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MAPPING THE SYLLABUS: MULTIMODAL DIGITAL MAPPING TOOLS

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ABSTRACT

This article focuses on an exploratory study on the use of digital mind mapping tools in a secondary ICT classroom in the UK. It uses a multimodal lens to examine students' meaning making practices as they engage with, and seek to map out, the ICT syllabus. In the analysis of data generated by the study, I consider the concept of the classroom as a multimodal learning space characterized by the overlap and dynamic interactivity of cognitive, physical and virtual environments. In so doing, I seek to show how students negotiate meanings across formal (syllabus) and informal (peer-supported) contexts. I describe ways in which this negotiation of meaning across multiple contexts facilitates and reshapes students' understandings of syllabus content. I go on to discuss the wider implications of these findings for technology-mediated learning in educational contexts, with a particular focus on the motivational and functional potential of digital mapping technologies in the classroom.

INTRODUCTION

The students in the research setting explored in this paper were following a course of study in ICT at AS (Advanced Subsidiary) level. Traditionally they studied the theoretical element of the course in note form supported by written texts in the form of a course textbook, paper articles, presentations and/or online course materials. Using these materials, students found it difficult to make connections between the different parts of the course syllabus. They tended to treat each section of the course as a separate entity, e.g. this chapter looks at presentation software, or this chapter looks at use of the Internet, and in so doing, failed to benefit from overlapping areas where different technologies shared similar features or dealt with similar issues, e.g. navigational structures, user requirements, etc. This paper presents findings from an exploratory study which looks at the use of digital mind mapping tools by students as a means of mapping the syllabus holistically and dynamically. It turns a multimodal lens on students' activities and meaning-making processes in and through the forms of representation and modes of content used to elaborate their studies. In so doing, it seeks to identify the motivational and functional aspects of multimodal digital mapping tools as a support for teaching and learning in the secondary school classroom. More specifically, this paper addresses the following question:

How might the use of digital mapping tools in the classroom:

1. enhance students' understanding of the wider contexts of a subject syllabus?

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2. reshape students' cognitive engagement with a subject syllabus?
3. motivate students' learning in and out of the classroom?

A qualitative methodology was used for the study, which included a teacher-generated syllabus map, student-generated mind maps and student-generated audio and video materials. Students' understanding of and engagement with the syllabus was measured through analysis of their digital mind-maps and related audio/video texts, together with a pre-project survey on the use of mind maps for learning. Motivational aspects were measured using a post-project questionnaire. It was anticipated that use of the digital mapping tools would encourage students to work cooperatively and with greater independence of the teacher and that the use of a range of interoperable technologies would enhance students' understanding of the contexts of the syllabus as well as motivate them to take their learning further and wider than was the case with traditional methods of studying theory in the ICT syllabus.

DIGITAL MAPPING TOOLS AS A SUPPORT FOR LEARNING

Digital mapping tools offer multiple modes of representation, ranging from a 'flat' (2D) representation of branch, text and image as map or visualisation to the incorporation of fully multimodal resources such as text, image, sound, moving image, animation, colour and the use of hyperlinks. The multimodal potentials of such features introduce the possibility for a multi-dimensional approach to learning, enabling conceptualisation to occur both at a surface level (actual interface) and at a metalevel (through hyperlinking). In this way, connections are able to be made both locally at the micro level and globally at the macro level (Novak and Cañas, 2006, p. 24), by direct embedding within the digital mind map or as a link to other digital texts on local and/or global networks. In contrast to conventional mind mapping activities, digital mapping tools offer a dynamic, distributed learning environment which expands the physical learning space and affords students a means of developing, organising and structuring their ideas using higher-order thinking skills and thereby enhancing their understanding of the subject syllabus or topic area (Novak and Cañas, 2006, p. 15). As such, the assumption behind the present study was that the use of digital mapping tools as a means of exploring the subject syllabus might usefully generate a hypermodal, digitally enhanced environment for knowledge sharing amongst students.

In this study, mind mapping (Buzan, 2000) was favoured over the concept map approach (Cañas et al., 2005). Mind mapping is a radial tree-like structure branching out from a central idea whilst concept mapping is a more structured activity where connections are made between linking concepts and 'labelling' of these connections forms an essential component in the construction of knowledge. It was felt that mind mapping offered a less structured approach, encouraging creative 'leaps' of thought, spinning out of a central theme or idea rather than constructing connected themes/ideas in a hierarchical manner. In so doing, it was anticipated that mind mapping would offer greater scope for students to generate unanticipated connections between topics and technologies and would deter them from adopting the hierarchical approach already prevalent in their existing textbooks and support materials. Buzan's (2000) description of mapping content as comprising colour,

images, words, lines, connectivity, units, holographic content, arrows, codes, geometrical shapes, etc. provided a useful starting point for an exploration of the multimodal potentials of digital mapping tools and was used in this study to explore the visual and spatial potentials of the screen (Jewitt, 2006) and the location/placement of key concepts within students' maps.

STUDENTS AS AUTHORS OF DIGITAL TEXTS

A report commissioned by Pew Internet, Lenhart and Madden (2005, p. 8) suggests that, in out-of-school contexts, teen content creators "create and share all kinds of content" including visual images, videos, music, stories, photos, remixed content (mashups) and personal web pages. The report also cited a higher incidence of such use amongst teenage girls. Drawing on the motivational aspects outlined in this report, the study explored in this paper was designed to generate a similar 'digitally creative zone' but to do so within the context of the school-based curriculum and subject syllabus. In this respect, the notion of encouraging students to use the available potentials of the digital mapping tools to incorporate multimodal features was developed. In so doing, the assumption was made that incorporation of interactive and dynamic materials would enable students to achieve a deeper level of engagement and interaction with the syllabus materials in and through their cooperative authoring of a hypermodal, digitally enriched, topic-based mind map. With this in mind, a key objective of the study was to encourage students to develop, incorporate and use a range of student-authored digital texts such as audio or video clips, animations, images, etc. into a network-based 'macro' map the underlying structures of which were cooperatively constructed by the class as a community of learners.

