 1993) or group theory (e.g. Leron & Dubinsky, 1995) reflect, in part, on attempts to make these subjects more engaging and meaningful for the majority of students. However a general perception remains that the teaching of mathematics at the undergraduate level has not to date made sufficient effort to deal with the backgrounds and needs of present day students. The research described here aims to go beyond particular practices, to seek a more general awareness and understanding of the relationships between teaching and learning at undergraduate level. It draws also on research at other levels of mathematics

teaching, seeking commonalities and differences. For example, it explores the use of the Teaching Triad, used to characterize and analyze mathematics teaching at secondary level (Jaworski, 1994).

Methodology of Data Collection and Data Analysis

The UMP methodology might be described as *critically qualitative* with a strong emphasis on *participation* (Jaworski, 1994; 1998). Participants are university researchers (3: BJ/EN/SH) and mathematics tutors (6). *Qualitative* data is sought to allow access to the complexities of tutors' epistemology and its relation to pedagogy. The *critical* nature of the research is in its questioning of processes and practices at all levels.

In the following we describe the processes of data collection and the currently developing data analysis. These processes are presented in condensed form in Fig.1:



The process of data collection outlined below was formed and rehearsed in a Pilot Study, which focused on 7 tutors and lasted one week. Two hours of tutorials were observed for each tutor. A 30 minute interview followed. The purpose of the pilot was to try out observational and interview approaches, data gathering techniques and analytical procedures; to induct tutors into research practices; and to enable the researchers to adjust, critically, the mutuality of their perceptions of the research methodology.

During the main study, approximately two hours of each tutor's *tutorials* were *observed* and *audio-recorded*. Also *observation notes* were taken. Learning and teaching episodes from the tutorials were selected and formed the basis of the interview agenda. The interview with the tutor followed shortly – a few hours or a day later. The interview agenda was largely determined by the contents of the *observation protocols* (these are the observation notes annotated by the observer after the tutorials with indicators of potential foci for the interview).

The *interviews* were *semi-structured* around these foci and audio-recorded. They lasted approximately 30 minutes. Questions from researchers to tutors sought access to tutors' thinking underpinning observed actions in tutorials. The earlier research suggested that such questions will lead to questioning by the tutors of their own practices and associated theories and beliefs.

Analysis during data-collection involved scrutiny of recorded interviews and production of *interview protocols* and condensed *maps* of the interview contents for the purpose of a preliminary ordering of the data as well as of maintaining an overview of content. An interview protocol is a time-indexed factual account of the

interview contents, one for each interview. A map is a weekly, abbreviated 6-column table with each column corresponding to the interview contents of one protocol. Data collection lasted 8 weeks.

After data-collection the interviews were *transcribed* and, along with the interview protocols and the maps which act as second-order data, are now scrutinised in order to extract characteristics and issues. Discussions in research group meetings are recorded and support the analysis of the interviews (Wagner, 1997).

Meetings between the researchers and the participants during the study developed a *clinical partnership* (*ibid.*). There, the researchers shared their ideas about the aims of the project and enabled a critical environment for the tutors to reflect and comment on the researchers' methods and preliminary characterisations. This, inevitably, refined and re-shaped the methodology as the researchers synthesised the participants' perceptions of the research and their personal expectations.

Characterisation involves seeking processes, practices and issues which might be seen to be germane to a larger number and wider variety of settings. Rigour is to be ensured through triangulation between alternative data sources, and a transparency of contextualisation and critique (Delamont and Hamilton, 1984; Ball, 1990). The three researchers are currently engaged in a process of *analytical triangulation*: using the various data sources, they attach, independently of each other and by means of currently forming procedures of labelling and coding, interpretations of significance to the data. Individual interpretations are then submitted to a tri-lateral scrutiny. It is intended that once this process is implemented to the totality of the data, a unified analytical framework will emerge and a consolidation of the analysis will follow.

References

- Ball S.J. (1990) 'Self doubt and soft data : social and technical trajectories in ethnographic fieldwork' in Qualitative Studies in Education, Vol 3 no 2, 157-171
- Carducci O.M. (1993) 'Four elementary Linear Algebra projects' in PRIMUS, Vol 3, No 4, 337-343
- Delamont S. and Hamilton D. (1984) 'Revisiting classroom research: a cautionary tale' in Delamont S. (Ed) Readings on interaction in the classroom, Methuen, London pp 3-24
- Ferrini-Mundy, J. & Graham, K. G. 1991. 'An overview of the calculus reform effort: issues for learning, teaching, and curriculum development.', American Mathematical Monthly, 98(7), 627-635
- Jaworski, B. (1994) Investigating Mathematics Teaching: A Constructivist Enquiry. London: Falmer Press
- Jaworski, B. (1998) Mathematics Teacher Research: Process, Practice and the Development of Teaching. Journal of Mathematics Teacher Education, 1: 3-31
- Leron, U. & Dubinsky, E. 1995. 'An Abstract Algebra Story', American Mathematical Monthly, 102(3), 227-242
- Nardi, E. (1996) The Novice Mathematician's Encounter With Mathematical Abstraction: Tensions in Concept-Image Construction and Formalisation. University of Oxford: Doctoral thesis.
- Nardi, E. (1998) Tutors' Reflections Upon the Difficulties of Learning and Teaching Mathematics at University Level: A Report of Work-in-Progress. Proceedings of the Conference of The British Society for the Research into Learning Mathematics. Birmingham 1998.
- Tall, D. 1991. Advanced Mathematical Thinking, Dordrecht / Boston / London: Kluwer Academic Publishers
- Wagner, J. (1997) The Unavoidable Intervention of Educational Research: A Framework for Reconsidering Researcher-Practitioner Cooperation. Educational Researcher. Vol. 26, No. 7. Pp. 13-21