The construct of 'resource system' as an analytic tool in understanding the work of teaching
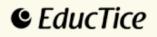
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Outline

- Notions of 'resource' and 'resource system'
- Euclid's *Elements* as a systematic logical organisation of resources
- Durell's *A New Geometry* as a systematic didactical organisation of resources
- From a multi-sourced collection of resources to an organised system
- The evolving notion of classroom resource system in the Structuring Features framework
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- Concluding thoughts

Notions of 'resource'

- Established everyday usage
  - a monetary, material or human asset capable of providing some form of support
- Specialised educational usage from 1960s onwards
  - curriculum-related materials to support learning or teaching activity
- Enabling and associated trends
  - Audio-visual and reprographic facilities broadened range of media for materials and facilitated local reproduction
  - Further shift has been taking place towards digitalising resources and accessing them online
  - Traditional library has become the modern 'resource centre' intended to support 'resource-based' learning and teaching

Notions of 'resource system'

- Central idea of a 'system' is one of organisation
  - some structure resulting from multiple entities being organised to form a functioning whole
  - some scheme or method which provides a basis for such organisation
- Corresponding notions of 'resource system' within the professional field
  - expanding the notion of textbook -– systematic curriculum scheme combining diverse resources into coherent programme
  - expanding the notion of library – resource repository organised systematically to make contents readily searchable and usable
- Further notions recently developed within our research field
  - to be examined in due course

Euclid's Elements as a systematic logical organisation of resources

- Created around 300 BCE and widely studied until the early years of the twentieth century

- Combined and adapted mathematical sources already available to produce a comprehensive and coherent text

§ 5. THE FORMAL DIVISIONS OF A PROPOSITION.

"Every problem," says Proclus[1], "and every theorem which is complete with all its parts perfect purports to contain in itself all of the following elements: enunciation (πρότασις), setting-out (ἔκθεσις), definition or specification (διορισμός), construction or machinery (κατασκευή), proof (ἀπόδειξις), conclusion (συμπέρασμα). Now of these the *enunciation* states what is given and what is that which is sought, the perfect *enunciation* consisting of both these parts. The *setting-out* marks off what is given, by itself, and adapts it beforehand for use in the investigation. The *definition* or *specification* states separately and makes clear what the particular thing is which is sought. The *construction* or *machinery* adds what is wanting to the datum for the purpose of finding what is sought. The *proof* draws the required inference by reasoning scientifically from acknowledged facts. The *conclusion* reverts again to the *enunciation*, confirming what has been demonstrated. These are all the parts of problems and theorems, but the most essential and those which are found in all are *enunciation, proof, conclusion.* For it is equally necessary to know

Euclid's Elements as a systematic logical organisation of resources (concluded)

- Came to fulfil an important sociocognitive function as a canonical text

- Provided a shared framework – both of substantive knowledge and argumentative forms – supporting and shaping the diffusion and development of mathematical knowledge

- Found favour within liberal education exposing students to classical models of thought displayed in 'great books'

- Intended to teach students to reason in an abstract realm removed from sensory perception

Durell's *A New Geometry* as a systematic didactical organisation of resources

Durell acknowledges the documentational genesis of *A New Geometry*

It is now almost fourteen years since the author's *Elementary Geometry* was published, and, in writing this entirely new book, he has taken the opportunity to recast his treatment of the subject in the light of the experience gained, and the suggestions received, since *Elementary Geometry* appeared. He has been able, also, as will be seen later, to make full use of the Second Report of the Mathematical Association on the Teaching of Geometry.

(i) *Examples for oral discussion.*

These are illustrated extensively by diagrams in order to simplify black-board work.

This oral work gives the pupil a clear understanding of the relevant facts, familiarises him with the arguments which will be used later in the formal proofs of theorems, and trains him in methods for solving riders. It includes, when appropriate, questions in which the data are numerical.

(ii) *An exercise of numerical examples.*

This gives practice in applying the facts deduced from oral discussion and ensures a firm grasp of these facts.

(iii) *Formal proofs of the corresponding theorems.*

The preliminary work makes it possible to deal with these proofs rapidly. Practice in writing out theorems is essential for examination purposes, but it will often be found sufficient to confine this to the key-theorem of each group, regarding the others as simple riders.

(iv) *An exercise of riders.*

The early examples in each exercise are direct and very simple applications of the properties of the group. Some assistance is supplied for the harder examples, but notes on method and hints of useful constructions are included in the text.

Durell's *A New Geometry* as a systematic didactical organisation of resources

- This core part of the text corresponds to the first sense of resource system as systematic curriculum sequence combining resources into a coherent programme

- Further features of the text correspond to the second sense of resource system as a repository of resources catalogued systematically so as to be readily searchable and usable

- Such a text is designed with the creation of a compact but comprehensive resource system in mind; meeting the various needs of teachers and pupils over the course as a whole.

