An extended 'learning by design' framework based on learner perceptions

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Abstract

This study focuses on Grade 6 learners' perceptions of 'learning as design' during the creation of a collaborative hypermedia product. Data were generated via a Likert Scale questionnaire, semi-structured interviews, learner journals, observational notes, Task Elicitation List, Task Ranking List and open-ended learner evaluation reports. The findings of the study are considered within Lehrer's framework for hyper-composition-based design, i.e. planning, translating and transforming, evaluation and revising. Inferences are made which suggest that a more explicit and comprehensive overview of the process can be presented as an 'extended learning by design' model. This framework or model is visually presented to prospective implementers.

Keywords: learning by design model, hypermedia, learner inferences

Introduction

Researchers contend that learners of today have to develop several 21st century technological abilities to prepare them for life (Prensky, 2010; Jonassen, Howland, Moore, Marra & Crismond, 2008; Eagleton & Dobler, 2007; Watts-Taffe & Gwinn, 2007). The South African Department of Education has recognised this contention for nearly a decade and advocates that Information and Communication Technology (ICT) integration should relate to a number of critical outcomes and curriculum imperatives (Department of Education, 2004). However, no explicit strategies or approaches of how ICT can be utilised to achieve these outcomes are provided (Hodgkinson-Williams, 2005). Such impediments are exacerbated by the fact that the majority of South African schools do not currently have computers (Department of Education, 2004; Howie, Muller & Paterson, 2005).

Despite these barriers to implementation, the need to explore ICT strategies, and to examine existing ICT related frameworks in the South African context, remains an issue if teachers are to be better prepared for current and future challenges. As such, this paper reports on a small sample of Grade 6 learners' perceptions of the 'learning by design' process via hypermedia artefacts in a South African primary school. The inferences drawn from these perceptions are taken into account when considering the applicability of 'learning by design' models as exemplified by Lehrer (1993).

Hypermedia and artefact concepts

Multimedia can be defined as a message or information conveyance tool which integrates different digital media elements such as text, graphics, sound, animation and video into an interactive computer application (Neo & Neo, 2001). Hypertext refers to the interactive dynamic links among the units of information (text) on a navigational system over which users have

navigational power, or where they control the sequence of accessing information (Nielsen, 1990). Hypertext can be used in a linear or non-linear manner to present information (Green & Brown, 2002). A text only website with hyperlinks (but without any graphical information, movement or sound) can be referred to as a hypertext website. Hypermedia is the extension of hypertext or the multimedia version of hypertext, i.e. the combination of multimedia and hypertext (Green & Brown, 2002).

A computer artefact is a realistic computer created product or presentation that can be used to represent the understanding of a learner or group of learners (Krajcik, Blumenfeld, Marx, & Soloway, 1994). It may take the form of a poster, pamphlet, model, presentation, dramatization, etc. (Harel & Papert, 1991; Kafai & Resnick, 1996). The hypermedia artefacts referred to in this research refer to the online or offline educational software created by learners to represent their understanding of, and solution to, a problem or scenario.

Learning by design

'Learning by design' or 'designing to learn' implies that learning and knowledge construction is an active process that occurs as a result of the designing or construction of learner created artefacts (Perkins, 1986). It can be argued that knowledge about a topic, as well as practical application of design related skills, is strengthened during the design process. In the context of computer design, 'learners as designers' would not learn *from* the computer in tutor mode, but would learn *with* the computers (Jonassen, Myers & McKillop, 1996). When learners design their own hypermedia products using computers as construction tools, they enter "into an intellectual partnership with technology" (Jonassen, Myers & McKillop, 1996, p. 96). The users are not controlled by technology, but are in fact the creators of an artefact by using the computer as a *generative* tool, a process that Hokanson and Hooper (2000) refer to as 'generative use' of computers, i.e. a context in which learners construct knowledge. Maddux and Johnson (2005) refer to this as a Type II application of technology, meaning that technology applications are used to learn in new and better ways that transcend traditional Type I approaches in which the computer is used in tutor or drill mode, also referred to as the learning *from* mode.

The design and construction of products or artefacts is an active process of meaning making (Bruner, 1996; Han & Bhattacharya, 2001) where the emphasis is not on teaching or instructing, but on building or creating. When learners design artefacts, the term constructionism instead of constructivism is used as an extension of constructivism. Constructionism acknowledges the principles of constructivism, but adds that an efficient way to acquire or to build knowledge is through constructing, building or creating artefacts or products (Johnston, 2006; Ackerman, 2001; Harel & Papert, 1991). The emphasis in constructionism is thus not on teaching or instructing, but on building or creating, hence emphasising product, process and understanding (Ackerman, 2001; Harel & Papert, 1991).

