Changing Metaphors for Designing Interactive Multimedia for Higher Education: From Media Producer to Dialogical Collaborator

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Introduction

Andrew, a Curtin University doctoral student under Peter's supervision, has been involved in designing an interactive multimedia program for teaching Special Relativity to undergraduate Physics students. After 18 months of design, the program was trialled at Eastern States University in November 2000. However, the design process was not straightforward or unproblematic.

In this paper, we: (a) review briefly the problematic nature of the initial design process and the subsequent paradigm shift in which the formerly separate strands of research and design became interwoven into a dialectical collaborative process, (b) outline the way in which the multimedia program makes possible a multi-dimensional curriculum including a constructivist epistemology of undergraduate teaching practice, and (c) illustrate why the epistemology of assessment needs to be a focus of future design dialectics.

Changing Metaphors

Initially, Andrew identified his designer role in terms of his previous experience as a media producer: The *designer as media producer* designs and delivers a finished product to a client, in this case, the undergraduate Physics student group. The Physics lecturer, Jacob, in whose teaching lab the program was to be trialled, was regarded as a peripheral stakeholder who would serve as a source of data on the success of the implementation.

At this stage, Andrew's designer and researcher roles were independent; the research serving as 'bookends' around the design process. At the front end of the project, research had provided a learning framework based on constructivist theory (von Glasersfeld, 1993). Constructivism is an epistemology (or theory of knowing) that highlights the active social and cognitive role of the learner in generating new conceptual understandings; it focuses on the process of learning. From this perspective, good learning involves students in reflecting critically on the adequacy of their prior knowledge, engaging enthusiastically in inquiry, and negotiating (with peers and/or teachers) the viability of their newly developing ideas and understandings. This perspective, as we shall later see, can be useful for shaping the social practices of designers and researchers.

At the tail end of the project, it was intended that research would serve as a means of assessing summatively the effectiveness of the program for improving student learning. At this stage, however, this process was little more than a blur on the horizon; most of Andrew's attention being focussed on the immediate process of design, which involved extensive writing of programming code.

Gradually, however, Andrew began to feel troubled. How could the (product-oriented) structured design process take account not only of Jacob's curriculum goals for teaching the content of Special Relativity, but also involve him in developing a teaching approach aligned with a (process-oriented) constructivist perspective on learning? The program was not designed to stand alone, in the tradition of programmed learning. Students' use of the lab-based program was intended to be mediated by Jacob, their usual lecturer. The answer to Andrew's dilemma lay in aligning research and design with a constructivist epistemology; a move that signalled an important shift to a dynamic and interactive process of design!

At about this time, Andrew became aware of Guba and Lincoln's (1989) model of *fourth generation evaluation* which is founded on a constructivist epistemology. This naturalistic paradigm *"rejects the controlling, manipulative (experimental) approach that characterizes science, and substitutes for it a hermeneutic/dialectic process that takes full advantage, and account, of the observer/observed interaction to create a constructed reality that is as informed and sophisticated as it can be made at a particular point in time"* (p.44). The research process is *hermeneutic* because it is interpretive, and *dialectic* because it contrasts and compares divergent views of stakeholders, with an emphasis on achieving *"higher-level synthesis of them all"* (p. 149). Further, the naturalistic approach does not provide an agenda for the justification of any stakeholder's position, *"rather it seeks connection between the change in the positions as a means to move to higher intellectual, moral and ethical ground"* (p. 139). Thus, stakeholders in the research are *educated*, as they now have the opportunity to identify and critique (re)constructions of themselves and of others, and *empowered* because they are given a forum in which power is collectively shared between researcher and researched. The end result of which is not to justify or attack any one construction, but rather to find *connection* between them that provides a platform for mutual exploration.

Directly aligned with a fourth generation model of evaluation is the metaphor of *"design as research/research as design"* (Swann, 1999), which draws on Schön's (1983) ideas of *reflection on/in action* and is aligned with *action research* in a naturalistic research paradigm. Here, the design process, itself, becomes a research process. *"The action of designing is the same as the moment of synthesis that occurs in all forms of research"* (p.5). And the goals of action research and design are well-aligned inasmuch as they both aim to transform a social situation. By coupling a fourth generation approach to evaluation with a dynamic and interactive model of design, Andrew had aligned the epistemologies of pedagogy, research and design. Importantly, research and design were now in dialog with one another. Andrew's role had shifted from designer as media producer to one of *designer as dialogic collaborator*.