- It is this explicit and systematic didactical organisation which makes Durell's text identifiably a textbook.

From a multi-sourced collection of resources to an organised system

- As resource-based approaches to teaching and learning became increasingly influential, there has been a shift away from the traditional model of a single course text.

- A key feature of resource-based initiatives during the 1970s and 1980s, such as SMILE, was development of a curriculum map into which carefully chosen (or specially devised) resources from different sources could be inserted

- In the case of SMILE, this curriculum map came to be paralleled by a graded assessment system, GAIM, based on criteria describing specific cognitively-based strategies which represent significant steps in mathematical development.

- A modern counterpart of this type of subject-specific 'shell' – for managing curricular resources and integrating assessment – is the Math-Mapper digital learning system organised around learning trajectories.

From a multi-sourced collection of resources to an organised system (continued)

- Initiatives such as SMILE developed into comprehensive curriculum programmes, distributed well beyond the contributing schools and teachers, and sustained by a group of core participants responsible for 'minding the system'

- Recognising that the local insertion of resources into such 'shells' makes considerable demands on teachers, Math-Mapper comes prepopulated with suitable curricular resources, so taking on a form closer to the contemporary e-textbook or digital curriculum programme

- Such trends indicate the continuing importance of comprehensive, externally developed systems of resources in supporting mathematics education in many schools

Researching teachers developing resource systems

- Recent research has approached the idea of a resource system through the teacher

- It has looked in particular at how teachers develop professional knowledge through the process of appropriating diverse resources to turn them into functional tools for teaching

The evolving notion of classroom resource system in the Structuring Features framework

- SFCP originated with a particular focus on the adaptation and development of teachers' professional knowledge in the course of seeking to incorporate digital mathematical tools into their classroom practice

- In outlining the SFCP framework, the structuring feature of 'resource system' made reference to the material resources – and different types of resource – in use in the classroom and to the ways in which their use – individually and collectively – is organised and made functional

- An example – developed from an earlier study – was presented of the evolving classroom practice and professional knowledge of a mathematics teacher introducing use of dynamic geometry software (Ruthven, 2009)

Establishing a rationale for integrating the new tool into the classroom resource system

- The teacher's intention was to complement established construction tasks using classical tools by introducing new tasks employing dynamic software

- The rationale for this double instrumentation was twofold:
    - to strengthen attention to the geometric ideas underpinning constructions through their mediation by named software actions
    - to give students experience of finding geometric rules and patterns through exploring a dynamic figure in ways impossible with static diagrams

- However, the teacher was finding the correspondence between classical and digital techniques to be imperfect in some important respects, reducing the desired congruence between old and new tools

Developing techniques and norms for a functional classroom resource system

- The teacher was developing knowledge of how the nuances of software operation might derail students' attempts at construction, but also of how such difficulties might be turned to advantage in reinforcing the mathematical focus of the task

- Recognising that students did not always appreciate the significant geometrical properties of a figure, the teacher was developing strategies for addressing this, notably through dragging

- Finding students deflected from the mathematical focus of tasks by ease of experimenting with software presentational options, the teacher sought to manage this by showing appropriate use of differing fonts and colour coding

- In these ways, then, the teacher was developing new techniques and norms contributing to a more effective functioning of the classroom resource system

The evolving notion of classroom resource system in the Structuring Features framework

- In a later study, the SCFP framework was applied more directly to investigation of teaching practices involving use of dynamic geometry software (Bozkurt, 2015; Bozkurt & Ruthven, 2017)

- Here, I will compare the classroom resource systems established by the least and most technologically experienced teachers in their teaching of the topic of transformations

- Both teachers sought to establish a classroom resource system in accord both with their didactical preferences and with their level of comfort with the technology

Similarities in classroom resource systems

- Teachers had students make use of the software rather than restricting its use to teacher demonstration to the whole class

- Teachers demonstrated unfamiliar features of the software in advance of students tackling tasks requiring these features

- The first task then assigned was typically intended to give students experience in using these features for themselves

- The material resources in play typically comprised prepared dynamic files and accompanying printed worksheets which gave instructions on how students should use the files and set aside space for them to record predictions and report findings

- Teachers pointed to ways in which, through providing forms of feedback, use of the software helped to create a classroom resource system which facilitated processes of self-testing and self-correcting by students

Differences in classroom resource systems

- Provenance of resources
  - Whereas the most experienced teacher had refined his own file/worksheet duos over a lengthy period, the least experienced teacher adopted a collection of duos found online
- Degree of task direction and closure
  - Whereas the least experienced teacher subsequently modified the borrowed worksheet to provide more explicit direction towards particular outcomes, the most experienced teacher provided task environments that were quite tightly constrained but allowed students to pursue different solution strategies
- Balance between media
  - Whereas the least experienced teacher subsequently added further worksheets to give students "practice on paper [of] what they had… seen on the computer", the most experienced teacher placed more emphasis on working within the dynamic software environment, projecting screens showing students' work to support class discussion of different strategies

