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## METHOD OF TEACHING FLUID MECHANICS IN SOME SOUTH AFRICAN UNIVERSITIES AND ITS IMPLICATIONS FOR LEARNING

**\*Sunday Faleye**

University of South Africa

[faleys@unisa.ac.za](mailto:faleys@unisa.ac.za)

**David L. Mogari**

University of South Africa

[mogarld@unisa.ac.za](mailto:mogarld@unisa.ac.za)

### Abstract

This study investigates the current method of teaching fluid mechanics and its implications for learning in undergraduate mechanical engineering classes in some South African universities. Open-ended questionnaires and classroom observation were used to gather qualitative data from both students and lecturers in this field. The results revealed that fluid mechanics is taught in a traditional form using Microsoft PowerPoint slides, textbooks and blackboards. It also emerged that this method of teaching presented learning difficulties for learners in some aspects of the fluid mechanics module. This study serves as a springboard for a more extensive study which measures the effect of introducing computer-animated instruction into the teaching of fluid mechanics in South African universities.

*Key words: symposium, engineering education, undergraduate, fluid mechanics, teaching approach, mechanical engineering*

*Correspondence to: S. Faleye, University of South Africa, South Africa. E-mail: [faleys@unisa.ac.za](mailto:faleys@unisa.ac.za)*

### 1. INTRODUCTION

In recent years there has been a shortage of qualified engineering experts (French, Immerkus & Oakes, 2005). Enrolment figures for engineering courses have dropped, while at the same time, the market demand for engineers is increasing (National Science Foundation (NSF), 2004; Li, McCoAch, Swaminathan & Tang, 2008). While enrolment for engineering courses in South African universities is very low, significant numbers of students also drop out or change course (French et al., 2005). In addition, larger percentages of students today are weak in mathematics (Felder & Brent, 2005). However, aspects of mathematics concepts form the fundamental conceptual framework in most of the engineering courses. Hence many engineering students find engineering modules too demanding because of their weak background in mathematics.

The motivation for this study emanated from awareness of the acute shortage of skilled workers in South Africa, particularly in the field of engineering. A considerable number of professionals, including engineers, have been leaving South Africa in search of greener pastures. Furthermore, the post-apartheid government inherited a crop of primary and secondary school science and mathematics teachers, the majority of whom do not have a

strong knowledge base in their discipline (Naidoo & Lewin, 1998). Even fifteen years after the demise of apartheid, government efforts to provide schools with competent science and mathematics teachers have not been fruitful. The learning of science and mathematics in schools has been problematic and the yearly pass rate has been declining.

The government has mounted a campaign to encourage learners to study science and mathematics at high schools so that they can proceed to university to study engineering and other science courses that play a significant role in the socioeconomic advancement of South African society at large. Financial aid schemes have been set up by the government to support this. To this end, the Joint Initiative for Priority Skills Acquisition (Jipsa) declared an intention to produce 2500 engineers a year as a national output priority for South Africa (Apple, 2008).

A number of researchers have investigated the issues relating to low enrolment and graduation figures in the engineering fields in South African universities. Reed and Case (2003) investigated the factors that influenced learners to follow a career in engineering with a view to promoting a higher rate of enrolment and graduation from engineering studies at South African universities. The duo suggested that focused interventions around the factors that influence learners to follow a career in engineering can serve to encourage more learners into engineering fields. The results of their study were similar to the findings of Jawitz and Case (1998). The study by Li et al. (2008) pursued the same objective of attracting more learners into the fields of engineering in the United States of America by using an attitude measuring instrument to help engineering educators understand why many students stay away from engineering. Taraban et al. (2007a) studied the problem from the angle of engineering students' learning and conceptual understanding, revealing a disconnection between students' conceptual and procedural knowledge that was likely to block the development of deeper understanding. Taraban et al. (2007b) suggested that to draw more students to engineering practice, an innovative assessment capable of telling engineering educators more about students' problems with engineering concepts is imperative.