As his consultation with Jacob unfolded, a *dialectical rationality* began to shape their discussion. Jacob's ideas and opinions (on the physics content and the user-interface) both influenced and were influenced by his interactions with Andrew and the developing components of the program. Dialog focussed, for example, on the educative utility of the software and the nature of a constructivist approach to teaching in the laboratory setting.

Andrew then utilized *rapid prototyping*, in which a number of short-term design changes are made to a program and then subject to further decision-making. Rapid prototyping enabled Jacob to experiment with new pedagogical approaches based on emergent design features of the program. This approach was sympathetic to Andrew's newly conceived dynamic approach to research/design in which "*reflective conversation … takes place in a rapid cycle of building prototypes, testing them, scrutinizing them, and redesigning them"* (Schrage, in Winograd, 1996, p.192). Because prototypes *"provide...backtalk to the designers (they) can serve as an essential medium for information, interaction, integration and collaboration."* (p.192). This constituted part of the hermeneutic/dialectic process of fourth generation evaluation and, as such, performed a mutually educative function. Prototypes can be seen also as performing an empowering function: *"If it is to succeed in its purpose, a prototype … has to be community property."* (p.201). Prototype development was consistent with the constructivist research methodology of fourth generation evaluation inasmuch as one of Andrew's goals was to empower Jacob, a key community stakeholder.

A Multi-dimensional Curriculum

We adapted Schubert's (1986) multi-dimensional curriculum model as an interpretive framework (Erickson, 1998) for assessing the implementation of the multimedia program. We chose seven images of curriculum, each of which has distinctive implications for the nature of teaching and learning. The more traditional curricular images, which together constitute a powerful transmission-oriented epistemology of teaching practice (and passive-reception learning), are those of *content*, *planned activities*, *discrete tasks or concepts* and *cultural reproduction*. These four images focus the teaching-learning enterprise on the end-product of learning which, in science, is usually the compliant acquisition of uncontestable, value-free concepts, formulae and standard problem types, and laboratory-based skills of measurement using various scientific equipment. An instrumental rationality prevails.

By contrast, constructivist curricular images generate a critical focus on the process of learning. The image of *experience* emphasises the need for engaging the learner in rich meaningful experiences which stimulate critical inquiry and collaboration. The image of *socio-cultural reconstruction* is concerned with empowering the learner to (a) assume greater control over her own learning by reconceptualizing the power-knowledge relationship between student and teacher roles (allowing, e.g., self-determined exploration of concepts beyond the set content/program/activities), and (b) construct an image of the nature of science as a process of critical reflective inquiry which generates contingent knowledge. The (elusively phenomenological) curricular image of *currere* promotes a reconceptualisation of the learner's own autobiographical lifeworld, as well of that of others, as a means of creating greater personal insightfulness. One question that students might pursue is how historically they were enculturated into a worldview that largely ignores the relativistic concept of time and space.

The multimedia program provided possibilities for enacting a rich multi-dimensional curriculum. Importantly, the program served the traditional (product-oriented) curriculum goals of enabling physics content (ie., Special Relativity) to be taught as discrete tasks and concepts by embedding them within a coherent program of computer-based activities. But, more than this, the program made possible innovative (process-oriented) curriculum goals emanating from a constructivist perspective on teaching and learning. Immersion in a virtual learning environment, in which students adopt the role of a space ship commander and undertake a compelling space mission, offered the possibility of experiencing first-hand science as an historical process of critical reflective inquiry and problem-solving.

