

TECHNOLOGY IMPLEMENTATION IN LEARNING AND TEACHING: - TOWARDS AN EFFECTIVE STRATEGY FOR VIRTUAL LABORATORY LEARNING

Clement Matasane , Mohamed Toriq Khan

University of Johannesburg, Doornfontein, Gauteng, South Africa, Cape Peninsula
University of Technology, Bellville, Cape Town, South Africa

Abstract: Lack of appropriate virtual laboratories in engineering to support learning methods has long been a problem. Computer based virtual laboratories have become a realistic option nowadays. Traditional teaching models are designed specifically to service students in groups and individual learning needs may be neglected. For development of an approach to help students in learning, it is important to have an understanding of how engineering students adapt and exercise their experience. This lack of understanding of the specific motivations and learning issues of engineering students is a major obstacle and is generally lumped into a mini thesis project in final year undergraduate engineering curricula or the design projects IV for Technikon students. Looking at the curriculum time, the main problem is to ensure that the time spent on learning is quality time and students are able to retain information to which they are exposed. Technology itself should act as a catalyst to the course material presented to students. The virtual laboratory design strategy must therefore transform the models of problem solving and constraints into a description of the system.

1. INTRODUCTION

Since the Victorian era education has commonly been based on a model which one can refer to as group-based education. The characteristics of this model include relatively large numbers of students moving, as a group and at the same rate, through the curriculum, the laboratories, and educators. This model, which has been frequently used for technical education, has implications for administration, evaluation, and learning. Some advantages of this group based model include ease of time-tabling as all students in a given group are at the same place at the same time. It also facilitates efficient use of teacher time as one teacher meets the learning needs of a significant number of students simultaneously. Additionally, physical facilities, such as expensive technical laboratories, are used efficiently in this model as many students are using the facilities at one time. There is also evaluation efficiency as tests and examinations can be administered in a large group format, such as national examinations. However, despite clear efficiency advantages there are also disadvantages to this method. As the model is designed specifically to service students in groups, individual learning needs may be neglected (Baron & Wolf).

Students often find it difficult to integrate and apply knowledge from previous courses in a new context. This is especially a problem with classic curricula, which are based on the assumption of a student's vertical integration of knowledge from previous courses. For example, at first semester level (at Technikons), it is expected that a student pass to the next level if all subjects have been passed, but the experience of the students has not been

challenged. This is being recognized as a growing problem with student adaptation in industry, as technology expands faster nowadays. As a result, there is an urgent need for engineers who can assimilate knowledge and translate it efficiently across and upward along discipline paths to achieve levels of experience.

In order to achieve this goal, it is important for each student to perform at his /her best of their ability throughout his/ her studies. For engineering a progression of knowledge is from the methods and analysis of past experiences to the analysis, interpretation and solutions of today's problems.

2. EVALUATING ENGINEERING STUDENTS

For development of an approach to help students in learning, it is important to have an understanding of how engineering students adapt and exercise their experience. This lack of understanding of the specific motivations and learning issues of engineering students is a major obstacle.

According to Vincenti and Polanyi, operational principles, which describe how a technological artifact fulfills its function, can not be deduced from natural laws alone [8].

"Finally, the operational principle provides an important point of difference between technology and science—it originates outside the body of scientific knowledge and comes into being to serve some innately technological purpose. The laws of physics may be used to analyze such things as air foils, propellers, and rivets once their operational principle has been devised, and they may even help in devising it; they in no way, however, contain or by themselves imply the principle."

Polanyi makes essentially the same point a bit differently:

"The physico-chemical topography of the object may in some cases serve as a clue to its technical interpretation, but by itself it would leave us completely in the dark [about how it achieves its operational purposes]. The complete [i.e., scientific] knowledge of a machine as an object tells us nothing about it as a machine."

The engineering students' ability to be evaluated in terms of understanding natural laws is generally easy. The laws of thermodynamics, electromagnetism, rectilinear optics or waves and light can be quantified explained and defined. Here the teacher is faced with the classification of learning styles and how materials are best presented to promote learning and how often it should be revised [3].

