Design and Implementation of Computer-Based Training: A Quality Assurance Approach

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Abstract

Distance Education is a non-traditional mode of training and can take many forms, one of which is the use of Computer Based Training (CBT). This paper reviews various quality assurance models for designing the delivery of programmes at the universities and other training institutions. It presents the findings of a CBT research that is currently being carried out at the Department of Mechanical and Manufacturing Engineering, University of the West Indies, Trinidad. The significance of the research is discussed with particular emphasis on the influence of curricula sequencing on knowledge acquisition in learners of varying cognitive styles. The paper concludes that adherence to quality assurance principles could result in the enhanced performance of users of the CBT.

Key Words: Quality Assurance, Computer Based Training, Education Technology

1. Introduction

Nowadays, the design of study programmes is implemented is no longer left solely to the discretion of curriculum designers. Universities and training institutions must subscribe to the dictates of the accreditation bodies on their programmes. They face pressures from their stakeholders to increase enrollment, while they are strapped with constraints on teaching, facilities, and financial resources.

In response to the requests from their stakeholders, many universities have sought to expand enrollment through the introduction of distance education courses, which may employ the use of CBT technologies. Many professional programmes at these universities and other training institutions are mandated to maintain international accreditation in order to satisfy the need of students and participants of having an internationally recognised certificate. Some quality systems stipulate that the students, which are participating in programmes of study via the distance route, should not be at a disadvantage in terms of the quality of the experience that they receive [1]. Thus it is imperative that the quality assurance (QA) systems that exist in the face-to-face mode of university education are expanded to the distance mode. The QA systems must take into consideration the design, implementation and evaluation of courses, which employ CBT.

According to the International Organisation of Standardisation (ISO), quality assurance denotes "all the planned and systematic activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfill requirements for quality" [2,3]. A variety of quality assurance approaches have been developed for various purposes and from different perspectives [4]. This paper seeks to capture the essence of these QA models and demonstrate how when they are applied to the design of a CBT, they result in not just enhanced performances of individuals, but of the entire group which utilises the CBT.

2. Quality Assurance in Education Technologies

There are two common approaches to quality assurance in education technologies. Firstly, Lifecycle Models originate from software engineering methods, and focus on different phases on a product. Secondly, Functional Models cover different functional areas of educational activities, ranging from administrative issues to the design of learning units [5-7].

2.1 Life-Cycle Models

Production and service processes follow a certain lifecycle, starting with the very first idea, ending with the termination of a product and abstracts the phases of a process. According to Pawlowski and Reiser [4], the lifecycle phases of a learning technology can be divided into nine phases, namely Analysis, Design, Development, Testing, Implementation/Realisation, Usage, Evaluation, Improvement, and Termination. These phases address specific phases of product lifecycles or software development [8]. However, they do not consider the pedagogical tenants of education, such as knowledge construction and learner characteristics, which are key to optimising the learning outcomes when utilising CBTs.

2.2 Functional Models

Another group of models focus on functional areas in the design process. This can be described as a classification of functions of educational activities, such as project management and performance against milestones [9] and advising and teaching [10]. Pawlowski and Reiser [4] advocate a typical functional model, "Quality on the line (QoL)" that was adopted by the Institute for Higher Education Policy in the USA. This provides a functional classification, including sub-processes for each functional area. Benchmarks can be interpreted as sub-processes. Table 1 shows the evaluation criteria and main processes of the model.

Quality Assurance (QA) can be placed in two categories with focus either on a result of a process, while on the other hand it can focus on the process itself [11]. Assuring the quality of processes implies that the results of these processes fulfill certain requirements as a consequence, while the other approaches only consider a certain product or service as the result of the processes. The criteria of evaluation differ significantly with different QA approaches. According to the Regional Accrediting Commission (RAC) [12] and the Quality assurance Agency (QAA) of New Zealand [1] several evaluation criteria for learning environments can be applied. These are:

- Infrastructure: Reliability, Adequacy for target group, adequacy of learning objectives, practical relevance,
- Design: navigation, presentation, interaction, and additional functions
- Methodology: didactics and pedagogy,
- Motivation
- Learning materials, delivery, structure, availability and relevance to presence
- Assessments: structure, use, content and feedback
- Support

In the application of quality assurance to E-Learning technologies, two distinct sets of criteria, namely *Content or Product Criteria and Process or Functional Criteria,* can be used [4,13] (see Table 2). The content Criteria seek to establish standards for what is included in the actual e-learning artifact. Whereas the process criteria seek to establish validity in the e-learning artifact, by ensuring that there are mechanisms in place to assure that the content is current and there are people responsible for the upkeep of the artifact. Moreover, Pawlowski and Reiser [4] have identified several process and product oriented approaches, which are employed in quality assurance for education technologies. These approaches are compared using the QoL criteria in the Table 3.