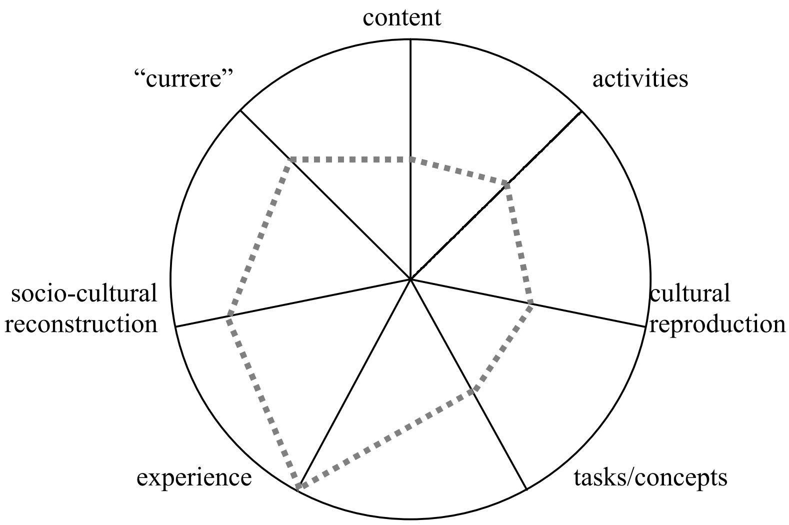

Figure 1

Andrew designed the program with the intention of engendering all seven curricular images, but to differing degrees. Fig 1 represents the intended extent of each image relative to the others. We have used a sliding scale to indicate qualitatively the desired influence of each curricular image on the overall teaching and learning enterprise. The scale ranges from "almost never" at the circle centre, to "sometimes" half way to the perimeter, and to "almost always" at the perimeter. The model represents the view that *"making sense of science is a dialectical process involving both content and process. The two can never be meaningfully separated*" (Tobin & Tippins, 1993, p.9*)*. It is noticeable that Andrew intended the program to promote relatively strongly aspects of process-orientation to teaching and learning (compared with product-orientation). It is non-trivial that the socio-cultural image figures highly on the ideal model as *under "a constructivist way of thinking, a curriculum is embedded in a culture and cannot be separated from culture…*" (p.9).

However, when the program was used by Physics students during four three-hour labs in October this year, Andrew observed that the enacted curricular images (*content, activities, cultural reproduction, tasks/concepts*) tended generally to be those which emphasised a traditional product-oriented approach to teaching and learning. Apart from a relatively strong emphasis on *experience,* the constructivist curricular images (*socio-cultural reconstruction, currere*) were very under-represented. Fig 2 represents, in a general sense, the relative degrees of emphasis of each of the enacted images.

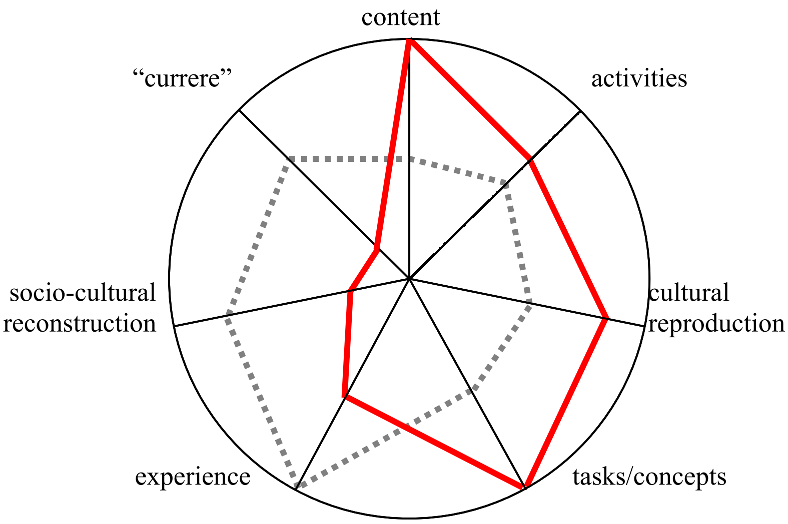

Figure 2

Further Design Dialectics

During the lab sessions, Andrew had served (laboriously and frantically) as tutor/researcher/designer. Unexpectedly, Jacob had assumed only a minor teaching role and was replaced by two tutors who usually supervised lab work but who had not been involved so far as stakeholders in the research/design process. Andrew took on the role of lead tutor, continued to diagnose the program for operational faults and design shortcomings (resulting in further rapid prototyping), and also maintained the critical eye of a reflective researcher. Loren White (1998) has attested to the considerable difficulties of enacting similar multiple roles in his school mathematics classroom.

Analysis of Andrew's fieldnotes, video recordings of students' computer interactions, interview/questionnaire surveys of students and tutors, and students' workbooks is underway currently. Here, we present results from a phenomenological perspective (van Maanen, 1988), a minimally interpretivist approach that describes patterns of social action without imputing intention to those whose actions are being represented. The aim is to identify key issues effecting the implementation of the program. Our preliminary analysis suggests that a richer enactment of a constructivist approach to teaching and learning depends on several key factors lying outside the original design parameters of the multimedia program:
• semiotics of the lab environment,
• lab tutors' teaching epistemologies, and
• students' learning epistemologies.