The hypermedia design process, arguably most clearly encapsulated in Lehrer's (1993) model, consists of planning, translating and transforming, evaluation and revising (see Figure 1 in the 'Results Section'), and provides learners with opportunities to develop complex mental skills such as project management, research skills, organisation and representation skills, and presentation and reflection skills (Carver, Lehrer, Connell & Erickson, 1992; Lehrer, Erickson & Connell, 1994). Lehrer (1993) and Beichner (1994) have reported that learner-based hypermedia design has had a positive impact on learners' retention and comprehension of content. Beichner (1994) also found that the design process had a positive effect on increased learners' motivation,

interest and cooperation. In addition, Beichner (1994) and Turner and Dipinto (1992) indicated that the design process made the learners more aware about their prospective audience. McGrath, Cumaranatunge, Chen, Broce and Wright (1997) reported that learner hypermedia construction had a positive impact on learners' self-esteem and confidence. Liu (1998, 2003) indicated that she found that learners were able to internalise the design skills involved, i.e. project management, research, organisation and representation skills, and presentation and reflection skills. A study by Yildirim (2005) reported that students not only preferred learning by hypermedia construction to learning in the traditional classroom, but that the students claimed that they have learned more effectively. The positive aspects noted above motivated this study to establish the perceptions of a small sample of South African children. These perceptions were taken into account when considering whether the 'learning by design' model as exemplified by Lehrer (1993) could be made more explicit in terms of understanding and using the process for teaching.

Rationale and teaching aim

In this study Grade 6 learners were required to construct hypermedia artefacts on the different thematic rooms of the Port Elizabeth Museum, South Africa. The thinking behind designing hypermedia artefacts of the different museum rooms was not only to introduce the learners to the museum, but to provide them with an opportunity to create a product that any other learner could use to inform them as to what the museum offers. At the same time, the artefacts were intended to provide interesting and extended information, images and even video material. In addition, learners could also insert any interesting information from other sources related to the museum theme that they had chosen. The rationale behind the project was to provide learners with an opportunity to become designers, to practice existing skills and to obtain new skills through hypermedia constructions in a project-based approach.

The teaching aim that followed from the rationale was to empower learners to design their collaborative hypermedia artefacts through the use of Microsoft FrontPage in order to address the critical outcomes (CO's) of the National Curriculum Statement (NCS), i.e. to provide learners with opportunities for planning, searching for information, assisting learners to determine whether information found were useful, to highlight the importance of summarising information and not just rewriting information found, assisting them to develop presentation as well as design skills through using technology, trying to find ways to solve problems during the design process, and working collaboratively in groups.

Intervention design

The learners were initially briefed about the duration of the project, *viz.* a two hour session per week over a period of nine weeks, and that it would entail the design of a hypermedia product. They were also told that they had to design a hypermedia product in groups that could be used by other learners.

The participants were taken to the Bayworld Museum in Port Elizabeth were tasked to explore the museum galleries, decide upon a gallery of interest; summarise interesting information about the topic; and take appropriate digital photographs if necessary. Groups of four to five members were formed on the basis of topic interest.

Once back at school, the learners were introduced to Microsoft FrontPage. The hypermedia design tool, FrontPage, is a web design software application that enables one to insert pictures,

drawings, scanned images, text, sound and hyperlinks onto web pages which can then be uploaded onto the internet or which can be used offline. The learners were shown how to download the digital images from the camera as well as how to incorporate digital images from a camera, Encarta and the internet. The learners had some experience of Microsoft applications, but they had not previously used Microsoft FrontPage as a hypermedia design tool.

Each session commenced with an explanation of what had to be done. Learners used their journal writing and reflection sheets for initial goal setting and planning for every session. The learners then worked on their projects, either individually or collaboratively, in the computer-room and the adjacent library. At the end of every session the learners completed their journals by writing about what they found easy and difficult, the problems they experienced, and whether the problems were resolved or not and by whom.

Methodology

The research was conducted as an exploratory case study with a view to investigating the perceived experiences of the participants.

Sample and consent

The hypermedia intervention was implemented in a Grade 6 class (n=27; 14 boys and 13 girls) at a middle class ex-Model C primary school which has a computer laboratory with 15 networked computers and a modern media centre. The learners divided themselves into five groups based upon the topics they wanted to explore. Learners were informed that this study formed part of a research project and that their participation was voluntary. Consent was elicited from the principal, parents, and the school governing body.

