IMPLICATIONS OF THE TECHNOLOGICAL PROCESS FOR TEACHING WEB DESIGN: A CASE STUDY

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ABSTRACT

The traditional methods for teaching information system design (ISD), including web page design, fail to concentrate on the explicit procedures for creating a learning environment conducive to technological problem solving. Methodological aspects that focus on technological problem solving are not appropriately applied in the present ISD environment. Thus, the needs of the information system designers are neglected.

The aim of this paper is to explore the implications of the technological process for the development of cognitive skills in an ISD environment.

In this study the methodology for ISD was integrated with the essential features of Technology Education. Learners were instructed in web design by means of an interface approach between Information Systems and Technology Education. The Web Design Project (WDP) - highlighting the technological process - was based on the stages of the technological process, which serve as a framework for building a software product.

The nature of this research required a qualitative, action-research approach where group interviewing, observation and document sources were used to gather data. WDP offered learners a constructivist vision of multi-method learning in the ISD environment, enlarging and strengthening the insight into the design process and a climate for enhancing intellectual processes and skills.

1. INTRODUCTION

Very little has so far been evident in the literature on the construction of an Information System Design (ISD) learning environment that will engage learners in the development of cognitive skills using present web design methodologies. Web design is without a doubt a key topic for the current and future applications of Information Technology. However, the present software development methodologies including the Team Structure Software Process (TSSP) methodology [1], do not raise the learners' awareness of the importance of reflecting on, and exploring a variety of strategies for learning more effectively. Based on practical experience the researcher of this study assumes that the integration of the technological stages with TSSP methodology will extend learners' cognitive capabilities and technological skills. It is important to consider that web design should be taught from both the content and the problem-solving perspective. "We have neglected the process dealing with thinking and doing to include design, problem solving, research and development ..." [2]. It is assumed that the elements, structure and functionality of the technological stages and a synergy with TSSP methodology have the potential to integrate and direct learning in a project-based classroom.

This paper reports on findings in a project-based classroom in which the Instructional Web Design Programme (IWDP) was implemented. The IWDP was based on an integration of the stages of the technological process and the TSSP methodology.

The key question addressed in this paper is: *What are the implications of the technological process for the development of cognitive skills of learners during web page design?* In considering this question, we argue for more emphasis on in-depth research on the technological stages and their implications for ISD. The process aspects of technology [2] and designing instruction for expanded learning need to receive attention. As the systematic structure of the technological stages is accommodated within the IWDP, the framework of the IWDP is the topic of the further analysis.

2. THE FRAMEWORK FOR THE INSTRUCTIONAL WEB DESIGN PROGRAMME (IWDP)

Complex thinking as an essential part of the technological process was used as theoretical framework for developing the IWDP. Complex thinking is an umbrella concept under which all other sub-processes (creative thinking, critical thinking, decision-making, problem-solving and design) and skills of higher-level thinking belong.

These sub-processes represent key components of the technological process. In addition, the IWDP is based on assessment criteria, range statements and performance indicators specified in the policy documents regarding Technology Education [3,4,5,6]. The development of the IWDP is based on both the behaviourist and constructivist instructional approaches and the critical importance of learning outcomes (problem solving, decision-making, designing, using critical and creative thinking) that are emphasized by educators [7,8] and the South African Qualification Authority [5]. The IWDP is developed with the purpose to guide learners through the stages and sub-processes of the technological process during a Web Design Project (WDP).

3.   CONCEPTUALIZING WEB PAGE DESIGN THROUGH THE TECHNOLOGICAL STAGES

3.1   THE TECHNOLOGICAL PROCESS

There are different perspectives on the technological process. The technological process includes "identifying needs and opportunities, exploring problems and constraints, gathering information from a variety of sources, modelling and testing production and evaluation" [9]. In the normal school curriculum the technological process is a strand that is divided into the following sub-strands: investigate, design and plan, make and evaluate [4]. Ankiewicz, De Swardt and Stark [10] state that the technological process consists of the following sub-processes:

- Thinking process (creative and critical thinking)
- Decision-making process
- Problem-solving process
- Design process.