Critical reflection

- Within the SFCP framework, the idea of classroom resource system has been used to date in a loosely defined manner

- This has had the advantage of ensuring that the construct is well grounded empirically, through allowing flexibility in identifying relevant phenomena and accommodating them

- However, as our knowledge of such phenomena grows, particularly across a wider range of educational contexts, it would be beneficial to demarcate the construct in a more precise manner, and to start to break it down into component parts and clarify their interrelation

The notions of 'resource' and 'document' in the Documentational Approach

- The DA adopts an expansive notion of resource as comprising not just material but non-material human and cultural assets

- The central concern of the DA is with the resource systems of teachers over the whole span of their professional activity

- In the psychologically influenced DA a crucial distinction is made between an artefactual *resource* and the result of its appropriation by a user (perhaps in combination with other resources) to form an instrumental *document* – comprising the resource(s) plus an associated *utilization scheme*, the latter conceived in terms of observable *usages* and not-directly-observable *operational invariants* governing these

The evolving notion of resource system in the Documentational Approach framework

- Early formulations of the DA avoided the term 'resource system', emphasising that:
  - "[E]ach resource must be viewed as a part of a wider 'set of resources' (used here instead of 'resource system' which suggests an *a priori* structure of the resource sets)." (Gueudet & Trouche, 2009)

- In due course, however, the DA embraced the term, while maintaining the crucial distinction between artefactual resource and instrumental document:
  - "The resource system of the teacher constitutes the 'resource' part of her documentation system (i.e. without the scheme part of the documents)." (Gueudet & Trouche, 2012)

The evolving notion of resource system in the Documentational Approach framework

- The rationale for considering this to be a system is that:
  - "each 'renewing' of a resource impacts on other teacher resources, and may have different outcomes for what we name teacher resource system — the word 'system' is purposefully chosen to emphasize that this system is highly structured, the structure being linked, more or less explicitly, to teacher activity." (Gueudet, Pepin & Trouche, 2013)

- Such structuring of the resource system may be attributable to the structure of the documentation system:
  - "Identifying [the] documentation system allows, for example, understanding the adoption or rejection of resources by the teacher (a new resource is more likely to be integrated if it matches other resources already present in the teacher's resource system)." (Gueudet et al., 2014)

Schematic representation of teacher resource systems

- However, a characteristic method used in DA studies suggests other types of structuring of a teacher's resource system

- In this method the researcher asks the teacher to draw a schematic representation of their resource system

- Typically, it seems, the process of eliciting such representations brings out socio-spatio-temporal dimensions of the organisation of teachers' work as well as the form and function of resources

Dimensions of teachers' representations of their resource systems

- A teacher identifies four 'zones' with which resources are associated: her work at home; her work at school without students; her work at school in the classroom with her students; her work in in-service training collectives (Gueudet & Trouche, 2012)

- A teacher's representation is configured first by worksite – home or school, linked by USB key – then, within site, by the places where resources are kept – e.g. shelves, bedroom or computer at home – and by resource form – emails, books, scientific journals, paper folders, digital folders (Gueudet, Pepin & Trouche, 2013)

- A teacher groups resources, first, according to function – lesson preparation, or communication with pupils and parents; then, for lesson preparation, according to form – audiovisual and online resources, games and similar activities – and status – the adopted textbook, other textbooks – or provenance – her own, from her colleagues (Gueudet, Pepin & Trouche, 2013)

Critical reflection

- The DA framework draws attention to two perspectives on teacher resource systems:
  - One deriving from the theorisation of teacher documentation systems with its focus on utilization schemes
  - Another operationalised in terms of teachers' representation of their resource systems in varied terms, including as the socio-spatio-temporal organization of their work as well as the form and function of the material resources available to them
- it would be beneficial to further clarify the relationship between these perspectives
- It would be interesting to explore congruences, complementarities and conflicts between the DA and theories of distributed cognition and situated knowledge which offer alternative socioculturally informed accounts of the organisation and development of professional knowledge

Concluding thoughts:
the protean 'resource system'

- Ideas of 'resource system' differ considerably in the ways in which they demarcate 'resources' and formulate 'system'.
- Equally, closer examination shows that different perspectives situate 'resource system' in contrasting ways:
  - as adhering to a particular type of agent – teacher, student, designer – or as intervening between such agents
  - as related to a specific educational entity – especially the classroom, the course, or the lesson – or as ranging across and beyond these
- Professionals and researchers have clearly found each of these variations useful for some purpose
- Could we benefit from a correspondingly overarching notion of 'resource system'?

Concluding thoughts:
beyond the teacher focus

- Within the research field, particular attention has been given to teachers in relation to resource systems

- This is reflected both in the specific aims of the studies conducted and the sources of data used

- There is scope, then, to develop theories and methods which give greater attention to other agents, notably students