

STA04616

**REPRESENTING THE FLOW OF R&D IN A THESIS:
DIACHRONIC STRUCTURE & HYPERLINKING**

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Abstract

Many doctoral researchers are adopting interpretive epistemologies of inquiry in which research design is emergent and is shaped by the developing subjectivity of the researcher-as-learner. When interpretive researchers also adopt narrative modes of inquiry and literary genres for representing their unfolding relationships with the participants of their inquiry (including the reader of their thesis), then the question arises as to what might constitute an appropriate thesis structure. We believe that, in succumbing to the structural template of positivism, interpretive researchers are in danger of creating distorted portrayals of their inquiries as timeless, lacking in contingency and without an emergent nature. In this paper we argue for a diachronic structure that allows the narrative flow of the inquiry to be revealed. Drawing on a recently completed doctoral study, in which a multimedia educational program was designed and implemented by the first author, we illustrate how a screenplay metaphor combined with electronic hyperlinking provided a non-linear thesis structure that allows multiple reading pathways, exploration of rich documentation and viewing of successive multimedia prototype designs.

The Literary Turn

In qualitative research the question of how to represent in writing¹ our inquiries has been called a 'crisis of representation'. The concept of 'representation' implies that written language is a necessarily limited means of (re)presenting for public viewing that which is inherently invisible – our thoughts, understandings, ideas, beliefs, values, attitudes, feelings, etc., especially their uncertainty, inconsistency, context-dependence and contingency. The concept of 'crisis' implies that researchers are now facing a major challenge in choosing and justifying any particular mode of representation from a multitude of unfolding possibilities arising from the 'literary turn' (Denzin & Lincoln, 2000).

In the field of education, the literary turn, which has its recent origins in arts-based inquiry (Barone, 2001; Eisner, 1997), has opened the door to alternative research writing styles, including narrative, fictive, impressionistic and confessional genres, and combinations of these and other styles (Bruner, 1986; Clandinin & Connelly, 1994; van Maanen, 1988). No longer are qualitative researchers governed necessarily by the 'science cultural myth of language' that restrains research writing to the third person, past tense, value neutral, passive voice, once advocated by Francis Bacon as the official language of science:

And for all that concerns ornaments of speech, similitudes, treasury of eloquence, and such like emptiness, let it be utterly dismissed. (Bacon, 1620, in Milne & Taylor, 1998, p.37)

Science educators may feel somewhat intimidated by the variety of literary choices now available. Critics may argue (unkindly) that a retreat from literary forms is a major reason that science educators chose to follow a career path heralded by the dispassionate voice of objectivity. But this voice has not always ruled science. Early natural philosophers were wont to poeticise their discoveries. Take, for example, Robert Hooke whose 'treasury of eloquence' in describing a flea under a microscope makes compelling reading:

But as for the beauty of it, the Microscope manifests it to be all over adorn'd with a curiously polish'd suit of sable. Armour, neatly jointed, and beset with multitudes of sharp pinns, shap'd almost like Porcupine's Quills or bright conical Steel-bodkins; his head is on either side beautify'd with a quick and round black eye. (Hooke, 1665, in Milne & Taylor, 1998, p.38)

Embraced with a sense of liberation, the literary turn presents qualitative researchers with exciting possibilities. However, shifting from one writing style to another is not necessarily a simple matter of translation, in the way that naïve students of language believe that all one needs to learn a foreign language is a comprehensive dictionary of vocabulary. Indeed learning deeply a foreign language involves enculturation into new

¹ Other modes of representation include (but are not limited to) speech, dance, painting, dreams; examples of which appear each year at the annual conference of the American Educational Research Association.

grammatical structures, value systems and social practices. Depending on the degree of 'strangeness' of the new culture (and his/her propensity for embracing it), the learner can be afforded a unique opportunity to realise that language has a key role in enabling us to co-construct our taken-as-shared understandings of the world. A similar epistemological perspective is offered by radical constructivism which holds that we make sense not directly of the world 'out there' but of our experience of it; and that we test recursively the viability of our constructs via dialogue with significant others (von Glasersfeld, 1995).