Ramsden (1992) notes that the approach to teaching is an important component of teaching that influences students' performance at university level and that a good teaching approach is likely to improve students' performance. This is why the problem of skills shortages in engineering in South Africa was approached from the angle of 'how the engineering modules are being taught'. The concern is to look into the current method of teaching engineering modules in South African universities with a view to introducing computer-animating aided instruction into the teaching method to facilitate teaching and learning. This view is in line with recent study on teaching (Nirmalakhandan, Ricketts, McShannon & Barrett, 2007).

Pre-study consultations with some of the lecturers in the field of engineering in South African universities revealed that fluid mechanics is one of the modules most engineering students find difficult to master, even though it is one of the principal modules in some of the engineering courses. Hence, this study focuses on the teaching of fluid mechanics at South African universities.

The traditional teaching of fluid mechanics concepts makes the module too abstract, dry and uninteresting. Timothy and Richard (2006) maintain that the traditional classroom instruction, whereby instructors illustrate engineering concepts with textbooks and blackboards as aids, is inappropriate. These media of instruction present the components of these objects in two-dimensions, whereas the concepts of mechanics are, in reality, three-dimensional. The result

is that these students find the two-dimensional presentation confusing, they find it difficult to visualise what the lecturer is trying to explain.

## **2. PURPOSE OF THE STUDY**

As noted, efforts are needed to promote engineering studies and to increase the qualifying rate of engineering students. Interventions are needed to retain students' interest and improve their understanding of key concepts, especially where fluid mechanics is concerned. The present study investigates the current method of teaching fluid mechanics and how it impacts on learning. The results are intended to serve as a springboard from which to proceed with deliberation and with a view to introducing computer-aided instruction (CAI) into the teaching and learning of fluid mechanics in mechanical engineering classes.

The following research questions were addressed:

- (1) How is fluid mechanics taught to mechanical engineering students in South African universities that offer engineering courses?
- (2) Do students experience conceptual learning difficulties in the field as a result of the way fluid mechanics is taught?

## **3. METHODOLOGY**

### **3.1 Research design**

The choice of a research design to follow is based on the nature of the study, as well as the research question (Pirie, 1997). In this study, there is a need to examine the feelings and thoughts of participants about the way fluid mechanics is taught. Therefore, the study follows an ethnographic approach, which evolved from an interest in discovering how fluid mechanics is being taught in a normal classroom setting (in the normal teaching environment) in each of the participating universities. Therefore, survey and classroom observation methods were used to collect data from both students and instructors of fluid mechanics. Triangulation was used to avail ourselves of coherent, detailed and precise data.

### **3.2 Instrumentation**

Questionnaire and observation checklist were the instruments used to collect the required data.

#### **3.2.1 Questionnaire**

The survey instrument was an open-ended questionnaire that had to be developed by the researchers, since the literature search failed to turn up an appropriate instrument that could be adapted to answer the research question. Validity and reliability checks were performed on the instrument.

Content validity-rating forms were given to 10 judges drawn from the fields of education and science education to validate the instrument. The judges were to report on the "sureness" and "relevance" of each item. There were three "sureness" levels with 1 = not very sure; 2 = pretty sure; 3 = very sure. And there were three relevance levels: 1 = low/not relevant; 2 = somewhat relevant; 3 = very relevant. Analysing the responses from the judges, items with a sureness mean  $\geq 2$  (this implies the judges were, at least, pretty sure about the item) and a relevance mean  $\geq 66\%$  (this being interpreted as, most of the judges rated the item as

somewhat or very relevant to what it is intended to measure) were retained. In addition, three of the judges that were used to validate the instrument were also used in the reliability check process. An internal consistency reliability check that was carried out gave a reliability coefficient of 0.76.

Similar questions (seven items) were presented to students and lecturers as separate questionnaires. The questions were couched to determine how fluid mechanics is taught and learned. The objective of effectively using two questionnaires (one for students and another for lecturers) was to collect convergence data.