The sub-strands correlate with the steps of the design process and the technological process is also divided into ten stages, where each stage indicates a period of time where an observable activity takes place [10]. According to these authors the technological process as a strand can be extended into the following ten stages: The problem statement; the design brief; investigation; writing a proposal; initial ideas; research; development; design and planning; making (realisation); evaluation and testing [10]. According to these authors each stage of the technological process can consist of more than one sub-process. "Critical and creative thinking is required for decision making; decision making is necessary in order to solve a problem and problem solving is a prerequisite for design" [10]. The technological stages could provide guidelines for ISD. Each stage will now be discussed briefly:

- The statement of the problem refers to the problem, need or want;
- The design brief is a detailed statement of how learners intend to solve the problem including the context or the environment;
- Investigation is the gathering of information related to the problem, needs, wants;
- Proposal is a formal written statement of what needs to be done in order to solve the problem;
- Initial ideas is the generation of initial ideas and possible solutions;
- Research is more specific investigation on problematic aspects of the chosen idea;
- Developing is the refinement of the chosen idea and the practical applications and the development of a model;
- Planning and design refers to planning on how to make, assemble and complete the product;
- Making is the realization of completed planning and modelling into a product;
- Evaluation and testing involve the testing and summative evaluation of the final product.

A range of case study, resource and capability tasks supplements the technological stages with their explicit structure and different functionalities. These tasks also require teacher's activities, which are located in the IWDP and aims to provide chronological guidelines to follow during the technological design process. *Case study tasks* contribute to the learners' wide range of knowledge through setting the base for resource and capability tasks [3], connecting the problem to the community outside the classroom. *Resource tasks* help learners to develop knowledge and understanding of web page design issues, project management skills including skills in using programming tools. *Capability tasks* are spread across the technological process and help learners to apply acquired knowledge and technological skills.

Learners need to be encouraged to investigate the context of the potential design task while the teacher is more involved in setting the task. (The National Curriculum for Design and Technology in England and Wales, 1988-1995) [11]. During the technological stages learners should have opportunities to explore a range of small, sequenced and pre-defined tasks. If learners are involved with larger tasks they will concentrate on the organisational aspects rather than developing solutions to the problem [9].

"Developing instructional activities and organizing them into a sensible and cumulative pattern is an important part of designing for instruction" [2]. Although the stages are regarded as linear, the technological process is iterative. These technological stages have something in common with Todd's [2] design approach and design loop.

3.2   SYNERGY BETWEEN THE STAGES OF THE TECHNOLOGICAL PROCESS AND THE TSSP METHODOLOGY

The emphasis of this paper is to combine the TSSP methodology with the framework for Technology Education. Implications of this conception of the Information Systems-Technology Education interface are important due to the fact that there are similarities with regard to the perspectives they bring to the study of design, problem solving and invention in functionally and strategically similar contexts. By considering ISD as a technological process the technological stages can be used as a framework for building a software product. The technological stages were used as a frame through which the TSSP methodology was implemented [1]. The major phases of the TSSP are:

- Scoping: The requirements, the basic needs to resolve the business issue are gathered and documented;
- High-level (functional) design: The functions that are needed to account for the requirements are enumerated and described at a high level. The platform design, the hardware, software and networking tools are chosen and documented;

- The detailed design consists of layouts and detailed logic of the functions in the high-level design. It also includes the design of the database and the test plans;
- The infrastructure ramp up: The hardware and software components necessary for solution development are installed;
- Construction: The applications are coded and unit tested;
- Testing: End-to-end system testing is performed, and if applicable user-acceptance testing is conducted;
- Support design: The Internet Service Provider (ISP) who will provide support, is identified;
- Implementation: The tasks necessary to bring the solution on-line, such as system testing, installation and training are executed. (Adapted from [1]).

Learners should be guided through the explicit strategies to manage organizational aspects of technological design [9]. The technological process as well as the rationale and criteria of web page design were explicitly explained to learners, especially through the integration of TSSP methodology and a range of tasks within the technological stages. The technological stages set a large framework for problem solving and provide a means of reiterating the problem-solving process not clearly identifiable in the TSSP methodology. DeLuca [12] highlights the importance of a knowledge base for technological problem solving. Attending to the synergy between the technological stages and the TSSP methodology should bring about a better balance of the technological knowledge and problem-solving skills of learners.

3.3   CRITERIA FOR THE DEVELOPMENT OF THE IWDP

Based on the sub-processes and stages of the technological process and the TSSP the following criteria for the development of the IWDP were derived:

Table 1: Criteria For The Development Of The Iwdp

NO.	DESCRIPTION
Cr1	The integration of the stages of the technological process and the TSSP methodology will explicitly guide and direct learners through technological problem solving.
Cr2	The problem solving component of the technological process will complement the TSSP methodology positively influencing complex thinking.
Cr3	The variety of functional characteristics concerning the stages of the technological process will provide instructional opportunities for the teacher in teaching WDP.

