

**THE EFFECT OF INTRODUCING ANIMATED COMPUTER INSTRUCTIONAL
AID IN THE LEARNING OF FLUID MECHANICS**

by

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Declaration

I declare that INTRODUCTION OF ANIMATED COMPUTER INSTRUCTIONAL AID IN THE TEACHING OF FLUID MECHANICS IN SOME SOUTH AFRICAN UNIVERSITIES is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE
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DATE

Acknowledgment

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Dedication

This work is dedicated to GOD ALMITHY who has made it possible and to every member of my families who endured with me in the course of this achievement.

SUMMARY OF THE STUDY

This study was carried out to investigate the effect of introducing animated computer instructional aid (ACIA) in the learning of fluid mechanics. It was also intended as a means to evaluate the Constructionist Computer-Animated Instructional Model of Learning (CCAIML), which was developed and proposed for learning fluid mechanics. CCAIML includes the use of ACIA as a learning aid. Three theories underpins CCAIML learning model: the Constructionist learning theory, Media-Affects-learning hypothesis and Multiple representation principle.

The study participants were the intact classes of first-time fluid mechanics' students in Mechanical Engineering in four South African universities, who offer Bachelor of Engineering degrees in Mechanical Engineering. The study followed a mixed method approach: involving a static group design and a descriptive survey design. The control groups were the two consecutive, immediately preceding intact groups, who were taught fluid mechanics through the traditional lecturing method. The intervention groups were the non-randomized mechanical engineering students, who were taught by the same lecturer, who taught the control groups the same course material through a traditional approach, but taught the intervention group using the CCAIML learning approach.

The findings of the study showed that:

- ACIA facilitated the learning of the fluid mechanics module taught during the intervention, in CCAIML learning environment;
- ACIA aroused the study participants' interest in the learning of fluid mechanics module taught during the intervention;

- The study participants understood the fluid mechanics module taught during the intervention better, in CCAIML learning environment, and were able to demonstrate this in the post intervention examination;
- CCAIML learning approach encouraged classroom interaction, group and individual knowledge construction, practical demonstration of understanding of concepts and consequently improved classroom dynamics;
- The majority of the study participants achieved higher scores in the fluid module taught during the intervention at the post intervention examination, by using CCAIML learning approach compared to the traditional approach;
- No relationship was established between the level of study participants' interest in the software used to aid learning ACIA and the study participants' post-intervention achievement; and
- Where the language medium of the instructional aid was different to that of the classroom medium of instruction, the learners' achievement was affected.

Key words: engineering education, undergraduate, fluid mechanics, teaching approach, learning method, mechanical engineering, mixed method design, CCAIML learning approach, instructional aid, learning theories

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CHAPTER 1

INTRODUCTION

1.1 PREAMBLE

This study investigated the effect of introducing Animated Computer Instructional Aid (ACIA) in the learning of fluid mechanics. Furthermore, it was the implementation and evaluation of "Constructionist Computer-Animated Instructional Model of Learning" (CCAIML) for the learning of fluid mechanics in mechanical engineering classes, in South African universities.

Fluid mechanics is a module normally taught at honours and masters mathematics levels, and at undergraduate level in engineering classes, in South African universities. Part of the fundamental training in mechanical engineering, is learning fluid mechanics. To possess fluid flow technical-know-how is paramount, both in the theoretical work and field practices of a competent engineer. Fluid mechanics is also considered essential for fluid-flow modelling, research, and consultancy services.

This study, therefore, focused on the learning of fluid mechanics in undergraduate mechanical engineering classes, in South African universities. Generally, the number of mathematics students that register for fluid mechanics, is very low, compared to the engineering fields, where it is a compulsory module. Possible reasons for low enrolment could be the high cognitive demands fluid mechanics requires from students that register for it and the uninspiring way fluid mechanics is generally taught (subsection 5.2.1 refereed). This is the basis for the current study's perusal.