Somekh et al. (2003), using image-based concept mapping (manual method) to explore students' conceptualisation of the role of computers in today's world, suggest that technology-mediated learning has the potential to transform students' activity and practice. They go on to suggest that the ability to develop "mental representations of networked technologies" enables students to "use them creatively and develop skills in their use quickly and easily". Whilst the focus there lay principally in a phenographic and semiotic exploration of students' conceptualisations, in this paper these analytical frameworks are expanded to include the hypermodal and multimodal potentials of digital mapping tools. As such, the paper looks not only at students' meaning making practices but also at the kinds of connections they make between different elements (nodes) of the syllabus. Jewitt (2006) looks at students' production of digital texts and provides a multimodal framework for analysis of such texts, i.e. by turning attention to specific modes of representation such as the use of image, colour, sound, movement and gesture, gaze and focusing on aspects such as the spatial displacement of entities on screen. These are particularly useful concepts for exploring students' meaning making practices in their construction of digital mind maps as it enables a multi-dimensional analysis of students' digital maps.

THE STUDY

The study was conducted in May 2006 at Tonbridge Grammar School in Kent. The project was effected in normal lessons of one hour's duration carried out over a period of 5-6 weeks. The school is an academically selective school and the student population consists primarily of girls aged 11-18, with the exception of a small cohort of male students in the sixth form, which is mixed.

The school operates an accelerated learning programme at Key Stage 4 (ages 14-16) for students whose academic progress at Key Stage 3 (ages 11-14) suggests they would benefit from additional challenge. A number of subjects, including ICT (Information and Communications Technology) are offered to such students at AS Level (the Advanced Subsidiary examination normally taken by students in Key Stage 5 at age 17). The accelerated learning programme was introduced at the school for the first time during the 2004-5 academic year. The programme allows the one-year AS ICT course to be taught over a period of two years. In the first year, students are prepared for the AS syllabus, with strong links made between the development of practical skills and students' understanding of the theoretical elements of the course. In the second year, students follow the same syllabus structure as the parallel cohort studying AS ICT at Key Stage 5, although they continue to be taught separately as they have already covered much of the syllabus material by this time.

The preparatory year allows students additional time and space to grapple with the more complex requirements of ICT theory and practice which are characteristic of AS Level study. Students are encouraged to use the added flexibility of the two-year course to develop independent and cooperative approaches to learning. In the ICT department a wide range of alternative pedagogic practices have been adopted to facilitate a more flexible approach to learning, including the production of learning materials in the form of digital texts authored by students using flash animation, video and podcasting. This fits neatly with wider school policies on the accommodation of students' preferred learning styles and a move towards enquiry based learning, designed to encourage students to take responsibility for their own learning, whilst teachers adopt the role of facilitator. It is against this background that the study outlined in this paper takes place.

A key focus of the study was to develop an enhanced understanding of the multimodal potentials of digital mapping tools as a support for learning in the technology-mediated classroom. As such, the study builds on earlier studies on the use of digital mapping tools by Cain (2004), Polson (2004) and Cook and Ralston (2005).

The study comprised three phases. The first phase introduced students to the selected topic area of the ICT syllabus and to the idea of using mind mapping tools as a support for learning. This aims of this phase were twofold. Firstly, it was designed to identify a base level for students' understanding of the ICT syllabus and, secondly, it was used to examine, through an initial set of brainstorming activities, ways in which students engaged with syllabus content at a cognitive level. The second phase looked at students' activities as authors of digital texts in relation to the mind mapping project and explored the development of students' higher order thinking skills and levels of motivation as they

engaged with the syllabus using digital mapping tools to support their learning. The third phase examined students' response to a questionnaire in which they were asked a series of questions designed to elaborate their perceptions of digital mapping tools as a support for learning. Prior to this study, the majority of students had not used digital mapping tools and the phases of the project were designed to examine students' perceptions of these tools leading into (initial brainstorming task), during (through observation) and after (via questionnaire) the project.

Phase One: Ascertaining Students' Initial Perceptions of Mind Mapping as a Support for Learning

Phase one of the study involved a set of activities designed to familiarise students with the concept of mind mapping, to measure any prior experiences of mind mapping they may have had, and concluded with the cooperative development of a digital mind map. Students were asked to respond to a set of questions relating to four themes:

1. Mapping the key word "brainstorming".
2. Advantages and disadvantages of brainstorming.
3. What is brainstorming good for and how does it help you to learn?
4. Advantages and disadvantages of using software tools to design mind maps.

These themes were designed to provide a general overview of students' prior experiences and understanding of the relationship between brainstorming and mind mapping and to enable students to begin to grasp the potential of digital mind mapping as a support for learning. This initial phase involved manual mapping methods. Their contributions were timed to facilitate a process of 'automatic response' with each section being allocated 5 minutes.