Of all the approaches that have been identified, the Essen Learning Model (ELM) [14] best suits the needs of the current research. It is a generic development model, supporting

Table 1. Evaluation Criteria of the QoL Functional Model

Category	Explanation
Institutional Support	
Document Technology Plan	Description of electronic security measures
Reliability of Technology	Reliability of technology involved
Central Infrastructure	Central System for supporting the distance education infrastructure
Course Development	
Guidelines	Guidelines for minimum standards for course design and delivery
Review	Periodical Review of instructional materials
Student Engagement	Students are involved in analysis, synthesis, and evaluation as part of course/programme requirements
Teaching/Learning	
Interaction	Student interaction is facilitated by various communication technologies
Feedback	Feedback is provided in a constructively and timely manner
Research	Students are instructed in proper research and validation methods
Course Structure	
Motivation	Determination of student motivation and commitment for distance learning
Course Information	Providing supplemental course information (objectives, ideas, etc.)
Library Resources	Sufficient access to (digital) libraries
Time Agreements	Agreements for assignment and response timelines
Student Support	
Programme Information	Providing programme information for students
Information Search	Training for securing information through databases/archives/news/...
Technical Assistance for Students	Availability of technical assistance and support
Support Accuracy	Questions are answered directly and accurately
Faculty Support	
Technical Assistance for Course Developers	Availability of technical assistance and support for course designers
Assistance for Transition	Training for transition from classroom to online teaching and learning
Continuous Training	Availability of training for online teachers
Support Material	Availability of materials for dealing with students' problems
Evaluation and Assessment	
Continuous Evaluation and Assessment	Regular and continuous evaluation involving several methods
Data Availability	Availability of data about cost, enrolment, and effectiveness
Regular Review of Learning Outcomes	Learning outcomes are reviewed regularly to ensure clarity, utility, and appropriateness

Source: Abstracted from Pawlowski and Reiser [4]

Table 2. Summary of Content and Process Criteria

Criteria	**Descriptions**
Content	
Accuracy	Resource must not contain biases, mistakes or omissions
Appropriateness	The resource should use an appropriate and suitable vocabulary, language or concepts, avoid mistakes or stereotyping
Clarity	Information should provide a clear tie between the purpose and the content and procedures suggested
Completeness	The resource should be offer all the essential information and elements, as well as inclusion of such components as self-contained activities, materials required and prerequisites
Motivation	The resource should achieve the active engagement of the learner and be interesting and appealing, build on prior knowledge and skills, and promote relevant action on the part of the learner.
Organisation	The resource should be easy to use and logically sequenced, with each segment of the resource related to other segments
Process	
Information Integrity	Information contained in the resources should be updated and the duration of the information should be indicated
Site Integrity	Should permit the users to know if the site is current and accurate
System Integrity	The system should be stable and adequate measures should be taken to keep the system integrity

Source: Abstracted from Pawlowski and Reiser [4]

developers, educators, and users on different levels of educational activities. The model provides concepts for project management, quality assurance, process integration, curriculum development, and the development of learning sequences and learning units. Emerging learning technology standards such as Sharable Content Object Reference Model (SCORM) and Learning Object Metadata (LOM) are integrated in the development process, minimising the authors' specification effort. Additionally, a detailed specification for context and didactical models was developed.

ELM is a multilevel development model, which was designed to support the educational processes on three levels: 1) ELM-C; the design and implementation of curricula, 2) EML-D; learning sequences, and 3) ELM-E; learning units. It aims at eliminating the apparent weaknesses of many software development models that do not include didactical concepts adequately. ELM ensures the overall quality of the development process of learning environments at different levels. The model provides generic knowledge for a variety of contexts that could be customised depending on the user's needs and preferences. The knowledge can be transformed into a specific process model for each project. ELM provides