1.1.1 Skill shortage in engineering fields

There is a shortage of qualified engineers (French, Immerkus & Oakes, 2005), globally. On one hand, the problem seems to stem from the low students' enrolment figures in engineering courses. Apparently, students' poor performance in mathematics begets low enrolment in engineering studies, since mathematics undergirds such studies. In fact, the teaching/learning of mathematics in schools has been problematic and the yearly pass rate has been declining (Felder & Brent, 2005).

On the other hand, the brain drain, South Africa has been experiencing over the years, is another factor that has contributed considerably to the problem of the skills shortage experienced on a national scale. In actual fact, a considerable number of professionals, including engineers, have been leaving South Africa for some reasons. Regardless of all these, the country desperately needs these professionals, particularly engineers, for its economy to expand and in the process raise its infrastructure to an acceptable standard (National Science Foundation (NSF), 2004; Li, McCoAch, Swaminathan & Tang, 2008).

Realising that skills form the backbone on which every successful economy relies, the government has mounted a campaign to encourage learners, among others, to study mathematics at high schools, thus opening the doors to the study of engineering at university. Financial aid schemes have been set up by government to support this (Apple, 2008). In addition, "Joint Initiative for Priority Skills Acquisition" (JIPSA), which was launched on 27th March 2006 by South African government as an initiative to address the skill challenges facing the country. The organisation was saddled with the responsibility of supporting the Further Education & Training (FET) colleges and Higher Education institutions in their work to produce graduates who could meet the needs of employers in the public and private sectors. JIPSA declared an intention to produce 2500 engineers a year as a national output priority for South Africa (Apple, 2008), in a bid to achieve the objectives for its foundation.

There are research studies that have investigated the issues relating to skills challenges in South Africa, particularly in the field of engineering. For example, Brandon and Jennifer (2003), carried out a research, to determine which factors influence learners to follow a career in engineering, with a view to increasing enrolment figures as well as the graduation rate at South African universities. The duo suggests that focused interventions around the factors, which influence learners to follow careers in engineering, can serve to encourage more learners into the engineering fields. The findings of Brandon and Jennifer (2003), are similar to that of Jawitz and Case (1998), who investigated the reasons, given by South African engineering students, for studying engineering, with a view to attracting more learners into to the engineering field.

The present study, instead, focuses on the teaching and learning aspects of engineering using technology. The basis for the current study somehow emanates from the media-affects-learning hypothesis (Moreno, 2006a), that proposed that state-of-the-art instructional technologies promote deeper learning. In addition, the multiple representation principle states that it is better to present an explanation in words and pictures than solely in words (Mayer & Moreno, 1998). In view of the hypothesis and the representation principle, the present study seeks to find ways to facilitate the instruction of fluid mechanics in South African universities, by introducing ACIA in its teaching and learning in a constructionist approach. To this end, the researcher proposed CCAIML for the study of fluid mechanics in mechanical engineering classes, in South African universities.

1.1.2 Technology in the classroom

The introduction of multimedia devices into the classroom, dates back to the 20th century when Thomas Edison, the famous inventor of motion pictures proclaimed, "the motion picture is destined to revolutionize our education system" (Cuban, 1986). This author notes that in the 1950s, television was

believed to have impacted on education, by providing access to richer learning experiences at lower costs. Twenty years down the line, computer assisted instruction (CAI) has made its way into the classroom (Kinder, 1973). Zisow (2000:36), points out that today, access to computers, have moved from schools having computers in computer laboratories only to being available in each classroom. In addition, nowadays, even more numerous advanced technologies have also found their way into classrooms.

Studies have shown that the use of technology in teaching and learning has significant potential to enhance students' understanding (Kadiyala & Crynes, 2000; Mayer & Moreno, 2003 in Moreno 2006b; Wiske, Franz & Breit, 2005). However, Cuban (1986) and Mayer (2001), argue that most of the advantages that can be derived from the use of technology in the classrooms have not yet fully been realised; perhaps they are being used inappropriately. Hence, Mayer & Moreno (2003), suggest that the use of technology, as a teaching aid, should be guided by a research-based theory of how students learn. These theories are discussed in section 2.4.