Data gathering tools

Data gathering tools used were structured interviews, task ranking procedure (TRP), teacher observations, learner journal writing planning and reflection sheets, a Likert Scale Project Assessment Questionnaire (PAQ) and open-ended learner evaluation reports. The Likert Scale PAQ and evaluation report were completed at the end of the project. Learner journals were completed during each session while eight structured individual interviews were conducted from the third week onwards and three structured group interviews as well as another four structured interviews were conducted at the end of the project.

A 70-statement, seven-point Likert Scale PAQ, similar to what was used by Lehrer et al. (1994), Carver et al. (1992) and Liu (1998, 2003), was used to establish how the learners perceived the hypermedia design processes. Items referred to searching for information, planning, designing, mental effort, presenting ideas, designing and connecting, linking ideas, evaluating and reflecting, revising, collaborating and interest. Sample statements were, *"We have done a lot of planning in our group about what we should do"*, *"I do not achieve the goals that I set for each period"*, *"I think it is important to use illustrations, pictures, photos or AVI Video files in my project"*, and *"I make notes about the content that I read."* The seven-point Likert scale PAQ descriptors ranged from a one (*"Does not describe me very well"*) to seven (*"Describe me very well"*). All the responses indicated by one to three were totalled together to determine the number and percentage of learners who stated that the statement does not describe them very well. The same process was followed with the responses five to seven for learners agreeing that

the statement described them very well. All the responses in the middle, i.e. responses indicated by the number 4, were added and indicated that the learners were uncertain whether the statement described them well or not well. The median score was calculated to determine which responses the learners considered as most salient. In a similar manner to that of Lehrer et al. (1994) and Carver et al. (1992), only learner responses that had a median score of 6 or more (responded very positively), or 2 or less (very negatively) have been considered.

A Task Ranking List (TRL), based on the work of Lehrer et al. (1994) and Liu (1998), was distributed to learners at the end of the project. Learners had to rank tasks related to design from most important to least important. The ranking list consisted of 24 tasks such as *"Learning how to use the FrontPage software"*, *"Searching for books"*, etc. Learners had to choose the five most important and five least important tasks and rank them in order of greater and lesser importance. The rank mode and median were used to categorise the items as most and least salient.

At the end of the project, the learners listed all the tasks that they had to complete to develop their project on the front page of the Task Elicitation List (TEL). On the subsequent pages, numbered boxes were placed, each containing a section that requested the learners to indicate the tasks that they had to complete. The learners had to indicate for each task that they have mentioned what had helped and what had hindered them in the completion of the specified tasks that they had written down on the first page. Cantor and Kihlstrom (1987), with reference to Little (cited in Cantor and Kihlstrom, 1987), contend that the tasks which are mentioned are central organizing forces in an individual's behaviour. Hence, the mentioned tasks could indicate which *'forces'* or which aspects are viewed as being important.

The learner journal writing planning and reflection sheets comprised of two sections containing pre-determined questions. Section one was completed at the beginning of each session and contained one question, namely *"What are your goals for today?"* Section two was completed at the end of each session and consisted of sample questions such as *"Did you achieve your goals today? Yes or No? Give a reason for your answer"*, *"What did you enjoy today?"*, *"Which problems did you experience today?"*, *"Were the problems you experienced solved? How and/or by whom?"* and *"Anything that you want to write about today?"*

Structured individual interviews were conducted from the third week onwards as well as three group structured interviews. In addition, another five individual structured interviews were conducted at the end of the project. Sample questions in the structured interviews included aspects pertaining to searching for information (*"What do you do with the information found that seems to be relevant?"*), planning (*"What kind of planning did you do?"*, *"Where do you do your planning?"*, *"Why do you do your planning there?"*), designing and mental effort (*"What are the things that you think about during the project?"*), etc. The learners also completed an open-ended learner evaluation report in which they responded to questions such as, *"What did you learn during this project?"*, *"Which aspects or things deserve attention in your design?"* and *"Would you do the project in the same way next time if it is a similar project? Yes or No? Provide reasons."*

Data analysis

Pre-determined codes related to the Lehrer (1993) and Liu (1998, 2003) hypermedia design aspects were used to analyse the data. In an attempt to a provide a picture of the participants' perspectives (Patton, 2002) within the framework of the model under consideration, these codes

were arranged to fit the steps of Lehrer's (1993) hyper-composition-based design (Figure 1), *viz*. planning, transformation and translating, evaluating and revising.