Within qualitative research, adoption of alternative 'cultural' writing styles can have major implications for our epistemology of inquiry², including the way we conduct the inquiry and, significantly, the way we organise the structure of our research reports. It is the latter issue that this paper addresses. Laurel Richardson (2000), Carolyn Ellis and Art Bochner (2000), and Max van Manen (2003) are contemporary qualitative researchers who illustrate research writing within an alternative culture of inquiry. Eschewing the traditional objectivist perspective that regards research writing as a separate activity which reports, by looking backwards, on the completed empirical stage of an inquiry, they illustrate how the process of writing is, for them, inseparable from the process of inquiry: as one writes one inquires. In the preface of his book, 'Writing in the Dark', van Manen alternates between describing his physical surroundings and reflecting 'out loud' on his struggle to explain the art of phenomenological writing, thereby exemplifying the living nature of phenomenological inquiry. Ellis adds an autobiographical dimension that orients her writing to exploring her cultural situatedness (Ellis, 1997). She calls this 'autoethnography'; a mode of self-exploration that involves examining critically her relationship with the broader culture in which she has been immersed historically. In a chapter in the *Handbook of Qualitative Research*, Ellis discusses with Bochner, as he enters her room, her immediate struggle to explain the nature of autoethnography; in doing so her dialogical writing exemplifies the act and art of autoethnographic inquiry. This writing has a compelling immediacy about it, a fresh self-consciousness that exposes the writer's struggle to (re)construct her understandings and ideas in the moment of writing for a particular audience.

Common to these alternative forms of 'writing as inquiry' is a chronological structure in which the narrative flow carries us along from earlier events to later ones. A major advantage of this structure is the highly transparent nature of the ethnographic researcher's progressive subjectivity and the emergent nature of her methodology of inquiry (Erickson, 1998; Guba & Lincoln, 1989).

Literary Thesis Structures

Turning now to the main subject of this paper, we are concerned that, despite the literary turn in contemporary qualitative research, doctoral students in science education continue to labour under the illusion that their qualitative inquiries must conform closely to the standard template of the traditional thesis. This standard seems to be based

² By 'epistemology of inquiry' we mean a coherent and rigorous 'way of knowing' that shapes both our process of inquiry and the rhetorical style of language we use for expressing (the appropriate degree of uncertainty of) our knowledge claims.

on a largely uncontested assumption about the privileged nature of the epistemology of positivism which characterises research conducted in the natural sciences. This assumption has long colonised the social and human sciences. Based on the (hallowed) standards of the American Psychological Association (1994), with its propensity for reproducing the hegemonic science cultural myth of language, little more than a simple linear structuring is afforded. This structure is inscribed in the ‘mantra of positivism’: *Introduction, Literature Review, Methodology, Results, Conclusions & Implications*.

Linear structure implies (in extremis) that all related literature was reviewed during the initial conception of the research design, that the research design was fully formed prior to data ‘collection’, with all methodological aspects being cemented in place early in order to avoid invalidating the inquiry process, and that the ensuing results of the study were uncontaminated by the subjectivity of the (value neutral and unbiased) scientific researcher. For science educators, this taken-as-natural mode of representation probably has its genesis in our early enculturation into writing school science practical reports and, later, university science lab reports. To the extent that this mantra continues to be practised throughout science education, particularly in relation to qualitative research theses, the crisis of representation will appear not to exist and creative alternative thesis structures will not be afforded.