In view of the technology learning theories, the researcher contemplated that in a learning environment, such as, mechanical engineering classes, learners are expected to apply theoretical concepts to solve real life problems. Presenting these concepts in the form of computer animation in a constructionist approach, might therefore, facilitate knowledge construct and also enhance learning.

1.1.3 Constructionist Theory

Constructionist theory is an aspect of constructivist theory, according to Pepper (1993), who believes that learning happens most effectively when people are active in making tangible objects that others can see and critique. The theory emphasises that knowledge construction, which takes place in the head, often

happens felicitously, when it is supported by construction of a more public sort that is, the product of the construction can be shown.

Based on the above, the researcher proposed CCAIML (a learning model) mentioned in subsection 1.1.1. The researcher further believes that CCAIML will improve the learning of fluid mechanics in mechanical engineering classes (see details in section 2.5).

1.1.4 Constructionist Computer-Animated Instructional Model of Learning (CCAIML)

A model is a visual aid or picture, which highlights the main ideas and variables in a process or a system. CCAIML, as a learning model, explains the use of ACIA in the teaching/learning of fluid mechanics in a constructionist environment. The instructor displays the animated-concepts on the screen in the lecture room and allows students to explain the way they understand the concepts; as well as what they can discern from the animated-concepts. They should also be allowed to practically demonstrate their understanding of the concept. The instructor listens to contributions from various individuals and groups of students in the class, while the instructor moderates the discussion as students build their fluid mechanics knowledge structure, through the progressive internalization of actions. This learning situation helps the learners in self-directed learning, and ultimately facilitates the construction of new knowledge in view of the multiple representation principle.

In view of the above, the researcher formulated ACIA, to be used during lecture and tutorial classes in the learning of fluid mechanics in mechanical engineering classes, for the duration of the study intervention. In addition, the study participants were given one ACIA CD each for use during their private study (see section 2.5).

1.2 THE PROBLEM OF THE STUDY

The study sought to determine whether or not the use of a ACIA learning aid, in CCAIML learning environment, could facilitate the teaching and learning of fluid mechanics in the mechanical engineering classes as well as arouse students' interest in studying fluid mechanics.

This was hopefully be done by addressing the following research questions:

- Q₁: Does the use of ACAI facilitate the learning of fluid mechanics in the mechanical engineering classes?
- Q₂: Does ACIA, as a learning aid, arouse students' interest in fluid mechanics in an CCAIML learning environment?
- Q₃: Does CCAIML learning approach encourage instructor-students and students-students interactions?

Hypotheses

The following hypotheses stated in a null terms at 0.05 probability significant level were used to guide the study.

Hypothesis one

- H₀: There is no statistical significant difference in the study participants' post intervention mean achievement score in fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the mean achievement score in the control groups.
- H₁: There is statistical significant difference in the study participants' post intervention mean achievement score in fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the mean achievement score in the control groups.

Hypothesis two

H₀: There is no statistical significant relationship between the study participants' intervention examination achievement score and their achievement score of the Classroom knowledge test.

H₁: There is statistical significant relationship between the study participants' intervention examination achievement score and their achievement score of the Classroom knowledge test.

Hypothesis three

H₀: There is no statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and their achievement marks in the intervention examination.

H₁: There is statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and their achievement marks in the intervention examination.

1.3 SIGNIFICANCE OF THE STUDY

This study compared the studying of fluid mechanics in CCAIML approach to the traditional way of learning fluid mechanics. Ultimately, this was done with the view to facilitate the instruction of the module in South African universities.

The following reasons, which range from low enrolment figures as well as high student drop-outs, to the poor mathematics background of engineering students, emanated from literature, as the causes for the shortage of experts in the field of engineering. The researcher believed that, in addition, to the enumerated challenges facing engineering fields, the traditional method of teaching and learning engineering modules in South African universities, may be another serious factor to contend with. After deliberation, the researcher wanted

to ascertain whether the teaching and learning of engineering modules in a traditional method of knowledge dissemination, where the only media of instruction is a text book and blackboard, is inappropriate for this type of module. Engineering practice involves dealing with real physical objects and solving real life practical problems. If the concepts in mechanical engineering modules are explained to the students in their original 3-D forms, with the aid of computer animation, the learners may be able to imagine the practical applicability of these concepts, in solving both theoretical and real life problems, better. This method should supersede the abstract explanations, which leave too much to students' imaginations. However, as stated in subsection 1.1.1, the present study focused on the learning of fluid mechanics as one of the modules in engineering fields.