Table 3. Comparison of Quality Assurance Approaches

	Model/ Quality Assurance Approach	Method: Product Oriented	Method: Process Oriented	Target Group: Developers	Target Group: Learners	Target Group: Teachers	Target Group: Content Providers	Target Group: Media Designers	Processes: Institutional Support	Processes: Course Development	Processes: Teaching/Learning	Processes: Course Structure	Processes: Student Support	Processes: Faculty Support	Processes: Evaluation and Assessment
Process Oriented Approaches	British Association for Open Learning (BAOL)	-	X	+	+	+	+	+	+	+	+	+	+	+	+
	Development of an European Service for Information on Research and Education (DESIRE)	X	X	+	O	O	+	O	+	+	+	+	O	+	O
	Quality Assurance Agency (QAA)	-	X	+	+	+	+	+	+	O	O	-	+	+	+
	European Quality Improvement System (EQIS)	-	X	+	+	+	+	+	+	+	+	+	+	+	+
	The European Foundation Quality Management (EFQM)	-	X	+	+	+	+	+	+	+	+	+	+	+	+
	QAA mapped on EFQM	-	X	+	+	+	+	+	+	+	+	+	+	+	+
	National Grid for Learning (NGfL)	-	X	+	-	-	+	O	O	+	+	+	+	O	+
	US Regional Accrediting Commission Distance Education Guidelines Mapped with ISO9000	-	X	+	+	+	+	+	+	+	+	+	+	+	+
	The 2000 Education Criteria for Performance Excellence	-	X	+	+	+	+	+	+	+	+	+	+	+	+
	Essen Learning Model (ELM)	-	X	+	O	+	+	+	O	+	+	+	+	O	+
	European Treasurary Board (ETB) Quality Research	X	X	+	O	+	+	+	O	+	+	O	O	O	+
	European Treasurary Board (ETB) Quality Criteria	X	X	+	O	+	+	+	O	+	+	+	+	+	+
Product Oriented Approaches	Erlangen Catalogue	X	-	-	+	+	-	-	-	-	-	-	-	-	-
	E-Learning Certification Standards	X	-	+	-	-	-	-	-	-	-	-	-	-	-

Key: '+ Fully supported **O** partly supported - Not Supported or Not Appropriate

Source: Based on Pawlowski and Reiser [4] a framework for educational technology projects, specifying the timeline of the project, involved participants, and information technologies. It also supports conceptual and implementation decisions.

The result of ELM-C is a detailed network of learning objectives and goals, which determines the structure and relations of learning sequences (courses). Based on these results, learning sequences are developed in ELM-D, which focuses on finding an adequate didactical method including the right technology depending on learning objectives and the user group. Single learning units are then designed and implemented in ELM-E. A diagrammatic representation of the Essen Learning Model is given in Figure 1, and the common life-cycle/product-oriented evaluation criteria are listed in Table 4.

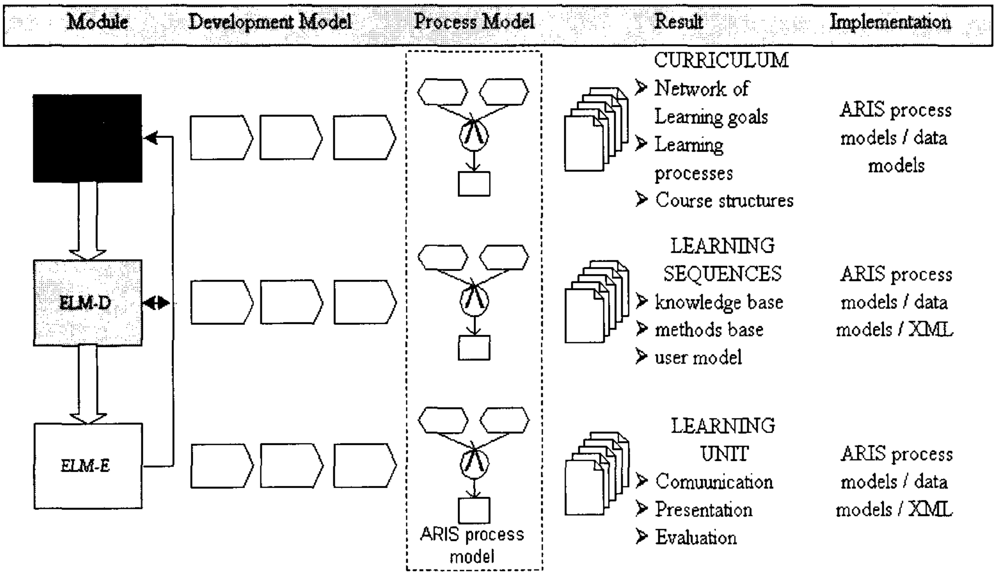

Figure 1. Essen Learning Model

Source: Based on ELM [14]

The more significant product-oriented approaches to quality assurance in the area of E-learning technologies are as follows

1. The Erlangen Catalog, which is an evaluation for students and teachers, measuring the quality of learning environments. This evaluation was designed for CBTs
2. The E-Learning Certification by the American Society for Training and Development, which covers technical and pedagogical aspects of E-learning, and although a certificate is presented, this standard does neglect important aspects of learning environments [15]. The

original classification includes:

- *Usability:* Navigation, Orientation, Links, Links Labels, Help, Legibility, and Text Production Quality.
- *Technical Standards:* Technical Requirements, Install/Uninstall, Reliability, Responsiveness, and Exit.
- *Instructional Design:* Communicate Purpose, Require Application, Gain Attention and Sustain Interest, Maintain Motivation, Elicit Relevant Knowledge, Show Examples and Demonstrations, Illustrate and Clarify Content, Provide Application Practice, Promote Near-Transfer Learning, Promote Far-Transfer Learning, Provide Integrative Practice Opportunities, Provide Feedback, Near-Transfer Feedback, Far-Transfer Feedback, Offer Instructional Help, Assess Learning, Use Media, and Avoid Cognitive Load.