4.   RESEARCH METHODOLOGY

4.1   RESEARCH APPROACH

This research can be described as a case study seeing that the learning experience of students are being investigated relating to a specific event [13,14,15]. In this single evaluative case study action research was applied to obtain a holistic picture of the learners' and teacher's experience of the technological process. It gave freedom of action to act because some instructional strategies, during the stages of the technological process, were diagnosed as problematic. Thus, the researcher diagnosed, planned and implemented changes as the study progressed. The learners evaluated the interventions in the ISD environment.

4.2   SAMPLING

Two distinct mixed cultural groups of learners were identified in this study: five second-year learners (2 females and 3 males - average age 20) enrolled for the Information Systems Diploma at a Technikon, 12 first-year learners (5 girls and 7 boys - average age 19) enrolled for the International Diploma in Computer Studies at the National Computer Centre (NCC) in England. Most of learners from the NCC group come from a low socio-economic environment. Learners from the TSA group come from a middle socio-economic environment. Participants from the two groups present a purposive convenient sample. These learners followed the IWDP at a university in Johannesburg. Lectures were presented once a week for 13 weeks, with duration of four hours per session.

4.3   DATA-GATHERING METHODS

The IWDP was implemented and evaluated by the teacher and evaluated by the learners in the project-based classroom. The researcher played the role of the teacher who evaluated the IWDP through the retrospective interview and classrooms observations. Learners evaluated the IWDP through focus group interviews and journals. Learners evaluated their experience of changes in instruction through an essay. They expressed expectations, with regard to the IWDP in the narrative form. An independent researcher conducted the whole process of interviewing. Data gathered through multiple data gathering resources (which satisfy the criteria for triangulation) were processed and consolidated relating to the teacher's and learners' experience of the IWDP and specifically of the stages of the technological process.

5.   RESULTS

This section is organized into three main parts: Findings regarding the teacher's experience of the technological stages; findings in terms the learners' experience of the technological stages; findings concerning the teacher's and learners' experience of the technological stages.

5.1   PART A: FINDINGS REGARDING THE TEACHER'S EXPERIENCE OF THE TECHNOLOGICAL STAGES

Emerging from the interview and classroom observation relating to the teacher's experience of the IWDP, the following findings relevant for the technological stages were derived:

(a) **The technological stages served as an instructional tool for the teacher in creating opportunities for learners to improve their problem-solving and research skills**

The teacher facilitated problem analysis and the refinement of ideas, which occurred during the technological stages:

" ... Refinement of ideas happening throughout technological stages ... Technological stages provided problem decomposition ...".

The teacher commented that the IWDP/WDP required the facilitation of opportunities for the learners to practise research skills:

"...they had no previous research skills... they discussed different research methods during the Investigation stage...".

The teacher reported learners' positive feelings regarding guidance provided by the technological stages:

"... Technological stages are very useful... learners had feelings that there was guidance, but technological stages do not follow in the exact order...."

The teacher helped learners in constructing and implementing interviews, writing reflective notes and analysing documents and statistics relevant to the technological problem. The technological stages and the TSSP methodology were explicitly discussed, analysed and visually displayed to learners.

The teacher's activities were set to control the basic aspects of technological problem solving starting with demonstrations of technological skills and providing a frequent modelling of thinking through a repetitive, cyclic mode of teaching.

The teacher observed that the technological stages gave learners a feeling of direction and guidance through a range of the teacher's activities (Cr1). However, observation indicated that there should be careful consideration of the sequence and the inclusion of all the technological stages. Observations led to the conclusion that the IWDP with the technological stages promoted the instructional competency for creating opportunities for learners to improve their problem-solving and research skills (Cr3). The teacher felt that only after the establishment of refined ideas, during the technological stages, learners were able to move to "real-life context using design processes as tools for creation and exploration " [16].

(b) **The lack of sufficient time impacted on the quality of the teaching and on the learners' design solutions, and influenced the teacher's engagement with the stages of the technological process**

The teacher reported that there was insufficient time allocated for the technological stages:

"... They were coming once a week ...Learners need more time for design ...time limitation was evident ... "there was no time for modelling ... there was more time for research and the problem decomposition".

Difficulties observed by the teachers in facilitating tasks could be attributed to an underestimation of time for each technological stage. Too many tasks were offered to learners with limited knowledge and technological skills. Lack of performance of some tasks could also be attributed to uneven distribution of tasks to members in teams. Dissatisfaction with the fulfilment of some technological tasks indicates the essential need for accurate time planning for each technological stage and its corresponding tasks. Learners must have time and freedom to think of what is being said and be able to compare it with their experiences [17].