Items 1 and 2 in the lecturers' instrument are meant to ascertain the number of students enrolled compared to the actual class attendance. The deficit accounts for the dropout rate. Some students might have dropped out if they could not cope in fluid mechanics classes. Items 3 and 4 were intended to solicit data on how fluid mechanics is taught, while the objective of items 5 to 7 was to gauge the effectiveness of the teaching method. The questions include: *In your own view, which topic in fluid mechanics do students normally find difficult? How would you describe students' perception of fluid mechanics as a module in a mechanical engineering course?*

Item 1 of the students' questionnaire was intended to determine the gender of the participants. Items 2 and 3 were intended to gauge the effect on learning of the method used in teaching fluid mechanics. The questions include: *Which topic/s do you find most challenging in fluid mechanics?* (item 2); *Do you find fluid mechanics classes too theoretical and uninteresting?* (item 3). Questions to ascertain how fluid mechanics is taught include the following: *Please describe how your fluid mechanics lectures are normally conducted* (item 4); *please describe how a typical tutorial session referred to in 6 is normally conducted* (item 7).

A member of staff of the University of South Africa who specialises in data analysis and questionnaire development was requested to undertake a peer review of the instrument, which was also piloted with the help of first-year thermodynamics students and their lecturer at one of the universities within the country. The students and lecturer who participated in the pilot study were not involved in the main study. The few changes resulting from the pilot study were made to items that were considered potentially confusing, and that might therefore not yield the required information.

The lecturers' and students' questionnaires were sent to study participants by email to give them enough time to patiently complete it. In some instances, the researcher administered the questionnaires directly to participants during classroom observation. Only six of the eight participating universities returned responses. This represented 75% return rate.

### 3.2.2 Classroom observation

Classroom observation was meant to corroborate the data gleaned from the questionnaire items. An observation checklist was prepared to collect data during the classroom visit. The checklist format contained the events and behaviour to be observed and how this information is to be recorded. The instrument content covers the teaching approach used by the lecturer; the lecturer's review of previous work; student population; classroom space; furniture (including modern classroom electronic equipment used as aids); how a new topic was introduced; guided practice; and students' independent practice.

The checklist contents need to meet the objectives for which the instrument is constructed to be able to measure what it supposes to measure. Hence, the instrument was face-validated by

an expert in the field of education; this exercise resulted in reconstruction of some parts of the contents. Again, an internal consistency reliability check on the instrument yielded 0.68.

Two rounds of scheduled classroom observations were conducted in each of the eight institutions. During the classroom observation relevant events were recorded using the observation checklist and in some instances notes were taken.

## **4. DATA ANALYSIS**

### **4.1 Analysis of the questionnaire responses**

We analysed responses to the questionnaire by classifying the survey items and identifying the coding units that answered the research questions. The responses were coded by specialists to provide an independent view of the data analysis.

The collected data were organised and a spreadsheet was created. The coding categories were formed as follows: 1 for traditional approach; 2 for traditional approach aided by Microsoft PowerPoint; 3 for student-centred approach aided by animation software; and 4 for other teaching methods. After this, data were sorted into different categories. This procedure enables us to identify the themes evolving from the survey. Like Mapolelo (2003) and Malone (1996), we compared all the evolved themes within each of the participating institutions (lecturers' responses were compared with students' responses and students' responses with each other), noting similarities and differences, after which we drew up an inter-institutional comparison.

### **4.2 Analysis of data gained from classroom observation**

Data from the observation checklist were gathered and organised, as we review all field notes and create a spreadsheet. The analysis includes an in-depth look at the method used by the participating lecturers to teach fluid mechanics and what the students were experiencing in building foundational knowledge. The data were put into spreadsheet format and grouped according to the research questions. For example, students' applying critical thinking skills as the lecture proceed by asking and answering questions, ease of building foundational knowledge, and students sharing knowledge with classmates as the lecture progresses.

## **5. RESULTS**

Six out of eight universities returned their survey responses but classroom observations were done in all the eight universities. Though we analysed all the data but our result were based on the six universities from which we got complete data.

The analysis of the questionnaire data showed that an average of five students per university stopped attending fluid mechanics classes a few weeks into the lectures. We could not interview this set of students to find out exactly why they dropped out: perhaps they find fluid mechanics difficult.

Both questionnaire and classroom observation data on the teaching method used revealed that the teaching of fluid mechanics conforms to the traditional approach in all the universities that participated in the study: in four of the universities, lecturers taught with the aid of PowerPoint presentation and data projection, but without interactive animation. In one other

institution the chalkboard and overhead projector were used as basic teaching aids: the overhead projector was used to display diagrams prepared on transparencies. In another participating institution, only a chalkboard was used. Data from the observed items revealed an average student population of 82, and most of the classrooms were spacious and reasonably furnished with equipment that facilitates teaching (like computers and electronic communication peripherals).