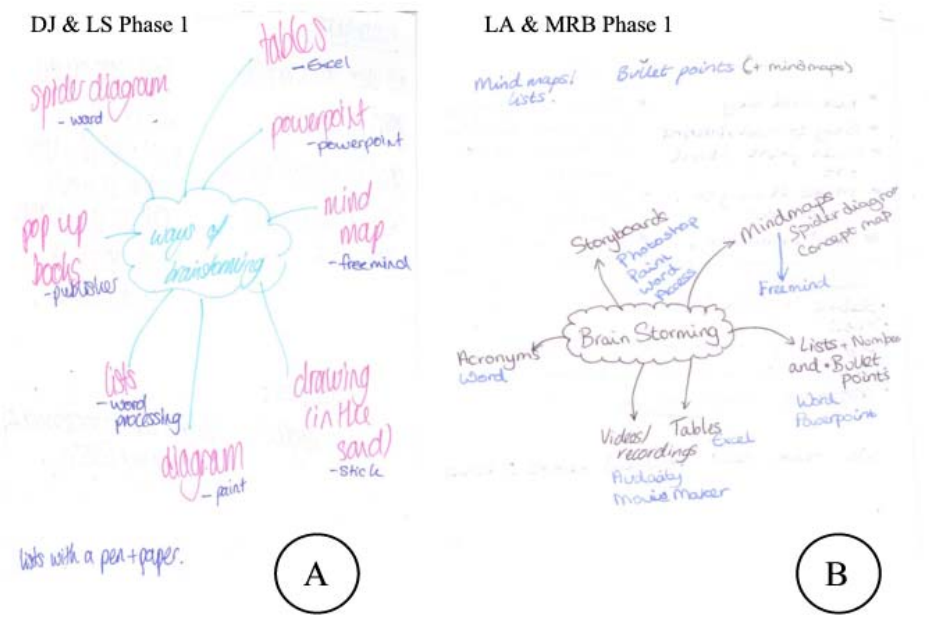

Figure 1: Sample of Students' mind maps in response to question 1

Fig. 1 reveals that students, even in the initial stages of the project, had a sound grasp of conventional mapping techniques. The central idea is clearly present, with key concepts radiating out from the centre. In addition, students in sample A have used a number of modalities, including coloured branches and labels. Students in sample B have also used colour and arrows. The use of arrows, particularly when branching, suggests a familiarity with concept mapping.

Discussion with students at this brainstorming stage suggested that the majority of students had prior experience of conventional mapping techniques outside of the study, and that they had used these primarily for the purposes of revision or homework. Certain subjects appeared to make regular use of mapping techniques (both concept and mind mapping) including Design Technology, English, Geography, and Science. The kinds of activities students had used mapping techniques for were: character development and essay planning (English), recall of previously taught topics (Mathematics), memorising key words (Science). Although very few of the students had previously used digital mapping tools, of those who had, instances of such use numbered less than 3-5 times, the majority of which had been conducted as part of an ICT lesson. There was, however, some evidence of digital concept mapping tools being used, mainly in Design Technology and Science.

Student response to the initial brainstorming task suggested that their perception of the use of mind mapping as a support for learning was that it was good for:

- combining ideas in one place;
- peer support;
- making links between ideas;

- expanding topic knowledge;
- allowing multiple contributions from different people; and
- easy reading.

In this sense, it appeared that students' perception of mind mapping at this stage of the project, based primarily on their past experiences of the method, was that it was a useful tool for collaboration, sharing and connectivity/expansion of ideas.

The fourth question was asked in order to ascertain students' perceptions on the use of digital mapping tools as opposed to manual methods (which the previous three questions had dealt with). As mentioned above, the majority of students had not yet used digital mapping tools, so their views were not necessarily based on direct experience of using these tools at this stage. It was felt that elaboration of their perceptions at this stage of the project would make for a useful comparison at a later stage of the project to ascertain whether students' perceptions had moved on as a result of using digital mapping software. Table 1 provides a summary of the potential advantages and disadvantages of digital mapping tools raised by students in response to this question.

Disadvantages of Software	Advantages of Software
Costs	Neater, clearer, organised
Takes more time	Easy to read, interpret
Can't add images easily	No size restrictions
Free software has limited options	Easy to rearrange objects on the page
Requires a computer	Multiple options, designs to choose from
More difficult to personalise	Gives you new ideas
Difficult to use, manipulate, format	Colourful

Table 1: Advantages and disadvantages of using software to create mind maps

The content of students' responses to the questions posed in phase one was used to generate a 'whole class' mind map (see Fig. 2 below) using the interactive whiteboard. The map was co-constructed by students and teacher. Whilst students were invited to generate the map, the few who had previously used the software lacked sufficient confidence to use the software via the interactive whiteboard. Insofar as the co-construction of the design was concerned, students provided oral input for the design and structure of the nodes and sub-nodes by calling out the information they had generated during the initial brainstorming session discussed above. Students were highly motivated by the resulting mind map and commented on the value of digital mapping tools for collaborative work, e.g. when combined with a projector for whole class discussion, suggesting that this was a very powerful advantage of digital mapping tools over conventional paper-based mind mapping techniques; an advantage also remarked upon by Novak and Cañas (2006, p. 16).