Table 4. Life-Cycle / Product Oriented Evaluation Criteria

Criteria	**Descriptions**
Usability	Installation, navigation, reliability, learning pace, and ease of use
Presentation	Structure, presentation, aesthetics, readability, content, control elements, screen layout, and difficulty
Didactics	Structure, additional information, help functions, glossary, explanations, didactical structure, text quality, levels, and learning objective orientation
Multimedia	Graphics, animation, colors, explanations, visualisation, realistic appearance, and resolution
Audio-/Video	Audio-/Video quality, design, use, combination of media
Assessments	Questions, question design, feedback, reports, number of trials, relation to content, and correction functions
Documentation	Quality of material, handbooks, and additional material
Domain	Usability in different domains
Motivation	Individual adaptation, curiosity, utility, stress, acceptance, and originality
Additional functions	Print option, annotations, bookmarks, solutions, control of learning objectives, reports, and uninstall

Source: Abstracted from Pawlowski and Reiser [4]

3. An Empirical Research on CBT

The research has been undertaking at the Department of Mechanical and Manufacturing

Engineering of The University of the West Indies (UWI), Trinidad and Tobago. Its focus is to develop a CBT that is to be used to test the effect of different modes of interactions/ sequencing on the learning outcomes of students form a diverse population. The University has three main campuses, situated on the islands of Jamaica in the north Caribbean, Barbados in the eastern Caribbean and Trinidad and Tobago, in the southern Caribbean. Given the separation of these three countries by water, and the fact that the programmes offered at each campus are different, the distance education mode of delivery can be used to bridge the offering in the different Caribbean territories.

The research began when there was a need to disseminate information about *emission control systems in modern automobiles* and ensure the survivability of the local auto-mechanics. This was a consequence of the 'opening-up' of the local automobile industry, which led to an influx of automobiles that utilised new emission control technologies and greater environmental awareness that pervade the society in the late 1990s.

3.1 Two Fundamental Phases

Phase 1: Web-Based Tutoring

A Web-Based Tutor, Heat Engine Control Technologies (HENCOT), was constructed, utilising the static web format, with little pedagogical considerations [16-17]. Learners were allowed to study the information, which was provided by the tutor, and then a paper-based examination was administered. It was found that this model for a tutor employing World Wide Web (WWW) technology lacked the necessary pedagogy that ensures that learning resulted from the student-computer interaction [17].

Phase 2: Adaptive Hypermedia

In the second phase of the research, the ECOTech Tutor was developed. In order to tackle the fundamental deficiency of HENCOT, the Tutor employs the techniques found in Adaptive Hypermedia Systems (AHS) [18-19]. The architecture of ECOTech-1 Tutor (Version 1) is shown in Figure 2. The current research is situated at the ELM-D level of the Essen Learning Model, where ECOTech has been developed and tested in order to identify the effect of the sequencing of learning materials on the knowledge acquired in both near and far learning. This tutor was developed utilising *Common Gateway Interfacing* (CGI) [20]. The model of the tutor reflected the technology being utilised. It consists of three main modules:

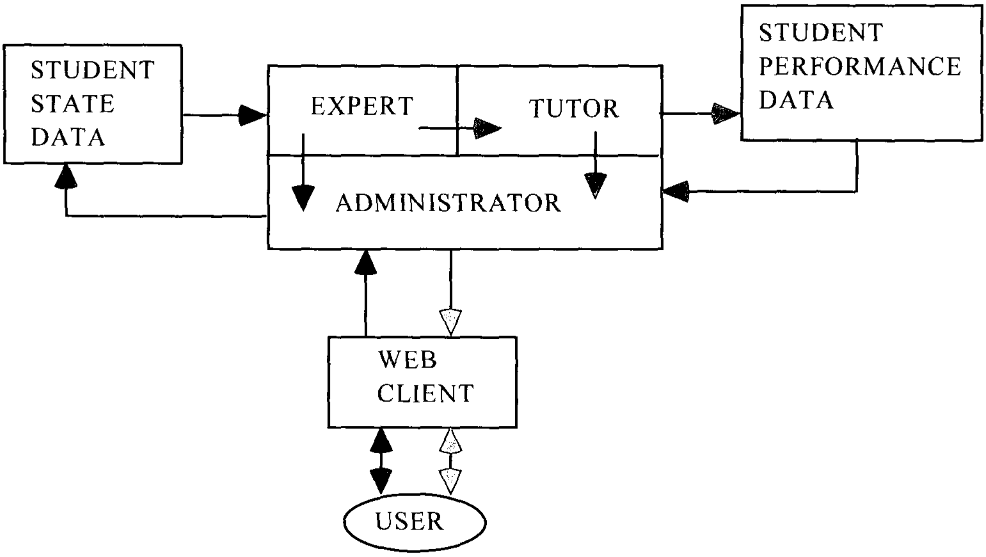

Figure 2. Architecture of ECOTech-1 Tutor

1) *The Teacher/Expert:* This module contains all the knowledge, which is to be transferred to the user. In this module resides all the information about the emission control technology. It is made granular enough as to avoid overload of the intended learners, both to focus the learning experience and to facilitate good ergonomics by limiting the amount of scrolling the learners must undertake in order to get to the end of a page.
2) *The Tutor:* Which is the module incorporating the teaching strategies and monitors the learner progress through the body of knowledge. The Tutor is that part of the design that adjusts the manner in which the ECOTech-1 Tutor interacts with learners. This module determines when and how many questions are to be presented to the learner, dependent on the learning state
3) *The Administrator:* Which interfaces with the learner databases and the web client/ browser in order to provide a user-friendly tutoring environment, which is a necessity in Computer Assisted Learning. This module stores all the information about the learner's progress and automatically sets up the last environment in which the learner was being tutored.

The hypothesis that drove the development of the tutor was that " there is a positive effect on learning outcomes in CBT Environments that is influenced by the sequencing/ rate of reinforcement of knowledge." This hypothesis was tested utilising three levels of sequencing/reinforcement, and was measured employing the standard deviation of the post-test scores of the learners.

3.2 Preliminary Results

Experimentation, including the three sequencing strategies was conducted to evaluate the Tutor [16]. In order to minimise the biases caused by a diverse learner population, a group of students whose ages ranged from 18-23 were selected. These learners, all having had completed their first year of the Two-year Auto-Diesel Technicians Diploma at one of the local Techno-vocational Institutes. In order to minimise the effects of the individual's characteristics as a contributor to learning, an almost homogeneous group of learners were tested. This was to ensure that the method of tutoring became the main factor that contributed to the learning outcomes. The learners were allowed to interact with the ECOTech Tutor at their own leisure and their performances were recorded and evaluated.

Results for HENCOT were obtained from the evaluation of one of the modules, which consisted of 15 pages of information and 30 tutorial questions followed by a 10-question examination. These results had indicated that the standard deviation in the post-test for learners obtaining a passing mark was 13.06 %, which was higher than that of the pre-test 11.13%. These values were quite large and were attributed to the fact that all the learners were subject to the same tutoring strategy, oblivious of their individual characteristics. The standard deviation of the scores, for learners passing the post-test of the ECOTech-1 Tutor, was found to be 4.47% and the average score was 92.0%, which shows that the different tutoring strategy has some impact on the level of knowledge acquisition of the learners. Some of the learners did fail the post-test. Observation has been that these learners are those who spent very little time pursuing the tutorials.

Based upon the results, there is some indication that the tutoring strategy is not all that contributes to the performance of the learners in tutoring, employing WWW technologies. The area of deficiency of the ECOTech-1 Tutor was in that of graphical communication. The Tutor failed to take advantage of animation technologies, which can be employed to demonstrate the operation and possible simulation of situations, which would test higher order learning skills developed by the learners. When these scores are desegregated into their individual components (such as Beginner, Intermediate and Advanced levels), the results are very significant. These can be seen in Figures 3, 4 and 5. With the exception of the performance projected for the Advance mode of tutoring, it can be seen that beyond some critical time, the performance of the student begins to decrease. The correlation coefficients are all above 0.99, which is a strong indication of the relationship between time on-task and student performance.