In Peter’s 10 years of experience as a supervisor and examiner of qualitative doctoral theses, the linear structure of the positivist form appears to be deeply implicated in gross misrepresentations of qualitative inquiries, despite valiant attempts by thesis writers to maintain their narrative voice. The imperative of structure tends to outweigh the importance of voice. The struggle to fit the round peg of their inquiry into the square hole of the standard thesis template often results in awkward and ugly writing. A retreat into depositing narrative writing in an appendix and the adoption of an authorial ‘voicelessness’ signals epistemological defeat for the qualitative writer. In succumbing to the structural mantra of positivism, novice qualitative writers are in danger of creating distorted portrayals of their inquiries as timeless, lacking in contingency and without an emergent nature.

By contrast, contemporary qualitative research writing employs modes of representation that are judged in terms of their polyvocality, reflexivity, verisimilitude, pedagogical thoughtfulness, etc. And accompanying standards of legitimacy (or validity) include evidence of the emergence of the research design, the shifting nature of the methodology, continuous reviewing of literature to establish significance of emergent issues, and the progressive subjectivity of the researcher (Denzin & Lincoln, 2000). If this is so, then why not afford similar opportunities to doctoral students to create theses that represent more authentically the processes of their qualitative inquiries? The issue, however, is not as simple as allowing alternative writing styles. It is an issue of recognising the need for alternative (literary) thesis structures.

In addressing this concern, Polkinghorne (1997) argues that the logic of narrative research should be reflected in the form of the research report. He advocates “diachronic” form, which represents the passage through time (and space) of the researcher’s actions.

I encourage social science researchers to conceive of their research endeavours as journeys whose destination is increased understanding of human beings and to use the narrative format to report their investigative travels. (pp. 18,19)

In this presentation we illustrate a narrative structure for a doctoral thesis that enabled Andrew to represent the intimate interrelationship between the processes of his research and development endeavours. Confessional and impressionistic voices provide unique insight and a strong sense of verisimilitude. We illustrate the use of electronic 'hot-links' that facilitate a coherent narrative pathway through the (electronic form of the) thesis and provide alternative reading pathways into situated reviews of related literature and methodological issues.

Rather than being viewed largely in aesthetic terms, this postmodern literary representation should be understood in terms of its important impact on the actual conduct (and conceptualisation) of Andrew's research. Indeed, the process of inquiry extended beyond Andrew's fieldwork into the drawn out act of thesis writing, thereby rendering the structuring and writing of the thesis part of the process of the research and creating a recursive relationship between the subject of the research and its written representation.

Representing The Flow of R&D

Unlike many of his peers who came from a teaching background, Andrew entered the field of educational research with qualifications in physics, media and science communication and professional experience in media production. Originally Andrew had considered a higher qualification in media studies, however he soon found that the field of science education provided a promising means of attempting a doctoral level inquiry into learning science with media. Although not formally a teacher, he had developed from previous qualifications in media and communication a good understanding of learning as building knowledge structures.

In his doctoral thesis research project Andrew set out to develop a game-like multimedia program for teaching Special Relativity theory. His plan was to design the game by drawing on his media production skills (including extensive computer programming skills) and then evaluate its implementation in a university Physics class. Thus he began the project with a view that the roles of media designer (or producer) and educational researcher were separate. This perspective was reinforced by his reading about contemporary constructivist educational methodologies - *Curriculum Development as Research* (Driver & Scott, 1996) and *Developmental Research* (Cobb, 1998) - in which curriculum/instructional design and subsequent research on classroom learning are conceived as distinct and separate activities. As a researcher, Andrew believed that the adoption of these methods would legitimise his inquiry as educational research. And as a designer, he believed that 'putting educational theory into the multimedia product' would promote acceptance of the finished prototype as being educational rather than being regarded as entertainment.

As the project progressed, however, Andrew experienced deep problems with this overall separatist approach. One of the most noticeable was that these adopted theories

and methods were focussed on the (unfamiliar) practice of teaching rather than being grounded in his own practice of media production. Andrew began to gain a new sense of the design process as a (constructivist) learning process. His role as media producer/designer came to influence his understanding of the topic of special relativity, computer graphics and educational theory. Increasingly, he came to interpret the (game) design process as one of (educational) research. However, this newfound insight was in diametrical opposition to the (positivistic) two-stage (design then research) methodology he had chosen for the inquiry.