The results of the study could be used to advise the universities' fluid mechanics' lecturers and their students in South Africa on the use of CCAIML in the study of fluid mechanics. The intentions are:

- to promote active learning of fluid mechanics;
- improve the quality of graduating mechanical engineers; and
- encourage more learners into engineering fields in South African universities.

1.4 DEFINITION OF KEY TERMS AND CONCEPTS

It is pertinent, at this stage of the study, to clarify key concepts used in this work. The following listed concepts shall refer to:

Active learning:

Any learning or teaching situation which is characterized by active participation on the part of the learners, as opposed to passive learning from listening or observing.

Achievements test:

- (i) Is a test designed to measure conceptual understanding in fluid mechanics topics learnt; or

Fluid mechanics:

The study of fluids either in motion (fluid dynamics) or at rest (fluid static).

Instructional technology:

The totality of the means employed to provide the conditions necessary to promote learning (Pytlikzillig, Bodvarsson, & Bruning, 2005).

Media:

The physical system or vehicle used to deliver instruction, such as lecturer's prepared notes, a textbook, television or a computer.

Multimedia Instruction:

Teaching with a combination of visual information, such as, pictures and at the same time, giving the corresponding verbal information.

New Technology:

Any new tools for information and communication beyond the ones traditionally used for teaching and learning (Wiske et al., 2005).

Technology:

The totality of the means employed to provide objects necessary for human sustenance and comfort (Webster, 2003, *in* Pytlikzillig et al., 2005).

Traditional universities:

Universities that have been in existence before the current post-apartheid era in South Africa.

Formation of ideas:

Deriving a tentative understanding of a concept or problem, following the integration of a new experience and prior knowledge (Mayer, 2003).

1.5 STRUCTURE OF THE THESIS

The process of scientific inquiry is in three main parts:

- Firstly, reviewing the accepted knowledge (literature review);
- Secondly, evaluation of the reality (what is currently happening and the results of the current study); and
- Thirdly, the inquiry's contribution to the existing knowledge (discussions and theories).

In the light of the foregoing, this subsection highlights the layout of the study.

Having discussed the background, the problem and hypotheses to the study, the researcher presents, hereunder, the focus of the remaining chapters.

Chapter 2

Chapter two discusses the conceptual underpinning of the study. The concept of learning and learning theories are elucidated with specific attention on the

meaning and origin of constructivism and constructionism learning theories. Similarities and differences between the two theories are enumerated. The chapter also dwells on the use of technology to enhance learning. It also presents CCAIML learning model, which the researcher designed for learning fluid mechanics in the intervention mechanical engineering classes. The beliefs of constructionist, method-affects-learning, and multiple representation principle, were combined to derive the principle of CCAIML learning model.

Chapter 3

In this chapter, current similar studies are reviewed. The reviewed previous work was categorized into two: the studies that use technology to facilitate the learning of engineering modules and those ones that improve existing theories or propagate new theories to facilitate learning.

Chapter 4

Chapter four describes the methodology of this study. The two phases, which characterized the study; that is, the baseline study and main study as well as the research procedures followed in the two phases, are explained. In addition, it also describes the selection of the study participants, the research instrumentations and the development thereof, data collection as well as ethical issues.

Chapter 5

This chapter presents the techniques for data analysis. The results of the following are presented:

- the descriptive and inferential analysis;
- the means difference between the previous groups and the intervention groups;
- the hypotheses testing;
- the questionnaire data analysis; and

- the qualitative data analysis, which includes analysis of data gleaned from classroom observations.

Chapter 6

It presents the summary of the study. The results of the data from the questionnaire, and classroom observations are utilized to justify the experimental results. The relevance of the ACIA package and CCAIML learning model in the study of fluid mechanics in mechanical engineering classes are expounded, based on both the researcher's findings and the literature study. The implications of the various results from the data analysis are discussed in this chapter. Recommendations for further research are also presented.