Results

The data are presented below according to the 'learning as design' framework (Figure 1) for hyper-composition-based design by Lehrer (1993).

PLANNING
- Make decisions about:
  ◊ Major goals
  ◊ Topics / Components
  ◊ Relations among components
  ◊ Macro structure of the browser
  ◊ Design team collaboration (role assignment)

TRANSFORMING & TRANSLATING
- Search and collect information
- Develop new information
- Select and Interpret information sources
- Segment information into nodes
- Decide on the nature of the presentation
- Cross reference nodes by semantic link construction (Decide on the nature of the link)

EVALUATE
- Evaluate constraint satisfaction
- Self-test browsing
- Obtain browser feedback

REVISE
- Changes in representations
- Changes in semantic structure
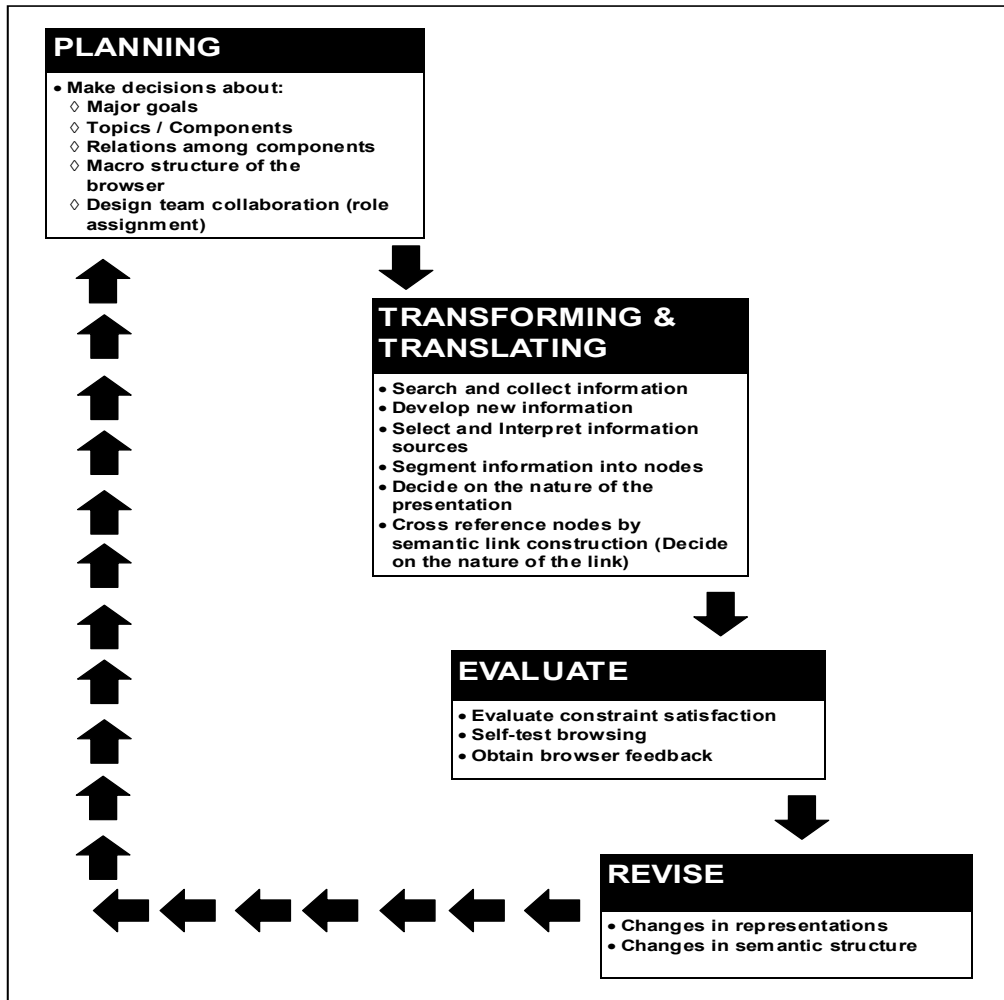
Figure 1: A framework for hyper-composition-based design (Lehrer, 1993, p. 202)

Planning

The children's responses during the interviews suggest that a major aspect of their planning process was the consideration of the project being 'doable'. Examples of positive responses were, *"I thought that I would be able to get information"* and *"I had lots of information about*

my topic." An example of learners feeling that the project was 'not doable' is illustrated by the response *"We were too scared to do this."*

The data from the Task Ranking List (TRL) suggest that the learners perceived the following aspects as the most important tasks for a hypermedia design project: learning how to use Microsoft FrontPage as design software tool, designing screens [storyboarding] on paper or on cards, searching for books with information about the topic, visiting the library, using the internet to search for information, creating a timeline for planning purposes, discussing with team members what information to be included and taking notes on what one reads. The responses on the Task Elicitation List (TEL) indicate that working together, sharing of ideas and teamwork, as well as searching for information were seen as being the most important aspects during a hypermedia design project.