After adopting several quite different approaches to designing the game over a period of a little over one year of full-time study, Andrew realized that the separation of the design and research processes had reached a crisis. Although the game design process had provided him with many invaluable lessons and insights, under the positivistic 'cause-effect' paradigm of educational research that he had unwittingly adopted, in which the game design was conceived as 'the cause' and classroom implementation as 'the effect', the design process itself seemed to be situated outside the realm of educational inquiry and thus outside of the scope his thesis. The subsequent brief implementation and evaluation phase (planned to take only 2-3 weeks) seemed to be the only legitimate focus of his thesis research. Andrew resolved this crisis by synthesising the design and research processes. Drawing on a paper by Cal Swann (Swann, 1999), in the field of Design, and on 'Fourth Generation Evaluation' (Guba & Lincoln, 1989), with its constructivist methodology, Andrew reconceptualised his (game) design process as a research process and his research (evaluation) process as a design process.

A major advantage of this new perspective was the alignment of the constructivist epistemology of the research with the constructivist epistemology of student learning upon which the game design had been based. This recursive methodology - RADDAR (Research As Design – Design As Research) - recognizes that both qualitative research and the design process require dialogue among participants and subsequent critical self reflection and interpretation. Further, Andrew's adoption of Schön's (1983) notion of "design as a conversation with the materials of a situation" (p. 78) abstracted and extended the notion of a participant to include the electronic medium itself. The RADDAR methodology became a key referent for the remainder of the *design* stage and shaped a close working relationship between Andrew and other key stakeholders, notably the university lecturer in whose first-year Physics class the multimedia game was to be trialled.

During the implementation, and quite unexpectedly, Andrew enacted the role of teacher alongside his established roles as (game) designer and (educational) researcher. Although the new role complexified Andrew's RADDAR practice, it generated valuable insights into student learning. Thus, during the inquiry, for Andrew a number of different voices emerged, all of which were engaged in dialogue; some were internal, such as his researcher and designer voices, and other voices were external, such as those of the lecturer, demonstrators and students, as well as the medium itself (see Fig. 1).