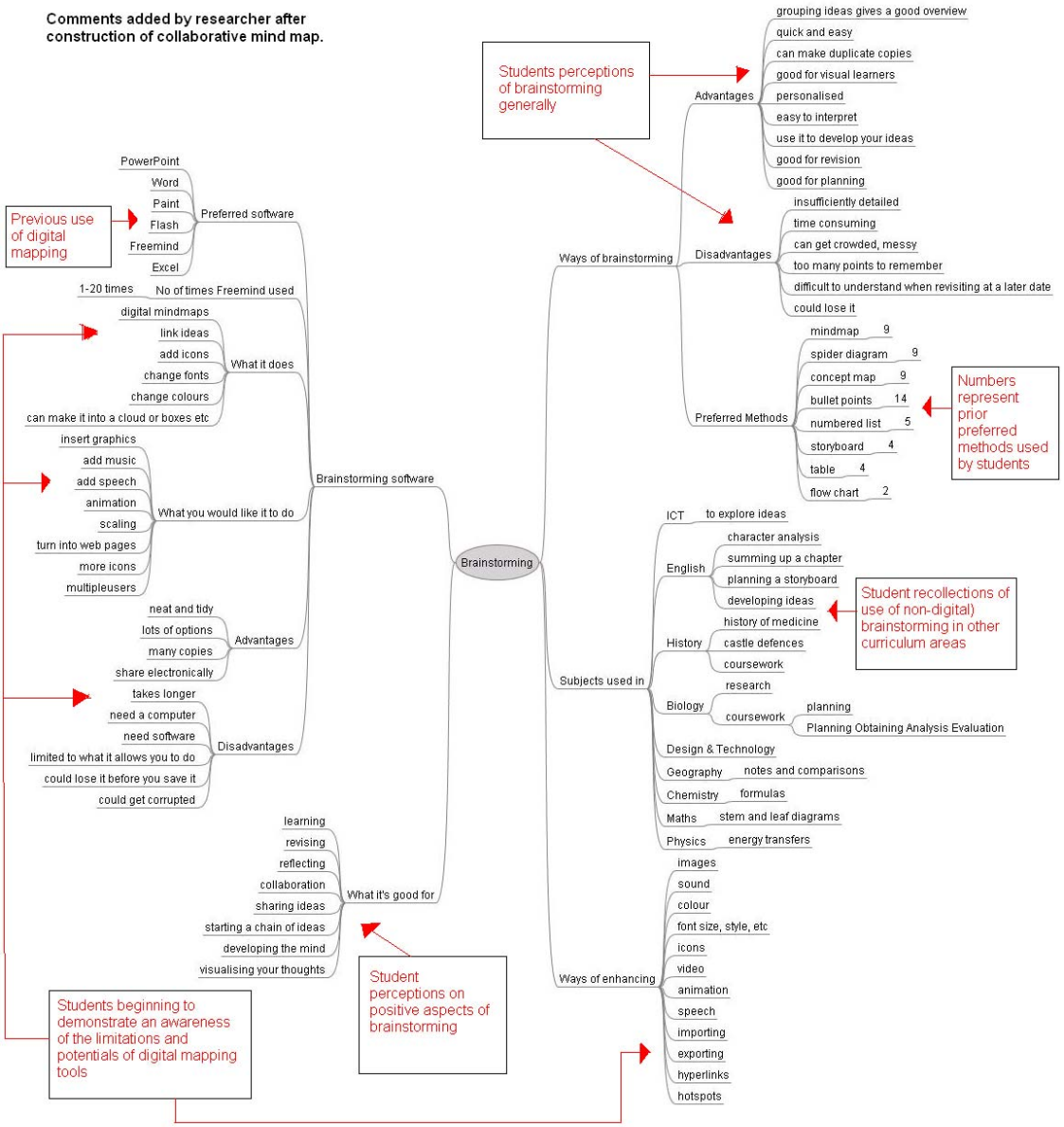

Figure 2: Co-constructed digital mind map on the topic of brainstorming

The key topics of the map correspond to the questions posed to students in the initial brainstorming task and these radiate out from the central theme – brainstorming – in a clockwork fashion. The sub-topics represent (1) additional questions posed by the teacher, e.g. advantages/disadvantages, followed by a further sub-division of topic branches to incorporate student responses or (2) student identification of key areas (e.g. subject areas) in response to the questions raised, followed by further sub-division into deeper levels of description such as 'reasons for using'. The 'preferred methods' branch was also derived from the initial question set and the numbers represent those within the group of 18

participants who preferred each of the respective methods of brainstorming, obtained via a spot poll as the class co-constructed the mind map.

A key feature of the co-constructed digital mind map was that group visualisation and discussion enabled students to reflect on the content of the map as it was developed and their ideas about the limitations and potentials of digital mapping tools were, at this point, greatly increased and expanded upon. A particular area of expansion was in the branches relating to 'what digital mapping does' and 'what they would like it to do'. It certainly appeared, here, that the act of engaging with the digital mapping software caused students to reflect more directly on its capabilities. The branch relating to 'ways of enhancing mind mapping' was also significantly expanded at this point.

At the end of phase one, students were informed that this introductory session was preparation for an experimental unit of work in which they would explore the potential of digital mapping tools and in which they would be asked to consider, in particular:

1. Whether the use of digital mapping tools helped them to develop a better understanding of a syllabus topic and, if so, how and why.
2. Whether the use of digital mapping tools helped them to develop and/or share ideas more effectively.
3. Whether, and if so how, different kinds of software and media might be combined with the use of digital mapping tools to make learning more dynamic, more fun, and/or more useful to them as learners.

These questions were explored in phase two of the study and were designed to elaborate the multimodal potentials of digital mapping tools, the effectiveness of digital mapping tools as a support for students' learning and the usefulness of digital mapping tools to enhance students cognitive engagement with, and understanding of, syllabus materials.

As a bridge between the general overview of mind mapping techniques explored in phase one and the specific application of digital mapping techniques to syllabus content in phase two of the study, students' were shown a teacher-generated syllabus map (see Fig. 3 below) for the selected topic area, in which each pair was allocated (randomly) a sub-topic to explore as part of a co-constructed whole class syllabus map. Novak and Cañas (2006) refer to this sub-division of syllabus topics as 'macro mapping' and 'micro mapping' respectively, and go on to suggest that the deconstruction of syllabus materials in this way serves to make topics 'conceptually transparent' to students, at least some of whom may otherwise struggle to ascertain key concepts within the topic area.