The PAQ data indicated that more than half of the learners felt that they had planned extensively in their groups. Interview data concurred that learners understood what planning entails with statements such as *"We got together and said this is what we are going to do now and this is what we are going to do at a later stage."* Data from the TEL suggested that working together in teams was perceived as an important aspect in the hypermedia design project, as did data from the open-ended learner evaluation report. These data also suggest that the learners were aware that planning has to be improved when some wrote in the Learner Evaluation Report, *"We will work together as a group on one aspect and not separately", "Our tasks would be: one must search for information, one must work on the computer, one must try to design the screens, one must do the typing. Maybe one can type faster and the other one know more about computers [designing].*

Several self-critical views emerged such as *"Our planning was not really good. Learner A started immediately, Learner B and I planned first what we are going to do on the computer. Sometimes we did not plan correctly"* and next time *"we would change a bit. We would discuss first what we should do. We would rectify the aspects in which we made mistakes."*

The TEL data also suggests that on reflection, learners felt that collaboration was an important aspect of this hypermedia design project; that not working well together can become constraint, i.e. it could influence the quality of the project. Collaboration helped them comprehend what was expected of them and mentioned tasks such as *"Assist one another", "Planning collectively"*, and *"Assist other group members when I have finished"*. The PAQ data revealed that over two-thirds of the learners believed that they had worked well together and that they could accomplish more as a group than as solitary workers. Three quarters of the PAQ respondents indicated that they would ask peers or an expert (usually their teacher) for assistance when they did not understand something or did not know what to do.

Transforming and translating

Analysis of the journal data revealed that the great majority of learners indicated that they started searching for textual information during the first two sessions. However, small number has indicated that they were also concerned with planning what they had to do; drawing storyboards, looking at the images that were taken at the museum and using their notes that they had made during their museum visit. Their journal writing also suggests that different types of goals relating to different aspects and tasks were set at different stages. For example, during the first four weeks goals referring to the search process seem to be important, but as the project commenced, the searching-related goals became less important. Such goals related to designing on the computer,

to finishing the project and to editing and rounding off the design, were not a high priority at the start, but their importance increased towards the end of the project. Their journal entries suggest that, although the majority of their goals were met, not all were achieved during each session.

Responses in the PAQ indicated that two-thirds of the learners responded that they spent the majority of their time finding information. Only 68% of the learners indicated that they used the internet as a source for information. Interview data suggest that some learners did not use the internet *"because I obtained enough information in the library."* Those who did use the internet, did not limit their information gathering to online searches, but also used Encarta and other sources, *"I tried to use the Internet. But I then used software, Oceans* [Microsoft CD] *and there I found lots of information."* It was also observed that the marine group used photo edition software to zoom in on images, where after they were able to read and summarise the information from these images.

Responses to the PAQ also suggest that the learners were aware that they could not always use all the information that they found. They felt that note making was very important (91% of responses) a view confirmed by the data from the TRL, TEL and interviews, *"We summarise on small pieces of paper, because we do not want to write every single word, so we use our own words"* and other learners agreed by stating *"I write only the main words"*; and *"Sir, I read and then I try to put what I read in my own words."*

In the PAQ more than two-thirds indicated that they used storyboarding on cards as a technique to design their screens. The perceived importance of designing on paper was confirmed in their journals (mentioned 27 times by 13 learners during the first four weeks of the project). Visual material was also seen as important to assist with meaning making, i.e. to convey or enhance the textual. The PAQ data revealed that over 90% of the students saw visual material as being an important aspect of their project and more than two-thirds of the learners had recorded that they had reflected on the best way to present an idea. The TEL data also indicated that learners felt that the collation of visual material was an important task during the hypermedia design process, as did the interview data, for example, *"If you have to look at a page of information in front of you that just contains typed text, then it sometimes gets a bit boring, but if there are more video clips and pictures included it becomes very interesting."* Goals related to visual material were mentioned several times in learner's journals. Examples of these goals stated by different learners were; *"Search and view appropriate video AVI clips", "Scan pictures plus rounding off [the project]"* and *"To add more pictures"*. The learners regularly visited the folder that contained the AVI video clips and museum photo gallery that was made available to them on the networked server.