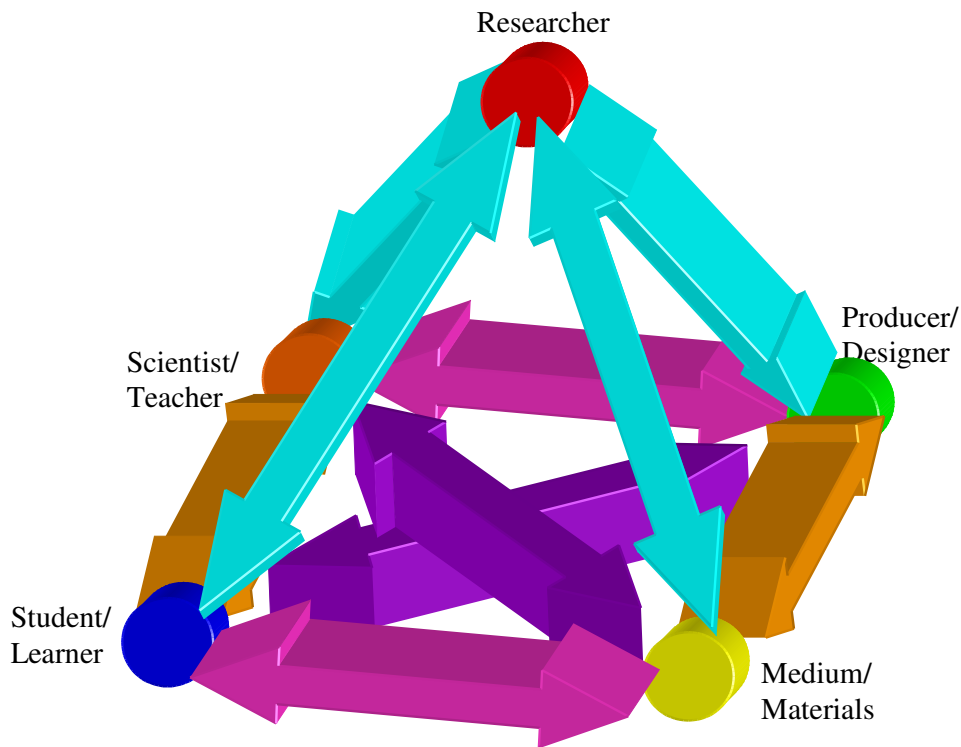


Figure 1. Final Voices in the Research/Design Process

Further, Andrew began to conceptualise his inquiry as being comprised of three main (temporal) stages. The first stage, *methodological design*, included the project's early development up until the dissonance between the (educational) research and (game) design. Stage two, *methodological synthesis*, heralds the synthesis of these processes in the form of RADDAR and follows the evolution of the game's design under the RADDAR methodology. The final stage, *product implementation*, focuses primarily on the implementation of the game within the university Physics laboratory.

Diachronic Structure and Voice

In designing the form of the thesis, Andrew reflected on how best to represent the evolving nature of the inquiry in a way that virtually placed the reader in the *lifeworlds* of the key participants. In particular, he wanted to situate the reader within the context of his own professional practice of media production by portraying his experience in struggling to develop a coherent 'research' identity. Thus, more than a narrative voice was required to represent the researcher's journey; the structure of the thesis needed to be aligned with the structure of the overall inquiry. Andrew decided to represent his 3-year research inquiry in terms of the three main stages of methodological design, methodological synthesis and product implementation. During each stage a relatively

unique methodology and theoretical framework had been employed within the evolving methodological structure of the whole project.

Andrew conceived a *screenplay metaphor* in which each of the three major stages of the research is represented within the thesis as an *act*, thereby following the classic three-act (beginning, middle and end) narrative structure (e.g., see Frensham, 1996):

- ACT I: identifies the problematic nature of the (initially) independent roles of researcher and designer, and tracks the evolution of the methodological crisis that eventuated.
- ACT II: resolves the conflict between Andrew's researcher and designer roles by creating a synthesized research methodology (RADDAR).
- ACT III: follows the period of implementation of the game in the Physics laboratory and the subsequent (re)interpretations and understandings while writing the thesis.

Each act comprises three *scenes*. Scene One presents a narrative account of that particular stage of the research journey, providing a rich personal account of Andrew's interpretations of his experiences (and those of other participants); Scene Two presents the corresponding theoretical framework, and Scene Three portrays the salient methodology. For example, Act I comprises:

- Scene One: A Science Producer Lost in the Digital Aether
- Scene Two: Theoretical Framework
- Scene Three: Methodology

The screenplay metaphor provided a conceptually powerful and professionally relevant theme for Andrew's structuring of his qualitative thesis. The metaphor provided also coherence at the micro levels of the thesis structure. Where necessary, scenes were broken down into *shots*, and shots into *frames*. For example, Act II, Scene One comprises:

- Shot 1: (Re)Searching for a (Methodo)Logical (De)Sign
 - Frame 1: Jacob gets a Voice
- Shot 2: Synthesis!
- Shot 3: The (En)light(ening) Clocks
 - Frame 1: (Re)Searching for a Story
 - Frame 2: (An) Illuminating Time

This complex but elegant thematic structure provides multiple reading pathways through the thesis. The main pathway follows the researcher's narrative voice through the first scene of each of the three acts (see Fig 2). Along this pathway, the reader encounters a

purposefully evocative, emotional, dramatic and interpretive account of Andrew’s personal journey through the inquiry. Thus, one can encounter the researcher’s experiential and situated knowing-in-action, free from the disruptive (and distorting) effect of the formal academic voice of the theorist and methodologist. These latter voices can be heard in the second and third scenes, respectively.