The inclusion of all the technological stages was questionable as learners decided not to follow all the stages in their prescribed sequence within the limited time frame. The tasks belonging to the technological stage of developing were not performed due to the lack of time.

If learners had completed the task schedule it would have positively affected the quality of the design. The following can be concluded: Insufficient time left gaps in learners acquiring technological and cognitive skills of learners' and diminished the teaching of the WDP.

(c) **The technological stages supplemented by case study, resource and capability tasks and a corresponding array of the teacher's activities provide an essential foundation for developing learners' research skills and technological problem solving**

The teacher reported that learners had full control in choosing any sequence of the prescribed tasks and activities (TA) during the technological stages.

"They could perform TA in any order, they could construct their own set of TA, but the focus was on a particular set of activities in the technological stage..."

Varieties of tasks facilitated with a step-by-step instruction and the need for flexible tasks-activity structure (TA) in a collaborative learning environment were observed.

Learners were involved with research during both the investigation and research stage. Learners ignored the stage Initial Ideas as brainstorming and the generation of ideas occurred during previous stages.

The nature of ISD was conducive to the synergy between the TSSP methodology and the technological stages with a rich array of tasks, activities and teacher's activities.

From the point of view of the teacher, the technological stages proved to extend technological problem solving and to provide activity-based practice in varieties of research and problem-solving tasks, and the choice of strategies for the teacher, which helped learners to focus on the elements of the problem and linking them into an integrated structure (Cr2 and Cr3). The stages of the technological process linked with the TSSP methodology, collaborative learning and the teacher expertise in facilitating problem solving initiated learners' problem-solving skills (Cr1 and Cr2).

In terms of the teacher's experience of the technological stages it can be concluded that the criteria Cr1, Cr2 and Cr3 were accomplished.

5.2 PART B: FINDINGS REGARDING LEARNERS' EXPERIENCE OF THE TECHNOLOGICAL STAGES

Emerging from multiple data gathering sources relating to learners' experience of the technological stages, the following findings were identified:

(a) **Acquiring research, decision-making, critical thinking and problem-solving skills within the technological stages**

Learners reported an explicit link between research skills and decision-making skills during their involvement in the technological tasks:

> " *In the beginning we had to go out to different places, and get some information on different ways how things are actually done, and then we had to sit down and then figure out a way which suites us best, which we think would be best our way then you, afterwards had to take out some stuff that you found...and also put some of your own thoughts"... To get information you had to do research ...you do the research and then you do decision making...you get overall idea what the design is going to look like... "*

The technological stages played a significant part in advancing the learners' research and reflection skills, which formed a base for decision making and critical thinking. The technological stages further enhanced experiential learning, furnishing learners with real-life opportunities to increase their affective, motivational and problem-solving skills. This was particularly true as learners experienced multi-method learning through case study, resource and capability tasks during the technological stages. Evidence indicated that tasks influenced an explicit link between decision-making, research skills and design skills forming a background for problem solving (Cr2).

(b) **Case study, resource and capability tasks within the technological stages provided direction and an essential basis for practising research, decision-making, critical thinking and problem-solving skills**

Learners recorded their involvement in a variety of tasks during the technological stages and the opportunity to experience a direction:

> *"...Additional tasks such as evaluation of information, material search ... fulfilment of proposal... to make us have a direction, where we are supposed to go".*

Learners commented on the usefulness of pre-defined tasks and activities:

> ... *"It helps ... you to organize and to clarify, see what you did and what you would do... "They give you ideas and keeps you focused"... "Online and off line activities are important because it gives a knowledge on searching information".*

Previously prepared tasks and activities provided inexperienced learners with very concrete and specific support. Notes written in journals revealed that the pre-defined tasks and activities gave them *"a direction", "keeping them focused".* Emerging from data were the organizational benefits and learners' responsibilities acquired during the technological stages and their understanding of the technological problem by getting an *"overall idea of what the design is going to look like"* (Cr1).

(c) **The lack of sufficient time impacted on the quality of the learners' work**

Learners commented in a focus group interview that limited time made an impact on actual work on computers, and that they spent more time on the first two stages:

> *"...We need more formal time ... we spend a lot of time on first two stages... "*

Learners commented in journals that insufficient time was allocated for the WDP:

> *"... There is little time left for us to complete work... "*

Although time was inadequate for the completion of all the tasks and learners did not recognize the importance of all the technological stages the fact that learners completed tasks relating to problem decomposition and research, stimulated cognitive skills of learners. If learners had enough time to complete all tasks during the technological stages, it would lead to a more creatively oriented web design.