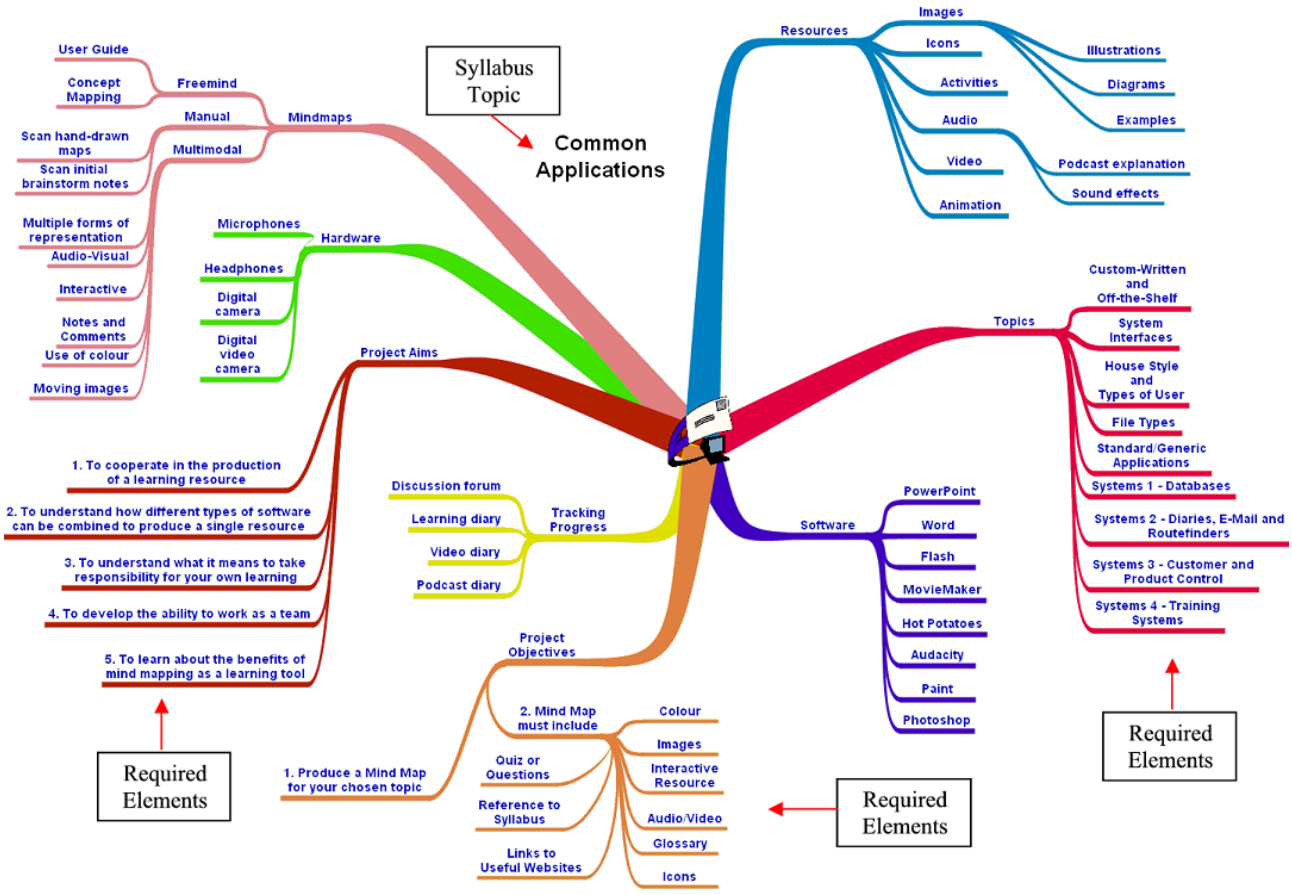

Figure 3: Teacher-generated mind map setting initial task objectives

The teacher-generated mind map was an integral feature of the study. It represents the pedagogical content knowledge (Shulman, 1992) of the teacher and provides a foundational structure which allows students to work independently of the teacher, thus enabling the teacher to operate as a facilitator rather than a director of student learning and activities.

The teacher-generated map comprised required content (syllabus, task aims and objectives) and supplementary content (flexibility of approach in use of tools, presentation of ideas). The three required elements are important as these are designed to ensure that relevant learning, both theoretical and practical, is achieved by students during the project. The flexibility of the supplementary elements are designed, by contrast, to facilitate creativity, imagination and reflection on the part of students.

Phase Two: Developing the Study

Phase two of the study was designed to encourage students to work independently (of the teacher) but co-operatively (with their peers) – in pairs and as participants in a whole class project dedicated to the co-construction of a network-based digital mind map relating to the selected topic area of the ICT syllabus. Each pair of students worked together to produce an individual node representing a sub-topic of the syllabus. The aim of this phase of the study was to ascertain whether, and if so how, students' learning was enhanced and supported through their use of digital mapping tools. In particular, ways in which students bridged the gap between teacher-directed aims and objectives and their own emergent knowledge whilst using these tools was examined.

Students were encouraged to track their progress using a diary of some kind: written, audio or video. In the event, most students chose to use video, whilst some pairs used all three methods. All students were required to generate an interactive resource which was to be attached to the mind map. Students were also encouraged to save progressive iterations of their digital maps, as produced over a sequence of lessons, as a means of evidencing the evolution of their cognitive engagement with the syllabus.

During this phase, students worked independently of the teacher and collaboratively with their peers. The teacher adopted the role of facilitator. Typical interactions between students and teacher related to:

- software skills required to complete the task;
- clarification of task instructions;
- questions about student structuring of content (what to include, how much to say); and
- questions about the meaning of content (clarification of syllabus topic).

In order to explore these issues, student-authored digital texts in the form of diaries (audio, video and textual), digital maps were analysed, together with an analysis of student talk 'around' the task using a multimodal lens (Jewitt, 2006).

Students' development of sub-topic mind maps

Students worked on the development of their paired mind maps over a period of three lessons, structured as follows:

1. Students began to work on their mind maps in pairs, simultaneously developing an interactive resource. As a homework task, they were asked to generate a glossary of technical terms.
2. Students continued to develop their mind maps, adding hyperlinks, updating diaries, and simultaneously began working on video/animation tasks.
3. Students completed their mind maps and supporting resources.

