Towards a naturalistic conceptualisation of technology integration in classroom practice: The example of school mathematics

Kenneth Ruthven
Towards a more naturalistic perspective

• *Through the evolution of day-to-day classroom work of pioneering teachers with computers the prospects of deep change become more real.* (Papert, 1997)

• *Schooling is capable of no more than a slow incrementalism that will only marginally reshape deeply entrenched structures.* (Cuban, Kilpatrick and Peck, 2001)

• *If technology is to find a place in classroom practice it must be examined in the context of classroom life as teachers live it.* (Kerr, 1991)

• Teaching resources are necessarily incorporated into wider systems of classroom practice. (Ball and Cohen, 1996)
Eliciting practical theory of technology use

• This line of research focuses on the *practical theory* and *craft knowledge* that frame teachers’ thoughts and actions.

• Teacher accounts of successful technology use elicited through focus group interviews with subject departments.

• In later studies, nominated examples followed up through classroom observation and teacher interview.

• Evidence-base analysed qualitatively to map central themes and primary relationships between them.

• In the initial study, incidence of themes across sites, and coincidence of themes within accounts, analysed quantitatively to generate a model of practical theory.
Desired states assisted through technology use

- Enhancing ambiance
- Assisting tinkering
- Facilitating routine
- Accentuating features
- Improving motivation
- Intensifying engagement
- Alleviating restraints
- Effecting activity
- Raising attention
- Establishing ideas

(Ruthven & Hennessy, 2002)
Craft knowledge needed to achieve desired states

• With dynamic geometry, for example, teachers:
  – Established a ‘tidying’ routine in which students eliminated spurious points and lines created onscreen due to difficulties in physically manipulating the pointer.
  – Introduced lesson segments bridging between a dynamic geometry figure and what might otherwise have appeared to students as a dissimilar static counterpart. (Ruthven, Hennessy & Deaney, 2005)

• With graphing software, for example, teachers:
  – Developed expertise to support students in debugging unexpected graphs, and in modifying graph displays to underpin mathematical interpretation of results.
  – Adapted whole-class questioning techniques to exploit the opportunity to use the software to provide immediate feedback on student predictions. (Ruthven, Deaney & Hennessy, 2009)
Structuring features of classroom practice

- Key constructs distilled from synthesis of two literatures
- Recent studies of technology use in school mathematics
- Earlier studies of situated teacher expertise

(Ruthven, 2007)
Making use of computer-based tools and resources in teaching is often associated with changes in physical layout, class organisation, and classroom routines. (Jenson & Rose, 2006)

The concept of working environment focuses on the physical surroundings in which lessons are conducted, and the associated general infrastructure and organisation.

With the use of new technologies, routines which help lessons to start, proceed and close in a timely and purposeful manner often have to be adapted. In particular, organisational routines need to be established through which equipment is made ready and resources accessed for use, and through which results are recorded and shared.
Resource system

• Although new tools and materials are often represented as displacing old, it is more common to find some form of ‘double instrumentation’ involving both old and new.

• The concept of resource system focuses on the combined functioning of all the mathematically-related tools and materials in classroom use, particularly in terms of their compatibility and coherence.

• Thus resource is used here to refer to some (physical or virtual) artefact which has either been designed specifically for curricular purposes, or been the subject of educational appropriation for such purposes.

• The use of system reflects the challenge which teachers face in combining what otherwise would be merely a collection of resources to function in a co-ordinated way aligned with their teaching goals. (Amarel, 1983)
The concept of *activity format* focuses on the templates for action and interaction which frame the contributions of teacher and students to a particular type of lesson segment. (Burns & Anderson, 1987; Burns & Lash, 1986)

The crafting of lessons around familiar activity formats and their supporting classroom routines helps to make them flow smoothly in a focused, predictable and fluid way permitting the creation of prototypical *activity structures* or *activity cycles*. (Leinhardt, Weidman & Hammond, 1987)

The development of technology use in mathematics lessons is often associated with changes in activity formats (notably to incorporate the teacher-student-machine triad) and activity structures (notably towards more exploratory and discursive approaches) (Monaghan, 2004; Trouche, 2005)
• The concept of *curriculum script* focuses on a loosely ordered model of relevant goals and actions which guides the teaching of a topic, interweaving ideas to be developed, tasks to be undertaken, representations to be employed, arguments to be constructed, and difficulties to be anticipated. (Leinhardt, Putnam, Stein & Baxter, 1991)

• Teachers often talk about their use of new technologies in terms that appear to involve the adaptation and extension of established curriculum scripts, calling in particular for modified and extrapolated development of a topic.

• Sometimes, however, when teachers participate in development projects, they experience pressure (often self-administered) to abandon their existing curriculum script in pursuit of more ‘innovative’ approaches. (Monaghan, 2004)
Time economy

• The concept of *time economy* (Assude, 2005) focuses on how teachers manage the ‘rate’ at which the physical time available for classroom activity is converted into a ‘didactic time’ measured in terms of the advance of knowledge.

• Many studies report teachers’ concerns about the time costs of integrating technology into the curriculum.

• In particular, the ‘double instrumentation’ in which old and new tools are used alongside one another typically gives rise to additional time cost rather than the substitution and reduction implied by talk of a ‘time bonus’.

• A critical issue is what teachers perceive as the return in terms of recognised mathematical learning from investing in students using new tools.
An investigative lesson with dynamic geometry

• Application of framework to analyse existing case record.
• Session §39.036: Research on Mathematics Teaching and Learning in Secondary Schools
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• Scheduled Time: Wed, Apr 15 - 10:35am - 12:05pm
• Building/Room: San Diego Convention Center /Room 5A
An investigative lesson with dynamic geometry

- **Working environment** shifting between ordinary classroom conducive to lesson introductions, and new computer room where required organisational routines being established.
- **Resource system** developed such that, despite perceived lack of congruence, manual and computer tools are seen as fulfilling complementary roles.
- **Activity formats** developed around debugging of student-generated figures and redrafting of student-generated textbox formulations of geometrical properties.
- **Curriculum script** extended by exploiting dynamic potential to pose relational problem, calling for elaboration of teacher mathematical knowledge.
- **Time economy** shaped by concern for progression in student learning and valorisation of double instrumentation.
The focus here is on the functional organisation of teacher knowledge for accomplishing concrete professional tasks.

There may be political interest and epistemic value in trying to classify teacher knowledge as being of (subject) content or pedagogy, or some irreducible fusion of ‘pedagogical content knowledge’. (Wilson, Shulman & Richert, 1987)

Likewise, given the transparency of old technologies, there may be merit in highlighting a new technological aspect through three-way analysis culminating with ‘technological pedagogical content knowledge’. (Mishra & Koehler, 2006)

However, while development of some elements of a functionally-organised system of craft knowledge may be assisted by decontextualisation in terms of PCK or TPCK, it is not reducible to this.
Concluding thoughts

- This framework seeks to make certain crucial – but often overlooked – aspects of incorporating new technologies into classroom practice visible and analysable.

- By providing a system of constructs closer to the lived world of teacher experience and classroom practice, this framework may fulfil an important mediating function, allowing insights from more decontextualised theories to be translated into classroom action, and serving to draw attention to practical issues neglected in such theories.

- Although only employing a dataset conveniently available from earlier fieldwork, the case analysis starts to illuminate the combined influence of the key structuring features.

- The framework needs to be subjected to fuller testing and corresponding refinement through further studies in which both data collection and analysis are guided by it.