CHAPTER 2

LEARNING, CONSTRUCTIVISM, CONSTRUCTIONISM, AND CCAIML

The researcher's beliefs in the domain of learning are deeply grounded in personal convictions about what it means to be knowledgeable, intelligent, experienced, and what it takes to become so. This domain of learning spans numerous sets of theories that characterize the processes with which it appears to be endowed by the operation of distinction that brings forth learning. The advent of technology has further broadened the conceptual topological terrain of learning. Massy and Zemsky (1995:1) noted that information technology has potential to improve teaching and learning profoundly.

Therefore, the chapter attempts to explain the concept of learning, some learning theories that are important to the current study, more especially the constructivism and constructionism learning theories, were discussed as well as the use of technology to enhance learning.

2.1 THE CONCEPT OF LEARNING

2.1.1 What is learning?

The term *learning* is multifaceted and variegated, spanning a large semantic field; hence it is very difficult to give a singular, straight forward definition of learning. Säljö (1979) asked a group of adult students what they understood by the term *learning*. He listed their responses in the following five categories as quoted in Ramsden (1992:26):

- Learning as a quantitative increase in knowledge: Learning is acquiring information or "knowing a lot".

- Learning as memorizing: Learning is storing information that can be reproduced.
- Learning as acquiring facts, skills, and methods: Learnt skills can be retained and used if and when necessary.
- Learning as making sense or abstracting meaning: Learning involves relating parts of the subject matter to each other and to the real world.
- Learning as interpreting and understanding reality in a different way: Learning involves comprehending the world by reinterpreting knowledge.

According to Ramsden's analysis of the above meanings given to learning, the first three refer to learning as something external to the learner, something that was gotten or received and has to be reproduced. This implies that learning may be considered as a process of reproducing knowledge from those acquired aspects of knowledge. The last two look at the *internal* or personal aspect of learning: some prerequisite information or background knowledge to understanding the real world. Here, learning is seen as a process of knowledge construction from existing aspects of knowledge.

The first and third definitions above seem to agree with Bell-Gredler's (1986) definition of learning, 'learning as a process by which human beings acquire a vast variety of competencies, skills, and attitudes' and this definition is illustrated in the light of a growing human being. Bell-Gredler (1986) expounds that learning begins in infancy with the baby's acquisition of a few simple skills; at adolescence, a number of attitudes, values and social interaction skills are acquired as well as competencies in various subject areas. In adulthood the individual should have mastered specific job tasks and other functional skills.

However, Kein (1996) defines learning as an experiential process resulting in a relative permanent change in behaviour that cannot be explained by temporary states, maturation, or innate response tendencies. Perhaps what is prominent in this definition is "change in behaviour". To the behaviourist movement in

psychology, change in behaviour (responses) is a product of learning processes (stimuli) (Watson, 1913; Skinner, 1973; Hartley, 1998). Kein's definition identifies three learning components.

- First, learning reflects a change in the potential for behaviour. Learning does not automatically lead to a change in behaviour; rather sufficient motivation is needed to translate learning into behaviour.
- Second, changes in behaviour due to learning are relatively permanent; the previously learned behaviour gives way for new behaviour to be exhibited.
- Third, changes in behaviour can be due to processes other than learning. For example, our behaviour can change as a result of motivation, rather than learning, (see also Merriam & Caffarella, 1991:124).

As a result of the above stated components of leaning, Ramsden (1992:4) remarks that some statements have looked at identifying relatively permanent changes in behaviour as a result of experiences, but not all changes in behaviour result from experience involved learning. Therefore, if learning has taken place, experience should have been used in some way. Conditioning may result in a change in behaviour, but the change may not involve drawing upon experience to generate new knowledge.

Some years later, Rogers (2003) looked into change pertaining to learning and noted that the change is concrete, immediate, and confined to specific activities. Hence he remarked that, though, learners may not be conscious of learning, they are usually aware of the changes taking place particularly when they perform certain tasks. At this stage, it is only pertinent to consider how or why this change occurs, thus an exposition of some learning theories.