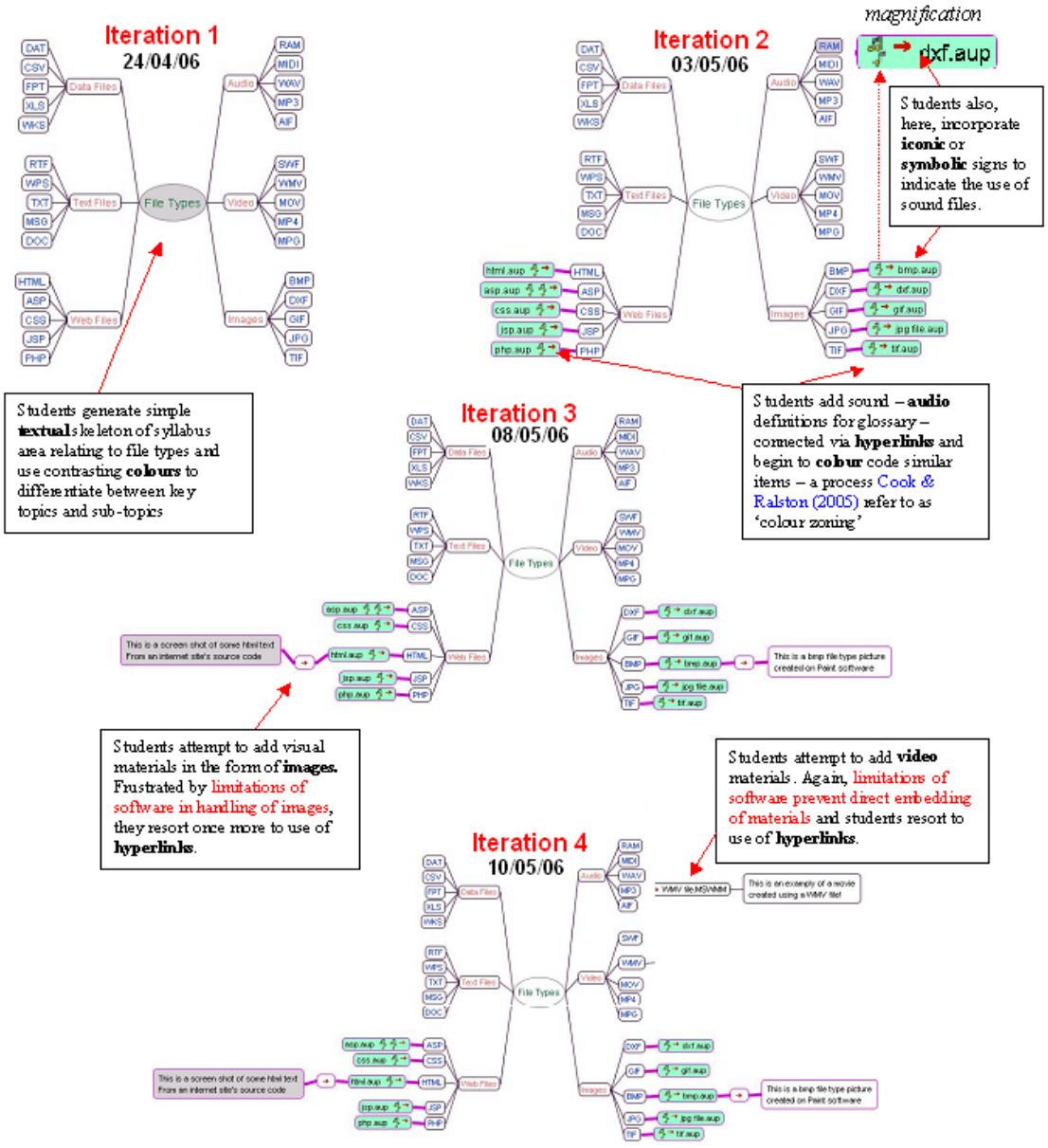

Figure 4: Example of progressive iterations of students' digital map

If the above iterations are compared to the task instructions set out in Figure 3, we see that this student pair has sought to (1) follow the syllabus requirements (2) include the required elements outlined in the task objectives; and (3) incorporate the suggested multimodal attributes (e.g. sound, colour, hyperlinks, images). It was during this stage, in particular, that the discrepancy between students' initial views of the potential of digital mapping tools (see Figure 2 above) to enhance learning and the actual limitations of the tools available to

them in reality began to emerge. This discrepancy is discussed further later in this paper. Suffice it to say, here, that the iterative production of students' digital maps, as indicated in the above example (Figure 4), begins to reflect students' struggles to work with the available potentials of the digital mapping tools, whilst at the same time demonstrating a growing conceptual awareness of their extended potential, in terms of the range of multimodal attributes they sought to incorporate into their digital maps, namely: audio, video, image, hyperlinks, colour, image, etc. In this example, the framed annotations have been added by the author to elaborate the analysis of the map's content from a multimodal perspective and to draw attention to potential limitations encountered by students in their use of the digital mapping tools.