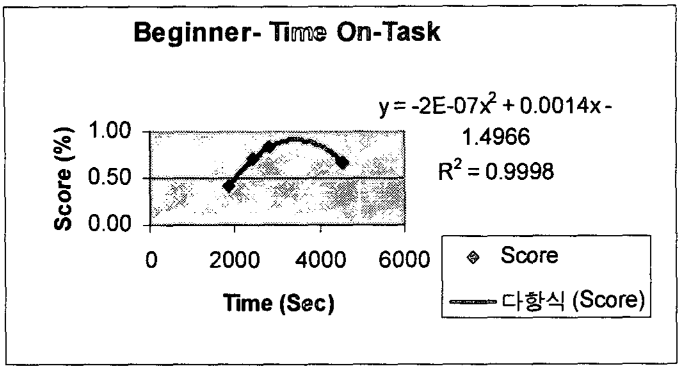

Figure 3. Beginner versus Time-on-Task

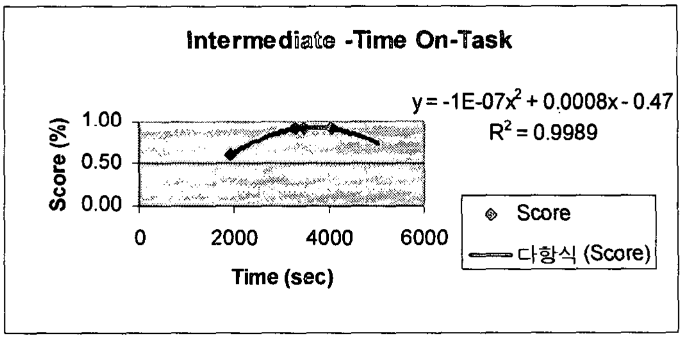

Figure 4. Intermediate versus Time-on-Task

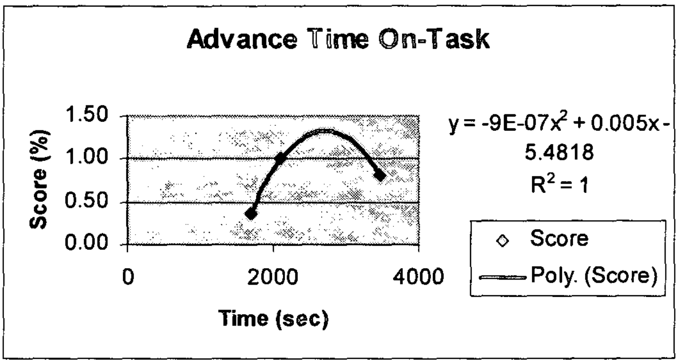

Figure 5. Advance versus Time-on-Task

Sprinthall *et al* [21] allude to the fact that in a classroom setting it is difficult to determine what is going on in a students' mind at any specific moment, thus minimising the correlation between time on-task and student performance. Using the Internet as the classroom where the student is actively engaged in his/her learning process, greater focus can be achieved, thus the significant correlation between time on-task and performance. A small amount of time on-task is an indication of students merely browsing instead of studying the material, while an extended time on-task could be an indication of the student being involved in activities other than the tutor at the same time. Thus, the students' performance is poor in both cases.

The results show that where the Advance and Intermediate modes of tutoring give the student the options of using hyper-textual links to obtain additional information on the subjects being tutored. The students seldom used these links and opted to utilise the tutor in a linear fashion. This concurs with the findings of Hothi and Hall [22] that students preferred to avoid wasting time reading material that may have been too complex or irrelevant to their particular task. In the case of the ECOTech-1 Tutor, the students would have already gleaned or information that would have been presented in a subsequent module of the Tutor.

3.3 The Design of Multimedia CBT

With the experience gained from the development of the Web-based Tutor and ECOTech-1 Tutor, a third design has been embarked upon. In this design, more of the individual characteristics of the learner will be taken into consideration. These characteristics were omitted in other designs, which could have led to some of the low performances that were observed. This is fundamentally the issue of learner preference or learning style. The determination of the learning style of an individual requires the assessment of that individual through the use of one or more testing instruments (TIs). These TIs can be categorised in three broad categories [13,23]:

1) *Cognitive styles:* the cognitive styles describe how the individual acquires knowledge (cognition) and how an individual processes information (conceptualisation). The cognitive styles are related to mental behaviors, habitually applied by an individual to problem solving, and generally to the way that information is obtained, sorted and utilised. Cognitive style a usually described as a personality dimension, which influences attitudes, values and social interaction.
2) *Personality-Psychological Styles:* The styles of this type describe the level at which our deepest personality traits shape the orientations we take towards the knowledge of the

world. They describe how the persistent potential abilities, varying from individual to individual, influence the process of learning.

3) *Social-Cultural Styles:* The social-cultural styles describe how the interaction of the learner with the teacher and the other learners, influences the learning process. In addition, this type examines the differences between male and female, younger and older learners. Finally, the cultural characteristics of the learners have a great influence in the way they obtain and process the knowledge.

For facilitating the implementation of the ECOTech-2 (Version 2) Tutor, a modified version of the "According to Three Senses" Model was used. The model is known as the VARK model and includes a fourth dimension of Reading/Writing [24]. VARK is a questionnaire that provides users with a profile of their preferences. These preferences are about the ways that they want to take-in and give-out information whilst learning. The VARK Model was chosen in that it minimised the time taken to determine a learners' Learning Style, in that it consists of only 13 questions and also, the responses of each question is weighted, thus making automating the assessment process relatively simple [17]. The learners go through a logic-flow sequence of activities (see Figure 6). These include:

1) *An Introduction:* this identifies the objectives of the tutor, and gives the guidelines for use.
2) *The Bio-Data of the Learner:* this is collected, along with a chosen user name and password for their use of the Tutor.
3) *Learner Type Test:* this uses the 13 questions form the VARK model to determine the Learning-Preference of the new learner. This is then stored in a database and referred to when the learner selects a new module for study.
4) *A Pre-Test:* this consists of a range of questions, covering the fundamentals of Emission Control Systems in automobiles. The results of this is used to determine the modes of interaction [17] that would optimise the time taken for learners of a specific grouping to complete the tutor, with a desired level of mastery of over 80%.