2.1.2 Learning theories

Some learning theories evolved from psychology, and date early in the twentieth century. It is for this reason that the related literature on these theories is somewhat considerably old. Nevertheless, the theories have made significant contributions in helping understand the learning process occurring in the classroom. To this end, each of the theories is distinctly reviewed.

2.1.2.1 Watson's Theory

Watson collated some of the research findings in behaviourism, with a view to eliciting a new perspective. This revealed to him that the inner experiences, which are the focus of psychology, cannot be studied since it is unobservable. In addition, the human personality develops through conditioning of various reflexes (Watson, 1926; Philips, 1976; Schwartz & Lazy, 1982; Hart & Kritsonis, 2006). Watson (1926), therefore, believes that psychology can only become a science through studying behaviour in the laboratory where experiments can be undertaken, because Watson sees this environment as providing stimuli to which individuals develop responses and the factors below characterize part of his learning process.

- Firstly, Merriam and Caffarella (1991:126) point out that Watson's theory emphasizes focus on the observable behaviour, instead of internal thought processes, since the author believes learning is manifested by a change in behaviour.
- Secondly, the environment shapes one's behaviour; hence what one learns is determined by the elements in the environment, not by the individual learner.

2.1.2.2 Thorndike's Theory

Watson's theories were foundations for Thorndike's learning theories. Thorndike developed the stimulus–response (S-R) theory of learning, which stipulates that stimulus retain the character of an inexorable force (Thorndike, 1911). By this, Thorndike means that responses (behaviours) are strengthened or weakened by the consequences of the behaviours.

Thorndike's theories were initially brought into being by using animals: chickens, dogs, fish, cats, and monkeys. This reference observed how an animal, confined in a cage, escaped in order to reach food. A puzzle box was used, from which the study subject could only escape if it utilized a mechanism that would facilitate its release. Thorndike noticed that, in an attempt to escape, the animal often engaged in various forms of behaviour; but as soon as it was able to overcome barrier mechanisms, the animal escaped to where the food was placed. However, a number of observations made, confirmed there was a decrease in both the behaviours unrelated to escape, as well as in escape time. This, Thorndike termed *instrumental conditioning*, since the selection of a response is instrumental in obtaining a reward (Thorndike, 1911).

The following laws of learning were derived from the instrumental conditioning experiment (Bell–Gredler, 1986):

1. The law of effect

Satisfying a state of affairs following the response strengthens the connection between the stimulus and the behaviour, whereas an annoying state weakens the connection. Thorndike later revised the law so that punishment was not equal to reward in its influence on learning.

2. The law of exercise

Repetition of the experience increases the probability of a correct response. That is practise makes perfect. Thorndike (1913) remarked that if the repetition does not result in satisfying the state of affairs, it does not enhance learning.

3. The law of readiness

The execution of an action in response to a strong impulse is satisfying; whereas the blocking of that action or forcing it under another condition is annoying.

In applying these theories to classroom learning, Thorndike saw learning as a cumulative addition of discrete pieces of behaviour (Phillips, 1976). The author believed that with every mental act, certain bonds of responses arose and that facility, in specific areas, depended on the number of connections acquired, relative to that area. The source termed this *intelligent*, and on this rationale the Phillips's intelligence test was based, claiming that this test measured a sample of associations useful in predicting a person's ability to learn further (Phillips, 1976:184).

On the effects of subsequent learning based on prior knowledge:

- Thorndike firstly believed that training in a particular task facilitated the later training, only if the tasks were similar; this relationship is known as *transfer of training* (Thorndike & Woodworth, 1901).
- Secondly, based on Plato's original concept of *mental discipline*, which advocates the study of certain curricula, particularly mathematics and the classics, the intellectual function is enhanced (Greene, 1953). It was believed that such school subjects would discipline the mind. However, Thorndike (1924) could not find a difference in the post course

achievement of high school students enrolled for either classical or vocational curricula.