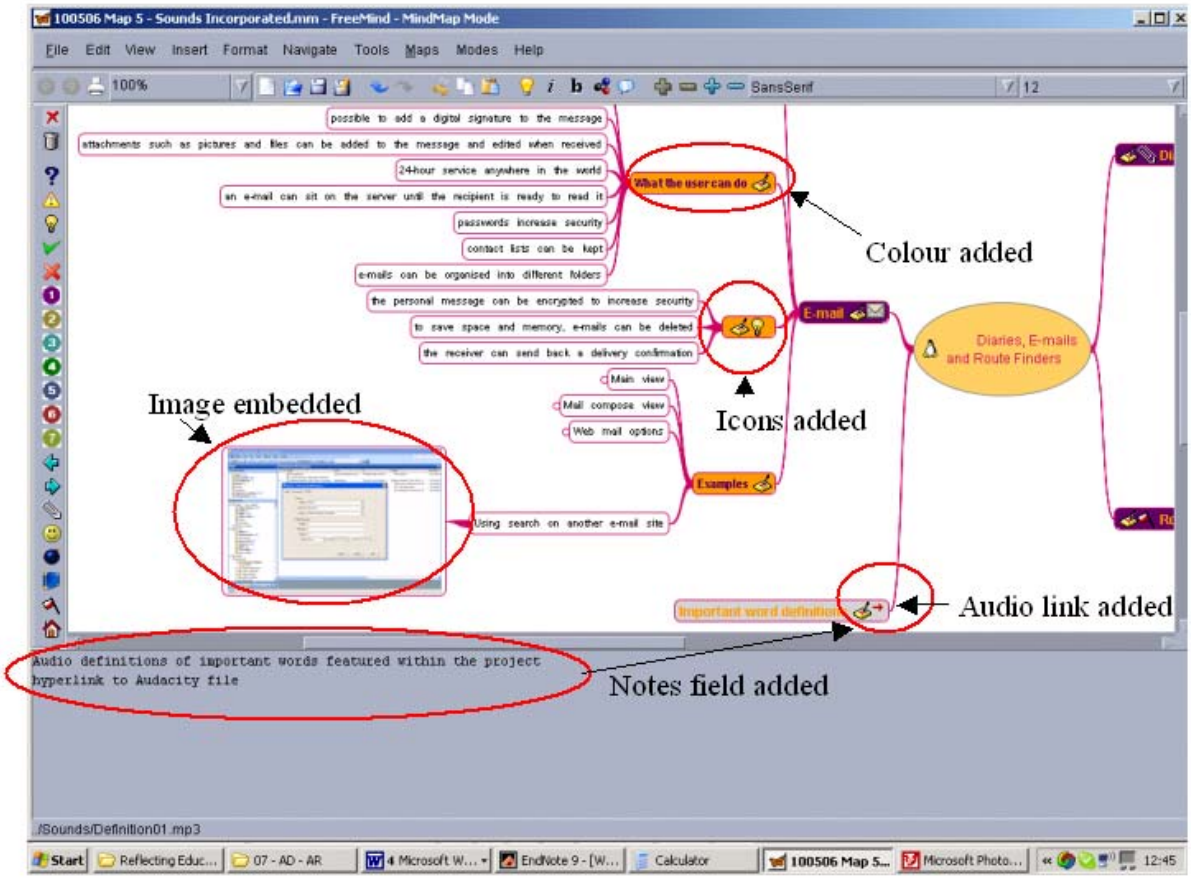

Figure 5: Example of students' digital mind map with multimodal attributes

In (Figure 5), we see an example of a student pair's digital mind map being used within the workspace of the digital mapping software. This student pair have used a range of multimodal attributes including embedded images, icons, hyperlinked audio clips, colour (Cook and Ralston, 2005) and hidden notes fields to enhance and expand the structure and presentation of the syllabus sub-topic area.

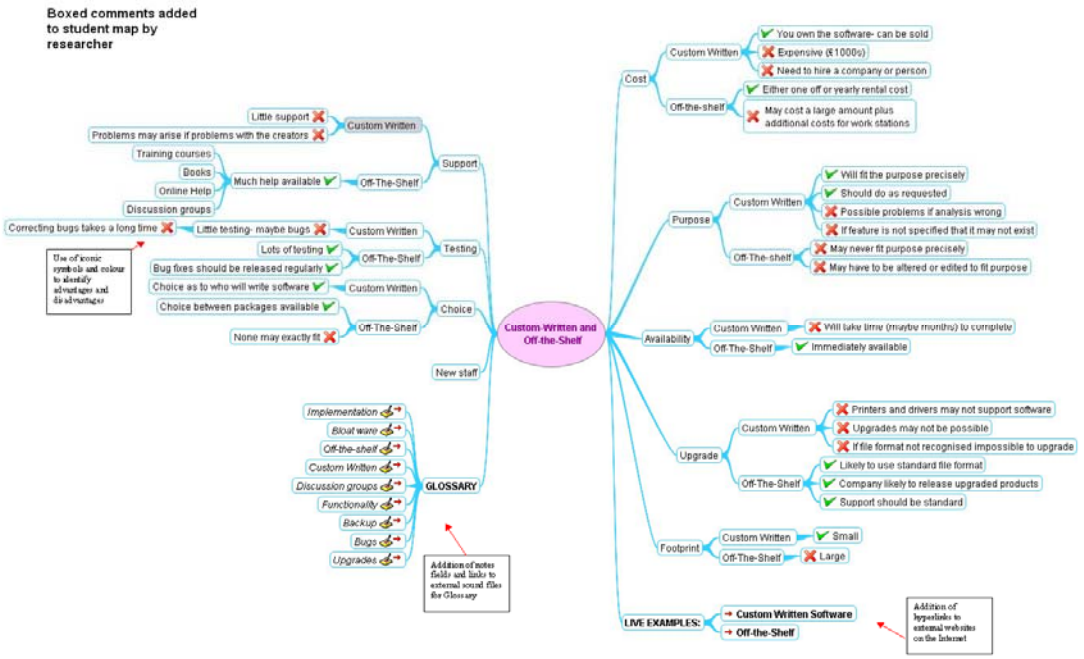

Figure 6: Example of students' final mind map using digital mapping tools

In the above example (Figure 6), evidence of students' linking to external files (sound files providing definitions for the glossary of terms – linked to the syllabus) and external websites (opportunities for further research) and the use of iconic symbols to quickly identify in a visual way the key advantages and disadvantages within this topic area of the syllabus show the beginnings of the multimodal, hypermodal and multimedial potentials of the digital mapping tools used by students. These elements can be said to enhance students' learning experience in the sense that they enable the learner to include elements it would not be possible to include in a conventional paper-based mind map (e.g. sound and hyperlinks) which, in turn, facilitates students' ability to 'go deeper', moving away from surface level learning to opportunities for the development of metalevel connectivity and cognitive development through the use of hyperlinks and networks to additional resources 'beyond the screen'.

Phase Two: Findings

It is clear that despite the multimodal potential of digital mapping tools, some important issues remained which, at least in these exploratory stages, had the potential to detract from an otherwise potentially positive learning experience which could serve to enhance students experience and understanding of syllabus contexts. Some examples of typical issues or difficulties met by students (these examples were derived from discussions with students during the production of their digital maps) follow:

- **Lack of knowledge about available features** – A student wanted to cross-link the divergent branches of her map. At first she compromised, using the graphic link

option, but was unhappy with this. A later discovery of the local hyperlink option solved this problem.