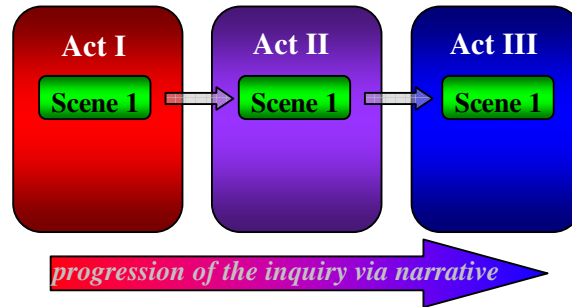


Figure 2. Main stages of the research as represented by the thesis.

In the second and third scenes not all is narrative; multiple writing styles have been used throughout the thesis in accordance with the writer’s need to represent differing epistemological aspects of his inquiry. Across the three acts, scenes two and three represent the researcher’s propositional deductive knowledge derived from his ongoing reading and reflecting on related research literature. Although there is some narrative voice and structure in these scenes, representing the writer’s processes of meaning making, none of the scenes is structured wholly as a clearly defined narrative. Rather, these scenes mostly present ‘chunks’ of coherent information whose order is determined by the order in which they appear in the narrative of scene one. Thus, scenes two and three can be understood as analogous to reference sections that support reading of scene one narratives.

The challenge for the thesis writer employing a non-linear structure is to facilitate the reader’s access to the supporting reference sections whilst preserving the integrity of the narrative structure. In this thesis, Andrew created hyperlinks at strategic places throughout the first scene of each act, particularly when an important theoretical concept is first introduced to the reader. A hyperlinked concept provides instant access, at the reader’s discretion, to relevant locations within scenes two or three where the concept is elaborated in the context of a literature review (see Fig 3). Thus, for example, the following excerpt from Act II, Scene One provides a narrative extracted from a video-conference discussion between Andrew and Peter regarding the methodological crisis; it contains a hyperlink to Scene Three:

During the discussions Peter suggested two methodological perspectives that he believed might help to resolve my concerns. The first and most influential, Guba and Lincoln’s (1989) “Fourth Generation Evaluation”, was the methodology of

constructivist inquiry (see Scene Three: Shot 2: Fourth Generation Evaluation²).
(Stapleton, 2003, p. 81)

Although hyperlinks are signalled in the hard copy of the thesis, needless to say, their full power is realisable only in the electronic form of the thesis.

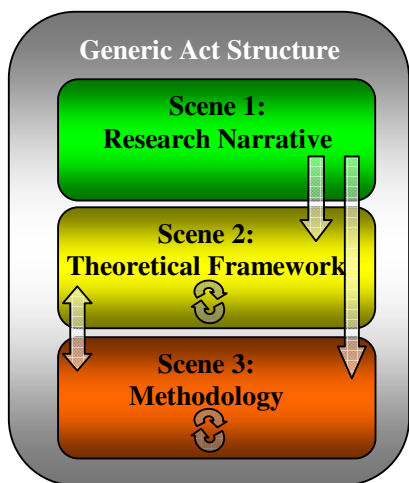


Figure 3. Key internal hyperlinking within a generic act

Andrew's interactive thesis makes more extensive use of hyperlinking to further create a rich and complex network of ideas, experiences, emotions, methods, data and theories in a variety of representational forms. Not only can hyperlinks take the reader from one point to another within the same scene (e.g., within the narrative of the research journey of Scene One), but they also afford the reader the opportunity to explore supplementary data sources, including: design sketches, storyboards, programming code, game prototypes, classroom photographs, desktop video-conferencing logs between Andrew and Peter, student workbooks, survey responses and concept maps. Thus, this multi-hyperlinked thesis text creates a rich tapestry into which is woven emergent narrative research accounts, theoretical frameworks and research methodologies. The result is a *bricolage* created from diverse texts and voices that informed Andrew's lifeworld of the research and hopefully helps inform the reader's lifeworld.