Hill [16] states that technological problem solving is open-ended and creative. In creation and invention, there are always states of order and disorder [16]. However, evidence revealed that it is also a systematic, step-by-step guided process.

The evidence lead to the following conclusions: i) The step-by-step instruction and in-depth involvement with

case study, resource and capability tasks, assisted learners in acquiring thinking skills; and ; ii) the technological stages gave learners direction, and acquiring an image of the whole system. Evidence based on learners' experience reveals the fulfilment of the criteria Cr1 and Cr2.

5.3   PART C: FINDINGS REGARDING BOTH THE TEACHER'S AND LEARNERS' EXPERIENCE OF THE TECHNO-LOGICAL STAGES

The commonalities between the findings of the teacher's and the learners' experience of the technological stages can be summarised as follows:

* The technological stages empowered learners with thinking skills particularly through engagement with the resource and capabilities tasks dealing with problem decomposition and research. This was expressed in an explicit link between decision making, research skills and reflection forming the basis for problem solving (Cr2).
* Guiding the learners through the technological stages helped them to create a picture of the whole system. According to Harris [18]: "... we are forced to conceptualise the component, which helps us identify the crucial elements and their relationship to the overall system ...". A good conceptual overview of a system helps learners to initiate the technological design and to remain on track (Cr1).
* By providing structured guidelines (learners had no experience in system design) through explicit tasks, learners' created a link between the methodological steps in system design. This contributed to self-reflection as learners mentally reviewed the sequence as they went through the stages of the technological process. Structured tasks are supported by research [19]. Todd [2] suggests that teachers should move away from pre-prepared activities. Providing learners with explicit indicators of what is expected from them, increases self-monitoring of their own design process and reflective thinking in general (Cr1 and Cr2).
* Advance planning of learners' activities, tasks and the teacher's activities freed the teacher and learners from concentrating on the organizational matters of the WDP and provided the opportunity to concentrate on creative aspects of designing the refinement of ideas. The synchronising of learners' tasks and the teacher's activities gradually gave way to a more independent mode of learning and teaching (Cr1 and Cr3).
* The specific sequence of the technological stages and the necessity of including all the stages during the WDP need to be considered by both the teacher and the learners.
* Insufficient time during the technological stages impeded the completion of most of the learners' tasks and the teacher's activities. However, by providing opportunities for the development of skills through 'hands on' activities as well as the incubation of ideas

through 'space repetition' during the technological stages, formed arenas for critical and creative thought.

Both the teacher and learners confirmed that the technological stages contributed to enhancing learning and teaching, which confirms the fulfilment of the criteria.

6.   CONCLUSION

The technological process has certain implications for the development of the cognitive skills of learners during web page design. The following conclusions can be drawn from this inquiry:

The technological stages with a pre-defined (TA) structure and the teacher's activities can supply learners with direction, and free learners as well as the teacher from concentrating on organizational matters of the WDP.

The technological stages provide the teacher with very concrete and specific support. These also assist learners in gaining important insight into how ISD works. Consequently, learners experience explicit exposure to practising complex thinking.

Through the IWDP learners' cognitive skills, leading to the next generation of software designers, can be improved. Learners need to develop an understanding of the software concepts and skills in performing procedures for ISD before they emerge into innovation. An array of instructional strategies and techniques available to teachers to choose from, can assist learners in developing their skills, knowledge, attitudes and thinking.

Learners have to be guided through the integration of the stages of the technological process and a software development methodology that could help them in problem analysis, extensive research and critical thinking.

Integrating the technological process and the TSSP methodology, on which the IWDP was based, proved to be a viable option. The Information Systems-Technology Education interface is important in adding meaning to learning and the teaching experience. Designing instruction around this synergy (expert type of teaching, guidance and collaborative work) can help learners as information system designers.

The findings from both the teacher and the learners support the virtues of the WDP as part of the IWDP for improving learners' cognitive skills. Based on the teacher's and learners' experience of the technological stages, the criteria were met, thus confirming the fact that a synergy between the technological stages and the TSSP methodology can enrich the instructional process as well as learners' learning in an ISD environment.

In conclusion, the criteria based on the sub-processes and the stages of the technological process and the TSSP, can

be used for further development of instructional programmes in ISD.

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