- **Size limitations and expanded notions of spatiality** – One student was concerned about the size of the map exceeding the print area – this provoked a discussion as to whether it was possible to print across multiple sheets and retain a sensible overview. The discussion then raised a comment from another student (in a different pairing) to the effect that printing wasn't an issue because you could just use the file and share it digitally, i.e. look at it on-screen.
- **Difficulty in manipulating the features of digital mapping software** – Some students struggled with skills relating to the incorporation of content (inserting images, hyperlinks, notes, images, sounds, etc.)
- **Lack of flexibility compared to manual mapping methods –** Students became frustrated with image manipulation 'knocking' their maps out of balance and the inability to easily move nodes around freely.

Despite the inherent difficulties of the software, it is clear from students' comments about the activities they attempt to bring into their digital mapping task, as well as their emergent ideas about what can be done with the digital maps both in collaborative terms (e.g. sharing it across a network) and in spatial terms (it can be viewed on-screen and, therefore, go beyond the physical constraints of the dimensions of a physical sheet of paper) that students' engagement with these digital tools does have the potential to enhance their cognitive engagement with syllabus materials and their learning generally.

Phase Three: Evaluation and Review

In the final phase of the project, students finalised their digital mind maps and reviewed the resources they had produced as a whole class. It became apparent that the most striking aspect of the study was students' initial perceptions of what multimodal mapping could bring to the learning experience and what, in this instance, it actually did offer. Students, in this final stage, were asked to complete a questionnaire, which addressed, amongst other things, the multimodal opportunities provided by digital mapping tools and their potential, actual or envisaged, to enhance or support students' learning.

Motivation: the mean enjoyment rating for the digital mapping project was 8/10.

Knowledge of syllabus: 60% of students participating in the digital mapping project felt it improved their knowledge of the subject syllabus.

Usefulness: the mean usefulness rating was 6/10 with students clearly distinguishing between the comparative uses of hand-drawn mind maps and digital maps.

Comments made by students on the benefits of digital mapping:

- More interesting as I didn't realise you could do so much.
- Not as boring as I anticipated.
- Can be fun and enjoyable.
- Didn't know you could insert so much media into one mind map.

- Has improved my knowledge of mind mapping.
- A much clearer way of expressing ideas.
- Has expanded how I think about mind mapping, can now see how it can be used for a wider range of things and I would use it in future for revision and other things.

Students' comparisons between hand-drawn and digital maps

Hand-drawn mind maps	Digital mind maps
Mind mapping by hand is simpler	Takes too much time
Hand-drawn maps are best for revision	Better for formal notes
Quicker and easier to mind map by hand	Can include sound, text, images, video and different types of multimedia
Doing mind maps by hand is better – you learn as you write	Many people can work on a digital map simultaneously to share ideas
Good for rough notes, fast and easy	Teachers can use it in lessons, collapsing nodes to focus on individual points
Can make them anywhere, anytime	Good for presentation, looks neat
Easy to carry around and amend	Allows you to change things and is flexible
Can personalise	Useful for projects

An analysis of students' responses to the post-project questionnaire and in further discussion with them about the limitations of the software and ways in which it could be further developed and improved to make the most of its multimodal affordances were identified and categorised as follows:

Connectivity: on screen and beyond the screen
- flexibility in movement and connectivity of modes;
- ability to link together unconnected nodes;
- ability to group nodes; and
- desire for more flexible flush effects (alignment of nodes).

Spatiality: desire for control of spatial attributes on and off screen
- ability to reduce size of map.

Representation: availability of a range of tools and desire for multiple layering
- ability to incorporate background images;
- shading to distinguish different topic areas;
- resources libraries (shapes, images, multimedia, animations, icons); and
- a wider variety of styles (node shapes).

Modalities: desire to incorporate visual, aural and kinaesthetic features
- Embedded multimedia (sound, video, music) playable within the mind map;
- Easy manipulation of images within the mind map (insertion, resizing, etc.);
- The ability to go beyond 'text', through use of colour and images; and
- Ability to incorporate multimedia and interactivity.

In terms of the open source digital mapping tool used by students in the study, the above features were expressed as desirable features for future development. Whilst the software allowed students to incorporate at least some of these elements, the degree to which they could be manipulated was viewed as unsatisfactory. Students were later introduced to a commercially produced digital mapping tool which did fulfil the desired criteria, resulting in a marked increase in motivation and appreciation of the potential of digital mapping tools for learning.

CONCLUSIONS

Enhancing students' understanding of the wider contexts of a subject syllabus

The results of the study, generated by an analysis of students' digital maps and the project diaries produced by students during the project, suggested that the use of the digital mapping tool did enhance students' understanding of the wider contexts of the syllabus in the sense that each individual pair's contribution was perceived as part of the wider context framed by the initial co-operative mind map and the teacher-generated project map.

Reshaping students' cognitive engagement with a subject syllabus

Students did respond positively to the study and did see a potentially positive contribution in their use of multimodal digital mapping tools as a support for learning, collaborative learning, in particular. They were enthused by opportunities for a seemingly endless expansion of their ideas and the notion of no longer being constrained by the physical limitations of paper. In this sense, the hypermodal potential of the digital mapping tools was one which generated a high level of interest in students. Students were also highly motivated by the ability to use and incorporate a wide variety of digital media into their multimodal maps and valued the opportunity this gave them to combine multiple modes of representation.

Motivating students' learning in and out of the classroom?

Overall students viewed digital mapping as a positive and useful pursuit, although it is clear that there is still some way to go before they are likely to view these as objects which are as easy to use as hand-drawn mind maps. Issues of time, portability, clarity and context were considered important in terms of deciding when and how to use digital mapping software for learning.

A number of less positive attributes did, however, also emerge during the study. Students were quick to point to issues relating to accessibility (both in terms of access to computers and development of the necessary skills to operate the software). They also pointed to the amount of time involved in the creation of such resources and queried whether this could be justified or not, given the constraints of available curriculum time.

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