2.1.2.3 Skinner's Theory

Skinner's research refined the Thorndike S-R theories and called it *operant conditioning*: reinforcing what you want people to do again and ignoring or punishing what you want people to stop doing. His scrutiny revealed that S-R theories, which looked at the behavioural change alone, are an incomplete account of the organism's interaction with the environment. He observed that numerous behaviours produce some change or consequence in the environment that affects the organism and thereby alters the likelihood of future response (Skinner, 1938). Thus, Skinner asserted that one can comprehend many of the behaviours exhibited by understanding the interrelationships between a stimulus situation, the organism's response, and the response consequence.

Skinner designed many studies to examine the factors that govern behaviour. The author's first approach was to study the variables responsible for a rat's behaviour: pressing a lever for food reinforcement in an operant chamber. Most of the research focused on the influence of reinforcement on operant responding. The concept of contingency is central to Skinner's research. Contingency is a specified relationship between behaviour and reinforcement. The author believes that the environment determines contingencies and people must perform the appropriate behaviour to obtain reinforcement.

On learning; Skinner (1950) describes it as a change in the likelihood or probability of a response: as the subject learns, responses increase and when unlearning occurs, the rate of responding falls. However, the Skinner (1950) observes that to measure the likelihood or probability of responding, may be difficult, hence the suggestion that learning should be measured by the rate or

frequency of responding. The author reported three advantages, which the rate-of-responding method of measuring learning has over other learning measures.

- Firstly, it provides an orderly and continuous record of behavioural change, free of arbitrary criteria.
- Secondly, the behavioural change is clearly specified.
- Thirdly, the response rate is applicable to a variety of behaviours; from responses of pigeons in the laboratory to students' responses in the classroom.

2.1.2.4 Gestalt Theory

The Gestalt theory is based on structures of thoughts and perceptions, because it believes that a change in the perception process is the basis for learning (Kohler 1929:108). Contrary to behaviourists and neo-behaviourists, like Thorndike, who are of the opinion that previous experiences guarantee the solution to a problem, the Gestaltists, conversely, insist that previous experiences are not enough; organization is also an important component to solving a problem. Kohler illustrated this concept experimentally by placing food out of reach of an animal, but provided an aiding mechanism nearby. If the animal utilized the mechanism maximally, the mechanism would help the animal to obtain the food. In addition, Kohler realized that whenever the animal perceived the mechanism as a tool to obtain the food, the problem was solved. This process, Gestaltist refers to as *insight* (Kohler, 1929:108). In the conclusive findings, the Kohler recommends that the learning formula of *stimulus-response* be replaced with the constellation of *stimuli-organization-reaction* in view of the results of these experiments.

Furthermore, Gestaltism includes the developmental description of new born babies as relatively undifferentiated structures to the differentiation ability of adulthood. Adults can differentiate specific subjects as a result of total experiences, but children's experiences are more unified. Thus, the learning experience for children should consist of activities, which relate to their total experience and not the specifically differentiated subjects of adulthood.

Psychologists see Gestaltism as returning to Herbartianism, which believes that the skillful teacher links new ideas with the apperceptive mass already existing in the pupil's mind. This, however, led to the doctrine that learning should centre on a child's interest, all of which, in Gestalt terms, are configuration needs, goals and purposes (Philips, 1976).

Moreover, according to Philips (1976), Gestaltism proposes that materials should be presented for learning in their proper relationships and that learning by the whole method is superior to learning by the part method. This is because configuration shows relationships, while part learning has no organization. For example, children understand units such as sentences, phrases and words at large, before they are able to segregate their individual letters and syllables.

2.1.2.5 Jean Piaget's Theory

This theory focuses on the acquisition and development of knowledge. Jean Piaget views knowledge as a process and describes knowledge as the continuous interaction between the individual and the environment (Piaget, 1970). Although Piaget (1970), recognizes the contribution of the environment, like behaviourists, it concentrates on changes in the internal cognitive structure.