The revised architecture of ECOTech-2 (Version 2) Tutor is shown in Figure 7. The tutor is being configured to employ varying levels of video, audio and interactive animations. This is in order to test it with learners of varying learning style preferences, in order to determine which level of interaction/sequencing has the greatest influence on the level of knowledge acquired by the learners.

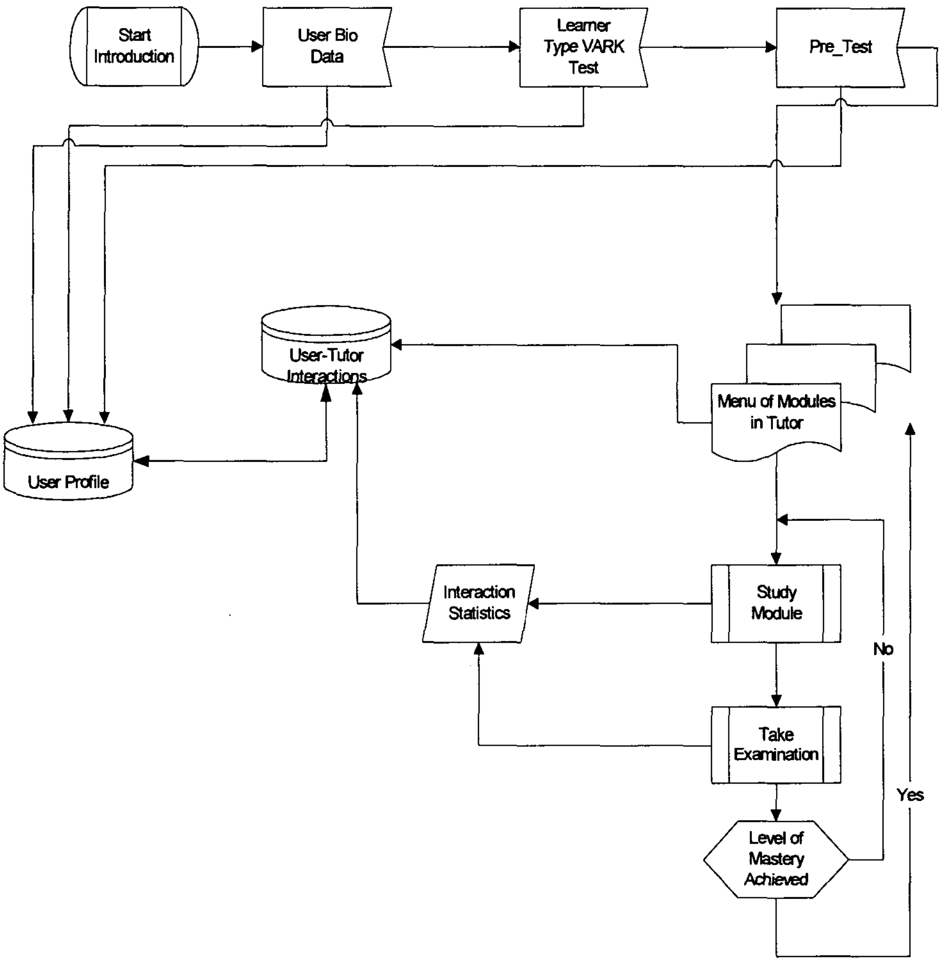

Figure 6. Flow Logic of ECOTech-2 Tutor

The Macromedia technology that is used to implement the tutor fulfills many of the positive criteria identified by the RAC [12] and the QAA [1]. These are: 1) the infrastructure, in terms of practical relevance; 2) Design through navigation and interaction functions; 3) the Methodology presented, which is based on constructivism; 4) Motivation that is implicit in regular and relevant feedback; and 5) the Assessments which are carried out, where the questions asked are pitched at different levels of Blooms taxonomy [25]. Given the icon-based authoring method that characterises Macromedia Authorware, the new tutor also demonstrates such characteristics as: 1) Extendibility, in that icons with additional information, drill and practice exercises and simulations can be added without disrupting the tutor; 2) Portability, which is implicit in the fact, that Authorware allows one to build software packages for distribution via Compact Disk, Local Area Networks or the Internet; and 3) Reusability, in that the actual content of each icon can be modified, resulting in a change in the information presented, but employing the same pedagogic and didactic rules.