How to evaluate the technological ability, or good engineering (design) ability of a candidate is not easy. This aspect is generally lumped into a mini thesis project in final year undergraduate engineering curricula or the design projects IV for Technikon students. In both cases it is hoped that the integration aspect of mathematics and the vast amount of subject exposure will do the necessary trick. Individual subject design expertise is another matter. How will one for instance evaluate effectively if a student of say Opto-Electronics can design, given certain outcomes, effectively any opto-electronic system based on current technology?

3. ENGINEERING STUDENT LEARNING STYLES

There is a difference between learning and teaching styles commonly found in engineering school. Student learning styles encompass a wide spectrum of classifications, but educators

usually teach only a fraction of these learning styles within their constraints of time and resources, if at all [6]. Different learning styles at Technikon have a direct impact on the final marks in a course. It is sometimes heavily influenced and dependent on the teaching style that is utilized as well. Students, whose learning style is comparable, normally earn higher grades.

It is therefore important for the engineering educator to encompass a variety of learning styles within their curricula. The educator is often required to look at the following aspects critically:

- Presentation of Engineering Material
- Iteration of Material
- Transfer of Knowledge

One aspect, which affects performance and knowledge of learners, is the resorting to memorization at a high cost in comprehension [7]. As the result, students who memorize have little basis for technology transfer of information from one class to another.

Looking at the curriculum time, the main problem is to ensure that the time spent on learning is quality time and students are able to retain information to which they are exposed. While time-on-task is necessary for all learners, it is not sufficient to guarantee that learners have learned [2, 4]. In addition, material must be presented in multiple contexts for clarity to ensure that students can retrieve information in non-context problems. A virtual laboratory implementation of this would indeed be a challenge but one that could quite possibly offer a solution to these problems in teaching methodology for self paced learning apart from group based approaches.

4. CONSIDERATIONS IN SETTING UP A VIRTUAL LABORATORY

It is clear from the previous discussion that engineering material must be presented in an appropriate learning style to capture the spectrum of students in the classroom, be repeated at given intervals, and be presented in multiple forms to assist students in knowledge transfer. Technology itself should act as a catalyst to the course material presented to students. It must also encourage interaction or easy approach to the instructor/ lecturer and other students outside of the traditional classroom.

The ability to study material through different approaches, and different nomenclatures, is indeed an encouraging sign for experiments in cross-disciplinary learning. Asking students to find data and ideas from various resources, regardless of disciplines, to solve problems using basic methods given in classroom does this.

With a virtual laboratory, the use of materials provided, must therefore also give students a quick grasp of the key issues in areas of interest during the assignment or practical.

The design strategy must transform the models of problem solving and constraints into a description of the system. In this process, the choice of design model will set the range of possibilities for the virtual laboratory developer, by deciding which phenomena can be described and therefore restricting the choices of action of the system [1].

Students at the beginning of their undergraduate or graduate course work will be exposed to this methodology, rather than waiting until higher-level courses are reached. Students may

develop a negative attitude when material is presented differently than they are used to in similar courses. This is where cross-disciplinary materials will solve the problems. This will particularly give a true effort required in the independent or critical thinking problems.

At the end, one will look at different outcomes, such as feedback from learning and experimenting using virtual laboratory, implementation of virtual laboratory and specific outcomes of virtual laboratory. In addition, the focus will be on graduate level student response, upper-class student response, lower-class student response and general student perception using the virtual laboratory.

5. TECHNOLOGY MODELLING STRATEGY FOR A VIRTUAL LEARNING ENVIRONMENT

The strategy adopted here would be based on a virtual laboratory that would allow learning by explanation as well as discovery. Interactive processing, not just web based or notes based instruction with online testing, is required. The use of appropriate software with appropriate GUI (graphical user interface) and (OM) object manipulation is therefore required. The domain of instruction in this case would be opto-electronic circuits and the laws that govern their behaviour.

The design of a series of qualitative causal models of opto-electronic processes will be undertaken to represent a progression from basic knowledge to expertise. The qualitative models will serve to drive further simulations to generate causal explanations of circuit behaviour that will then be implemented within the lesson plan as a set of expressive models that will visually simulate and verbally explain when say light of a particular intensity falls on silicon PN junction. We describe further how this model will be arrived at.