The results from the classroom observation were also indicative that during lecture and guided practice at the tutorial sessions, students struggled to understand the basic fluid mechanics concepts, and there was not much interaction between the students and lecturers in the class. Students were always quiet throughout a lecturer period and hardly answered the lecturers' questions correctly. The lecturers had to go over these concepts repeatedly, even those ones that were taught previously which were relevant to the present topics. It also emerged from the survey results that students find some aspects of fluid mechanics difficult.

An example of one of the lectures observed is given here which was on control volume. In this lesson the lecturer started by explaining the resolution of a problem relating to control volume. The problem was about a plate set up parallel to a flowing stream. After displaying the PowerPoint slide on which the problem was written, he went on to start solving the problem on the chalkboard without any student engagement as follows:

“Given a plate which was set up parallel to a flow, the stream is a river or a free stream of uniform velocity  $\mathbf{V} = U_0\mathbf{i}$ ”. He went on to explain: “Pressure is assumed to be uniform, the no-slip condition at the wall of the plates brings the fluid particles there to a halt.” Here the lecturer paused for about five seconds to read through a note which he had in his hand. He then went on to relate that “the slowly moving particles retard their neighbours above them so that at the end of the plate there is a significant retarded shear layer, or boundary layer of thickness  $y = \delta$ ”. He then moved to the other half of the board and started writing “the viscous stream along the wall can sum to a finite drag force on the plate”. As he was explaining and writing on the board, he pointed to the diagram he had on a PowerPoint screen. He then told the students “to make an integral analysis and find the drag force  $D$  in terms of the flow properties  $\rho$ ,  $U_0$ ,  $\delta$  and the plate dimension  $L$  and  $b$ ”. He later solved the problem on the chalkboard and gave a related problem to students to solve as homework. The lesson was completed in 40 minutes.

## 6. DISCUSSION

The results of the study under review showed that the lecturers adopted a traditional approach to the teaching of fluid mechanics at South African universities that offer BEng degree programmes. This method of teaching fluid mechanics in the participating universities impacted negatively on learners' conceptual understanding of the principles of fluid mechanics.

Effective learning of the mechanics of fluid flow cannot take place with the exclusive aid of textbooks and chalkboards or even of non-interactive PowerPoint displays. It emerged from the results that study participants were struggling to understand what they were taught: they were always quiet, looked passive and hardly answered questions correctly in the class. These media of instruction leave too much to students' imagination and may lead to alternative conceptions. Fluid flow is a physical, three-dimensional phenomenon, which could be the

reason why students found its abstract presentation difficult to grasp. This may be one of the reasons why some students dropped out of the fluid mechanics class a few weeks into the lectures.

In addition, the study participants also find fluid mechanics classes dry and uninteresting. In engineering lecture classes, there is supposed to be interaction between the lecturers and the students, and among the students, as they share knowledge and skills. This will encourage the students to work together and discuss concepts and ideas among themselves.

These study participants are studying to become practising mechanical engineers at the end of their training; they should be able to apply theoretical concepts to solving real-life practical problems. Georghiades (2000) describes knowledge transfer as the ability to apply new concepts and skills in multiple contexts. Hence, for learners to be able to apply the theoretical concepts gained in the class in real-life contexts, deeper understanding of the knowledge base is imperative.

## 7. CONCLUSIONS

Traditional lecturing to a passive audience creates a passive learning environment. However, engineering students learn better by participating, acting, reacting and reflecting (Nirmalakhandan et al., 2007). The researchers believe that such a learning environment can be achieved in a classroom where teaching is supported by computer-animated instructional aid (Shannon, 1994 in Marek, 2005). Such a teaching aid will help the lecturers to present fluid mechanics concepts in their original three-dimensional forms. It will also facilitate illustration of these concepts that would have otherwise presented a significant barrier to their students' understanding of fluid mechanics. Further research is needed to ascertain the impact of computer-based animated instruction in fluid mechanics classrooms.

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