In the PAQ, 73% of the learners indicated that they had tried to design their links in their projects in such a way that people can easily make connections between headings. In a similar way, 68% of the learners indicated in the PAQ that they tried to present their information in such a way that their prospective audience would easily understand what their topic is about. The data from the PAQ suggest that the majority of the learners had done their hyperlinking of screens and concepts on the computer only after they had finished designing all their screens on paper. It was observed that hyperlinking was left to near the end of the project. Interviews confirmed that learners experienced problems with hyperlinking and left it until the end of the project, *"We experienced problems with linking [on the computer]"*, and another learner stated towards the end of the project that *"I just have to make the links then I am completely finished."*

The majority of learners indicated in the PAQ that the journals had assisted them in their planning

and practical implementation. Interview data also revealed that journal writing had been seen as valuable as it assisted planning (setting goals for each session), deciding whether goals had been achieved, identifying what had been learned, and raised awareness of problems experienced and whether they had been solved or not.

Evaluating

The PAQ revealed that the majority (73%) valued browser testing and evaluating what their design looked like on the screen. Similarly the interviews confirmed that learners used Microsoft Internet Explorer to test how their design displays. For example, one learner said: *"We had tested it each time when we thought that there could have been an error".* Improvement was not limited to software and learners made use of their fellow group members, learners in other groups and their teacher to evaluate their projects. (*"We tested each other's work to check whether everything works OK"* and *"I have asked other learners whether they think it is correct and then I have looked at their recommendations and when Sir made suggestions, I tried to improve on them").*

Revising

TEFL and interview data indicate that the children felt that it was important to test, at regular intervals, how a browser such as Microsoft Internet Explorer would display their project in order to make revisions. The revisions made referred, for example, to links that did not work and pictures that might not be displayed. Corrections and changes to pages were made on a regular basis, not just at the end or towards the end of the project. This was normally done whenever learners thought that there could be a problem, when they completed a screen and sometimes when they entered the class to check whether everything was still working. An example of a learner's responses is *"When we completed a page, a screen, then we checked and saw whether it worked and then we went through everything [all the screens] and then checked whether we could go back to ascertain if everything was still working"* Other examples are, *"We checked each time when we entered the class what worked and what did not"*, and *"When we completed a page, I mean a screen, then we checked whether everything was OK, whether we can go back [hyperlinks working or not], is everything still working. This is important because the people who will look at the project will probably make some comments about the project when they view it."*

Data from the learners' journals indicated that they had made many changes to their designs. It was stated 19 times that during the last three weeks of the project that the learners wanted either to edit (round off) their projects, correct mistakes on their screens or correct their spelling in their presentations. In the PAQ, 77% of the learners indicated that after they had completed the project, they reflected on how they would improve (or revise) it in the future, as illustrated in the following interview statement *"Because I have learned more things on the computer I want to go back and do those things that I have learned .... I want to change [update] the information."*

Discussion and conclusion

The data show that, firstly, the planning aspect of 'learning by design' can probably be fruitfully extended, categorised and made more explicit than is presented in Lehrer's 1993 model (Figure

1). Selection of a topic (and why it is selected) remains a major goal, but the fact that the children in this study highlighted the 'doable' aspect of the project suggests that making this aspect of the process explicit would be valuable. Their responses also suggest that the planning aspect of the process may best be viewed as taking place in two distinct phases – firstly as planning the major goals, and then, after initial searches have taken place, planning specifics via storyboarding, sequence planning, ideas on presentation, etc. The processes they adopted seem to suggest that they found it most fruitful to do this before initiating the design process on the computer. The data also suggests that the learners did most of their evaluating while presenting their artefacts throughout the project – not just at the end – and that while designing they looked to their peers and others for feedback, resulting in multiple testing of their ideas, which helped them revise their presentations. Revising thus occurred not only at the end of the project, but happened throughout the duration.

Reflection on these inferences gave rise to the notion that a more explicit and comprehensive overview of the process could be presented in order to assist prospective implementers in a more denotative manner (Figure 2). In an attempt to do this it is suggested that the design model of Lehrer (1993) be made more explicit by dividing the 'Planning' section of the model into "Decide', 'Investigate' and 'Plan' components.