These factors were observed to mediate students' interactions with the program. Rather than regarding the factors as negative constraints to the implementation of an otherwise successful product, we prefer to regard them as opportunities for engaging dialectically with other stakeholders in future development of the (prototypical) program. We conclude this paper with a brief illustration of the second factor, written in a narrative style with Andrew's voice pre-eminent.

Lab Tutor's Teaching Epistemology

In designing the program, I had adopted an unconventional approach to communicating concepts of Special Relativity, drawing on the narrative approach of Bruce (1998), Gamow (1998) and Stannard (1989), the visual approach of Epstein (1997) and the scientific visualization approach of Daniel (2000) and Savage and Searle (1999), which I had embedded within a constructivist perspective on learning. As a scientific theory, Special Relativity (Einstein, 1961) tends to place a high cognitive load on learners as it requires emancipation from a Newtonian worldview, where concepts such as space and time are absolute, and the construction of an alternative Einsteinian worldview, where space and time are relative. This involves an ontological shift which necessarily changes the learner's view of reality.

As part of its rationality, Special Relativity involves the notion of *gedanken* (or thought) experiments. I had designed the program as a means for students to experience the "dream" of being introduced into the world of Special Relativity. The learning challenge for them was to make sense of the dream. One example of this in the program is the "Light Clock Machine" (Fig 3), which allows learners to manipulate a number of imaginary light clocks and serves the pedagogical function of introducing the concept of time dilation.

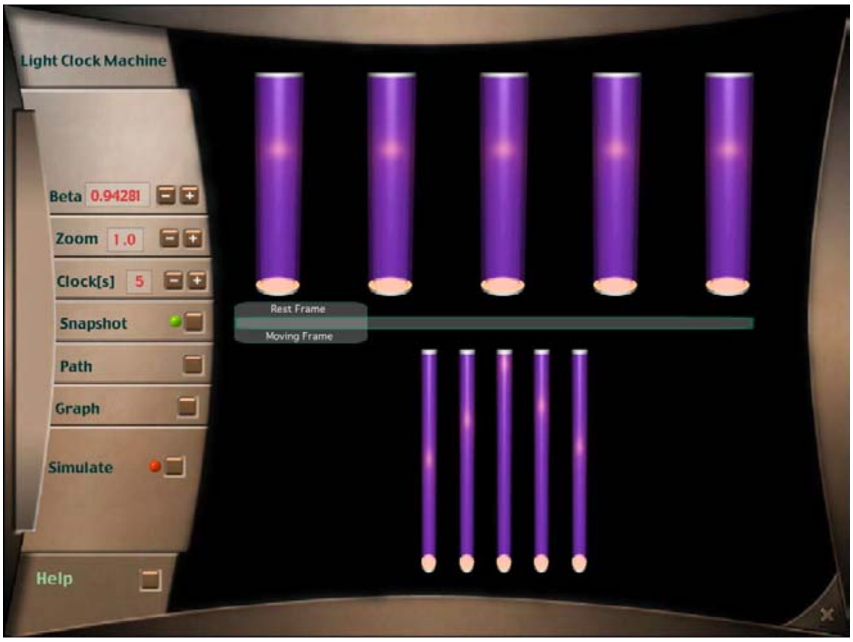

Figure 3

Another aspect of Special Relativity theory that lends itself to computer simulation is that its effects are noticeable only beyond our everyday experience. The program provides students with a qualitative conceptual experience that requires them to reflect on novel but highly counter-intuitive experiences and then examine critically their resulting conceptual constructions. The pedagogy of this approach differs markedly from the traditional mathematical formulaic approach of the lecture series on Special Relativity. Thus, I had intended the program as a mediator for students' critical reflection, rather than as a "factual tool".

Leon, a doctoral student in physics and one of the two (unexpected) tutors, was present at two of the four lab sessions. Leon and I engaged productively in dialogue about the program's conceptual approach to Special Relativity. He seemed excited about the program's unconventional way of visually presenting Special Relativity to learners via a narrative, and seemed to appreciate the amount of effort that I had put into the project. He commented that he saw the approach as a "good" one. His interactions with students working with the program seemed positive and helpful, and he appeared to reflect critically on his established teaching approach. Thus, although Leon was an established representative (and gatekeeper) of a culture of teaching and learning characterised by the traditional curriculum images of content, tasks, and activities (see Fig 2), he embraced a more constructivist (or process-oriented) teaching approach by engaging enthusiastically with students struggling to make sense of their learning experiences.