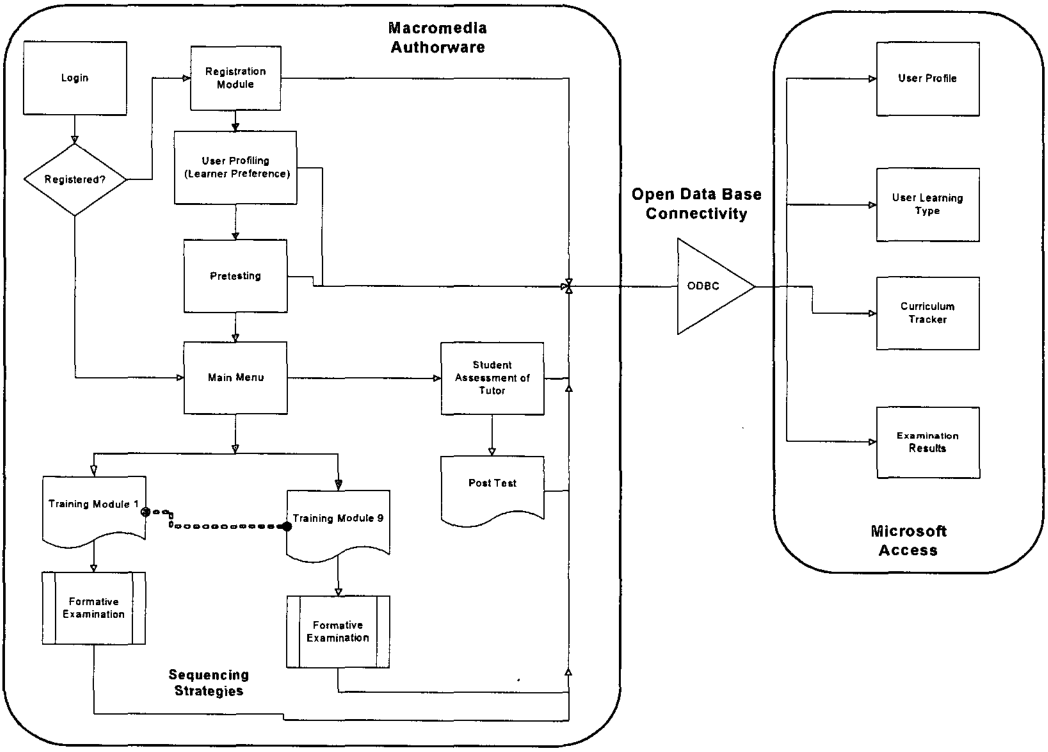

Figure 7. Architecture of ECOTech-2 Tutor

4. Discussion and Conclusions

As greater economic pressures are brought to bear on universities and teaching institutions, there will be an expanded role for technologies in the fulfillment of their respective curricula. The trend of many universities is to have their professional programmes accredited by internationally recognised accreditation bodies. These accreditation bodies take into account many varying dimensions of an education programme, including but not limited to; the mode of delivery, the teaching content, the teaching and support staff, the learning environment and the learners themselves. Universities must demonstrate due consideration to all these dimensions in order to have their individual programmes given a seal of approval, which allows the graduating students, the societies in which they are based and the governments and shareholders that finance them, to have the assurance that a *quality education* is being provided.

The design and development of CBT in order to meet the requirements of the accrediting bodies, in terms of quality assurance must incorporate the quality standards from both the technological, software development, perspective and the educational perspective. There are many quality assurance models, from which choices can be made in terms of the development and implementation of CBT systems. What is therefore needed to strengthen the credibility of the CBT technologies in accredited programmes is the inclusion of more techniques, which are based upon tried and proven educational paradigms. The CBT model presented in this paper utilises the ELM quality assurance approach as its' base and features the paradigm that different modes of interaction of information sequencing affects the learning outcomes, when a diverse group of learners are studied.

According to the empirical findings based on UWI, there was a 60% reduction in the standard deviation of the scores of learners achieving a passing grades in the previous implementations of the tutor, indicates that the improvements in the tutor, led to improvements in learner performance. The main improvement in the tutor was the inclusion of different sequencing/ rate of knowledge reinforcement strategies. These strategies maximised the learning outcomes for individuals of varying levels of pre-knowledge. The implications of this study thus far are that when CBT systems are designed, taking cognizance of the existing QA approaches, they become more facilitative of learning. Learning, not only from an individual standpoint, but also in terms of group performance. The relationships, which have been identified between time-on-task and performance implies that there may be a need to provide additional strategies in CBT systems that would guide learners to ensure that their performances are optimal.

In conclusion, it is shown that as more characteristics as specified in the various quality assurance approaches that are imbedded in the design and implementation of a CBT system, there is a representative enhancement in the performance of the learners. The technologies, which were selected to implement the ECOTech tutor, facilitated the inclusion of many of the best practices as specified by the various quality assurance approaches (such as QAA, ISO and RAC), this implies that even greater performances are expected from the learners during the next phase of testing. Thus when universities are considering utilising technology as a means of delivery in their curricula. CBT development that is based upon properly selected quality assurance approaches, will allow them to meet the requirements of their respective accrediting bodies, while ensuring that the performances of their students are optimally supported.

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