The 'Investigate' component affords learners-as-designers with an opportunity to reflect on whether their decisions in the 'Decide' component are realisable, while the major goals of the project are formulated in the 'Plan' component. Initial searching sets the scene for more detailed planning before creating the presentation via iteration using feedback from peers and experts (usually the teacher). These iterations allow for multiple revisions in contrast to the recursive nature of the Lehrer (1993) framework (the Lehrer framework implies that revising for experienced designers occurs as a result of evaluation and normally happens at the end of the design process). Lehrer (1993) argues that less-experienced designers might follow a more linear cycle. However, we are of the opinion that evaluating and revising are important from the start of the design process, as indicated by the responses of the learners that testing and changing was done virtually during every session. Hence the extended framework that is presented in this paper emphasises the fact that revisions should be made at any point related to the boxes denoted by search, plan design, create on PC, and present and evaluate.

The bulleted points under each component in the presented boxes indicate the aspects that have to receive attention, i.e. the skills required and the aspects or procedures that learners have to think about and/or have to follow in order to enable them to design their hypermedia products. For example, the teacher needs to ascertain whether the learners have the necessary decision making attributes, whether they are able to search for information, whether they understand goal setting, whether they can take notes and summarise information, whether they understand what is storyboarding, etc. The arrows that follow from 'Decide' to 'Investigate', from 'Investigate' to 'Plan Collectively' and from 'Plan Collectively' to the joined grouped boxes ranging from 'Search' to 'Test & Evaluate' denotes the preferred linear path to be followed. The arrows pointing diagonally and leftwards from 'Revise' (also represented by the vertical solid arrow line to the left of 'Revise at any point'), suggests that revising is an iterative process that not only happens when the project has been completed, but that is done throughout the 'learning by design' process, i.e. one should test and evaluate continuously and revise accordingly.
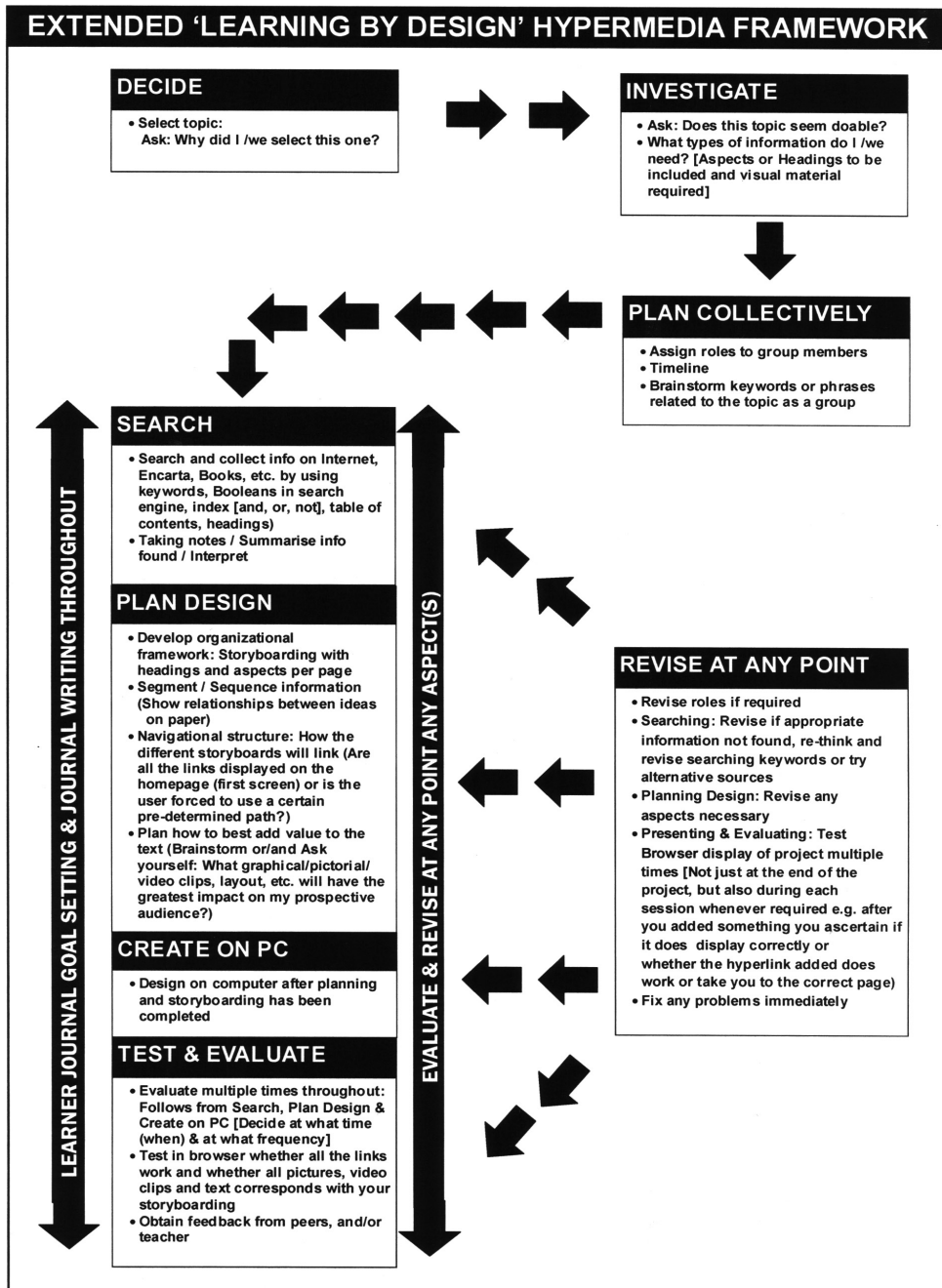
EXTENDED 'LEARNING BY DESIGN' HYPERMEDIA FRAMEWORK