A Technical Caveat

Theoretically it is possible for all macro and micro structural units of a thesis to be hyperlinked. But the question of where to stop is perhaps one of feasibility. For the thesis writer it can be very time-consuming, especially in later drafts, to check the integrity of every hyperlink (both within the thesis and external to it (i.e., to supporting digital data)), and all the corresponding reverse links that enable the reader to return to

² The underlined text is a hyperlink in the electronic form of the thesis that takes the reader into Scene Three (within Act II) where the concept of fourth generation evaluation is elaborated.

the starting point of his/her detour. The complexity of this task increases when, as in the case of Andrew's thesis, the external documents not only have return links back to the thesis, but also have links within and between external documents.

It also can be very time-consuming to create an interactive thesis that works well on all computer platforms. Consideration must be given to a variety of issues regarding the minimum requirements of target platform(s): CPU clock speed, RAM, operating system (e.g., MacOS or Windows) and version (e.g., OS9, OSX, Win95/98/NT, Win XP), screen resolution (e.g., 640 × 480, 1024 × 768 pixels), colour bit depth (e.g., 16 bits per pixel, 32 bits per pixel), peripherals (e.g., CD-ROM drive) as well as specific requirements (e.g., 32Mb 3D graphics accelerator card). Making these specifications explicit not only serves as a guide for the contemporary user but also provides an archival record for those with updated technology. Further, if the writer has decided to go cross-platform, we recommend testing the thesis early and often to minimize the possibility of potential problems later.

Consideration must be given also to the software requirements (including any non-standard fonts) needed to view the electronic thesis as the writer intended. Here we recommend software that is freely available in the public domain and has a large user and support base. Further, we suggest that the amount of software required to read the electronic thesis be kept to a minimum in order to reduce the reader's potential learning curve. For example, Adobe Acrobat is readily available cross-platform and allows for fonts to be embedded within documents thereby relieving the user of the need to install fonts to view documents as intended. Further, Acrobat provides methods of navigation within and between data sources.

Time must be allocated for the process of digitising materials in non-digital form such as sketches, personal notes, storyboards, and so on, and then converting them to file types such as PDF. Part of this process will most likely require some form of digital manipulation, using programs such as Adobe Photoshop, in order to protect the anonymity of data sources.

Thesis writers must remain aware of the constraints of their method of delivery (e.g., CD-ROM, DVD, online) and the requirements of their target platform ensuring that digitised data sources are presented in an appropriate format (e.g., using appropriate compression— such as JPEG—where required). The delivery method presents other challenges. The writer must consider, for example, whether to create a set of CD-ROMs for each specific platform or a single hybrid (e.g., Mac(HFS)/PC (ISO)) that will run cross-platform. The latter approach allows customisation of the contents of a CD-ROM (e.g., platform specific executables or Read Me files) on a single disc, with the knowledge that users will have access to shared files as well as any file designated as being specific to a particular platform.

The delivery method also raises the issue of copyright. For example, the doctoral student needs to be aware of copyright, licensing and distribution issues that may arise as a result of including particular third-party software or files on their completed delivery platform (e.g., CD-ROM). Some companies do not allow for individuals to redistribute software, even if it is freely available for no charge within the public domain, or if it is an educational version. Other companies may allow distribution of their software and files only if certain conditions are met.

In Closing

As a final note, with the advent of Denzin and Lincoln's (2000) seventh moment of qualitative research, the crisis of representation is not a simple matter of one media form (e.g., electronic hypertext) usurping another (e.g., the printed word). Rather, we understand the crisis as encouraging thesis research students to challenge the authority of the (written) text, to embrace and celebrate new, experimental and creative forms of thesis representation — theses that create vivid and compelling representations of the lifeworld of the research and researched.

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