It is imperative that one defines technology as verse versa of the objects or structures that we identify with it. A technological object or structure is a *physical object* with specific physical properties, governed by the laws of nature. An essential aspect of any technological object is its *function*. A match, a candle, a tungsten filament lamp are all objects with functions. A technological object has a function, which means that within a context of human action it can be used as a means to an end [5]. A physical object is the carrier of a function and it is by virtue of its function that that object is a *technological* object. This includes all objects of human design that is specifically made to realize a certain function. Function and physical carrier together constitute a technological object.

The links between object or structure and function is not always clear. Engineers as a matter of fact establish strong links between the structure and function of technological objects on the basis of technological explanations. The relation between structure and function is not always of a logical-deductive nature.

This can be demonstrated in the following way. Suppose that a causal relation exists between two events P and Q :

a) P is the cause of Q .

Whenever P takes place, Q will occur (all things being equal and that no disturbances occur). Suppose furthermore that it is (technologically) possible to bring about the occurrence of event P . Then on the basis of the causal relation in a) it is possible to draw up the following

rule of action or pragmatic maxim:

b) To realize Q , see to it that P takes place.

According to this rule of action, bringing about P is a means to letting Q take place, in other words, bringing about P has the *function* to produce Q . Note that the rule of action *b)* can not be derived from the causal relation *a)* in a logically deductive way.

Nevertheless, we are dealing here with a technological rule of action that from a pragmatic point of view may prove to be highly reliable. Whether that is the case depends on whether the causal relation *a)* is empirically well established and whether in the given context of action the *ceteris paribus* clause holds.

Let us now apply this to the example of an Optical fibre (OF) communication system. The complete system contains a description of the causal chain of events that will lead to the transmission of voice band audio of a human voice speaking into a telephone headset to be received on the other end and converted back to sound pressure waves by means of a speaker in the receiver headset.

We refer, for the sake of brevity, to the explanations as the "putting in operation of the OF communication system." The following causal claim can then be made:

a') Putting in operation the OF communication system (X) will cause the transmission and reception of voice band audio signals (Y).

On the basis of this claim, we formulate the following technological rule of action:

b') To cause the transmission and reception of voiceband audio signals (Y), put the OF communication system in operation (X).

This rule of action describes how a certain aim can be achieved by performing actions with an OF communication system. Within that context of action, the OF communication system becomes a means to an end, that is, acquires a function. That function is to provide voiceband audio communication. The OF communication system, however, can perform that function only by virtue of its (physical) structure, since rule of action *b')* is based on causal relation *a')* and the latter can only be derived on the basis of the detailed structure or design of the communication system.

According to this line of thought, the transformation of causal relations into pragmatic maxims (a transformation that does not have the form of a logical deduction) makes it possible to bridge the gap between structure and function in a technological design. A technological explanation, therefore, is not a deductive explanation; it connects structure and function on the basis of causal relations and pragmatic rules of actions based on these causal relations.

6. CONCLUSION

A fair amount of work still needs to be done in bringing this strategy to flesh. To provide students with truly interactive texts, a series of experiments will be created to demonstrate the application of this method of teaching. These experiments will give conceptual interfaces to

the equations of physics for opto-electronics and/or represent interaction with data that simulates a real physical experiment. These will target Opto-electronics classes for diploma. The presented virtual laboratory will have links to other similar laboratories, so that users can access more advanced materials, thus having a thorough covering of the contents of the Opto-electronic topics addressed by the lab.

The new paradigm has to integrate students and teachers as effective agents of the educational action and should make teachers fully realize how much the student can be active and creative in his learning process. Otherwise, the new technology will not transform automatically the usual resources used to expose the subjects and will not contribute significantly as an advance in education. The main focus of the new integrated educational system should move towards the student as the agent who can make use of the new technology to further explore the target topics. The outcomes of this strategy will be reported on in further communications.

8. REFERENCE

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Author:

Principal Author: Clement Matasane holds an Mtech degree in Electrical Engineering. At present he is a lecturer at the University of Johannesburg (Doornfontein Campus). Other duties include research, supervision and liaising with Industry.

Co author: Dr. MTE Kahn is a Professor in the Faculty of Engineering (Bellville Campus) of the Cape Peninsula University of Technology. He has authored over 60 papers in international conferences and refereed journals and his research interests are Energy Technology and Distributed sensor systems.

Presenter:

The paper is presented by Clement Matasane