DECIDE
- Select topic:
  Ask: Why did I /we select this one?

INVESTIGATE
- Ask: Does this topic seem doable?
- What types of information do I /we need? [Aspects or Headings to be included and visual material required]

PLAN COLLECTIVELY
- Assign roles to group members
- Timeline
- Brainstorm keywords or phrases related to the topic as a group

SEARCH
- Search and collect info on Internet, Encarta, Books, etc. by using keywords, Booleans in search engine, index [and, or, not], table of contents, headings)
- Taking notes / Summarise info found / Interpret

PLAN DESIGN
- Develop organizational framework: Storyboarding with headings and aspects per page
- Segment / Sequence information (Show relationships between ideas on paper)
- Navigational structure: How the different storyboards will link (Are all the links displayed on the homepage (first screen) or is the user forced to use a certain pre-determined path?)
- Plan how to best add value to the text (Brainstorm or/and Ask yourself: What graphical/pictorial/ video clips, layout, etc. will have the greatest impact on my prospective audience?)

CREATE ON PC
- Design on computer after planning and storyboarding has been completed

TEST & EVALUATE
- Evaluate multiple times throughout: Follows from Search, Plan Design & Create on PC [Decide at what time (when) & at what frequency]
- Test in browser whether all the links work and whether all pictures, video clips and text corresponds with your storyboarding
- Obtain feedback from peers, and/or teacher

LEARNER JOURNAL GOAL SETTING & JOURNAL WRITING THROUGHOUT

EVALUATE & REVISE AT ANY POINT ANY ASPECT(S)

REVISE AT ANY POINT
- Revise roles if required
- Searching: Revise if appropriate information not found, re-think and revise searching keywords or try alternative sources
- Planning Design: Revise any aspects necessary
- Presenting & Evaluating: Test Browser display of project multiple times [Not just at the end of the project, but also during each session whenever required e.g. after you added something you ascertain if it does display correctly or whether the hyperlink added does work or take you to the correct page)
- Fix any problems immediately

Figure 2: Proposed extended 'Learning by design' framework based on learner perceptions

The vertical solid arrow on the left highlights the fact that journal goal setting and journal reflective writing related to pre-determined questions should occur throughout the project. It

is important to note that this study has found that learners valued journal writing based on pre-determined questions and that the Lehrer (1993) design does not make use of learner journal writing. As learners highly valued the journal dimension, the extended framework clearly indicates its importance. Another important aspect to take note of is that 'Create on PC' was given its own 'box' in order to indicate that one should do most of the planning before one start with the hypermedia design on the computer, an aspect that was also indicated by the learners. We are of the opinion that making these processes and skills explicit in a representation of a model could help teachers towards a better understanding of the strategy and to plan their teaching in a way that assists their learners' master what is required.

In line with statements that teachers are in need of clear guidelines when implementing ICT teaching and learning strategies (Leach & Moon, 2000; Hodgkinson-Williams, 2005) we have tried to present the extended 'learning by design' hypermedia design framework in order to provide prospective implementers, possibly teachers, with a clearer picture of the aspects involved and the rationale behind each. As both ICT resources and ICT related learning practices are a concern within the South African context (Department of Education, 2004; Hodgkinson-Williams, 2005; Howie, Muller & Paterson, 2005), the motivation behind presenting the extended framework is to make the design process as clear as possible to prospective teachers as implementers, especially for those who do not have a great deal of experience in ICT hypermedia design projects.

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