However, Leon's teaching perception of the educational utility of the program contrasted sharply with his subsequent perception of assessing students' learning outcomes. After the lab sessions had concluded, he sent an email to Jacob, expressing his confusion about assessing the students' Log Books (i.e., specially designed instructional workbooks that I had designed to guide/record students' interactions with the program).

"My confusion arose from the fact that the two groups I took did not do the same work because of changes Andrew made to the Log Book. In both labs, no student completed either book…I didn't know where to start so that I could be fair to students…all students worked quietly and consistently for the whole length of the lab. Jacob, could this lab please be omitted from the students' assessments. Given the circumstances and nature of the experiment, the more I think about it, the more difficult I feel it is to put a mark to this that properly assesses the diligence of the students."

Leon's email highlights the incongruence of traditional assessment and a constructivist approach to teaching and learning. A traditional image of assessment, which serves the curricular images highlighted in Fig 2 (content, activities, tasks/concepts), is one that *"seem[s] to be associated with teaching roles akin to judging and rewarding"* (Tobin &Tippins, p.12). An implicit result of which, in the classroom culture, is that *"learners will work for grades much in the same way that employees work for pay*" (p.12). Within this epistemological framework, meaningful learning becomes a by-product of the process of completing tasks for numerical grades, rather than a major priority of tutors and students.

By contrast, a constructivist perspective on teaching and learning holds that *"students must be perplexed at times and struggle to resolve perturbations in the act of experiencing and trying to figure out puzzles associated with engaging in an intellectually meaningful manner"* (p.12). Thus, a constructivist perspective on assessment would focus on these dynamic aspects of students' conceptual development, thereby providing valuable (diagnostic) information about students' higher-order learning outcomes. Qualitative assessment tools such as concept mapping, interviewing, portfolios, self- and peer-review, are being used in higher education for this purpose (Taylor, Gilmer & Tobin, in press).

I had included concept mapping and interviewing as key research tools, and used them shortly after the final lab session to assess students' learning outcomes. Although I had earlier discussed their suitability with Jacob, the responsibility for assessment of the lab sessions, within the official teaching program, lay with Leon and the other tutor, neither of whom had been prepared to use these tools. Another way of looking at this issue is to say that the constructivist assessment tools were foreign artefacts with no legitimacy in the traditional curriculum culture characterised by an overriding concern to judge the common completion of set tasks and to report outcomes in numerical terms. Needless to say, assessment is a powerful factor in shielding the extant culture from foreign intrusions and ensuring its faithful reproduction (as evidenced in Fig 2).

Perhaps Leon's complaint was due to his recognition of the difficulty (impossibility? folly?) of using a traditional model of assessment to gauge meaningfully the range of student learning outcomes resulting from their differential interactions with the multimedia program.

It seems at this early stage in our analysis of the research data that, in order for the rich educational potential of the program to be fully realized, a change in the established culture of teaching and learning within the Physics Department is necessary. In order to be more fully aligned with the constructivist epistemology of the multimedia program, students would need to be introduced into a culture of science where conceptual learning is the one of the main objectives. Tutors would need to be exposed to additional images of curriculum, thereby becoming more learning process oriented. And, a broader range of qualitative assessment tools would need to be included. Such a cultural transformation does not, however, require replacing the traditional view with a constructivist one.

Conclusion

From a research perspective, the alignment of the epistemologies of research, design and pedagogy, provided a powerful approach to this study. A constructivist epistemology of research and learning, coupled with the metaphor of research as design/design as research, allowed for greater insight into the entire research/design process. Traditionally, the research thesis would include only an account of the educational principles governing the initial design process and an account of the impact on student learning. However, by adopting a recursive dialogical relationship between design and research, the mystique of the design process became transparent, and now forms an integral part of the research itself. In doing so, it illustrates the subjective nature of decisions made when developing educational technology and, consequently, illuminates why educational technology should not be regarded merely as an “objective tool” for teaching or learning science.

Preliminary analysis suggests strongly that realisation of the full educational potential of the program would benefit from the inclusion of all stakeholders (including students, lab demonstrators, lecturer) as dialogical and collaborative co-designers. Furthermore, a change in the culture of teaching and learning within the Physics Department of Eastern States University seems necessary. Traditional views of curriculum and assessment need to be scrutinized and enhanced by those aligned with a constructivist epistemology in order to achieve learning experiences that are more meaningful to students.

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