Piaget's interest in cognitive development stems from career onset. While working at the *Alfred Binet Testing Laboratory Paris*, Piaget became interested in the development of intellectual abilities in children. This later gave rise to the

genetic cognitive adaptation theory; a detailed and evolving analysis of the growth of cognition. The focus of this theory is on the development of natural thought from birth to adulthood (Piaget, 1975). The Piaget believed that the development of knowledge is not genetically programmed into the brain, but knowledge structure changes as the child grows. Changes in knowledge structures drive changes in fundamental cognitive capabilities.

Furthermore, the development of cognitive capabilities occurs in an orderly way since certain ways of thinking must be mastered to form the foundation for the subsequent ones. Central to this theory is the assumption that cognition is a process of adaptation to the environment. The individual cognition grows and develops through interaction with the environment (Piaget 1980). The Piaget postulates that cognitive abilities are acquired through assimilation, accommodation, and equilibrium (Piaget, 1977:3).

Piaget believes that as individuals interact with the environment, adaptation and learning take place through these interactions. In this sense, learning is seen as a process of adaptation to the environment and making sense of incidents with reference to prior knowledge, which enable individuals to construe new ideas. That is adaptation requires engrafting of new ideas into an existing cognitive structure. This Piaget called *assimilation*: making associations between new information and what is already known. However, Piaget and Inhelder, in Bell-Gredler (1986) remark that assimilation should not be seen as a passive registration of new ideas, but rather as a filtering of new ideas through an action structure, so that the structures are themselves enriched.

Accommodation is the process of adapting the cognitive structure to the new situation. This may be by adjusting the existing schemes or creating new schemas, such that the new ideas fit into it. Schemas are cognitive structures, which can endlessly be linked and woven as new learning is created. Assimilation and adaptation are two indissociable aspects of the same adaptation

process, the two sides of the same cognitive coin. As Bell-Gredler (1986) explains it, "the child presented with a green triangle made of felt material assimilates the already familiar characteristics (closed, three-sided figure)". At the same time the internal structure is accommodating the particular features of the triangle that is, colour and material.

Equilibrium implies that the individual remains open to new ideas that bring growth and survival as the individual continues to interact with the environment. It is a dynamic process that continuously regulates behaviour (Piaget in Bringuier, 1980:41). In cognitive development processes, equilibrium maintains the balance as the individual continues to grow, develop and change as a result of interaction with the environment. Piaget's cognitive theory introduces new requirements for the educational system that differ from those of the traditional learning theories (Bell-Gredler, 1986:211). In particular, the applications of this theory are in line with the constructivist approach to learning.

Constructivism and constructionism learning theories are discussed under separate subsections, because of their centrality to this study.

2.2 CONSTRUCTIVISM

2.2.1 Evolution and meaning of constructivism

The earlier scholars like Socrates and Plato believed that knowledge comes from sensory experiences (Crowther, 1997). In 1690, John Locke, an English philosopher, proposed in an essay: *Concerning Human Understanding* that people learn primarily from forces (Yolton, 1970). The philosopher claimed that at birth the human mind is a blank state, or *tabula rasa*, and empty of ideas. A human being acquires knowledge from the information about the objects in the world that the individual's senses bring to him or her. Each individual begins with simple ideas and then combine them into more complex ones. However, in

1710, Giambattista declared that the only knowledge one claims to possess is that which each individual constructed personally. Giambattista's assertion was not popular until 1916 when John Dewey remarked that education is the constant restructuring of experience (Dewey 1916; 1929). Dewey's claim incited debates in the education circles, which brought the constructivism learning approach into the limelight. Consequently, Dewey's constructivism application was introduced to the classroom in 1920 (Brooks & Brooks, 1995). Fifty-four years after that, Jean Piaget became famous as the father of modern constructivism for his work on his adaptation cognitive theory (Piaget, 1970).

What then is *Constructivism*? Constructivism, according to Confrey (1990:108), is a theory about our limits of knowledge, a belief that all knowledge is necessarily a product of our own cognitive acts. It is a theory of learning that likens the acquisition of knowledge to a process of building or construction. It involves active participation of the learner as each person constructs his or her knowledge. It is not concerned with the question of knowing, but the manner in which the knower constructs viable higher knowledge. Piaget argues that knowledge is constructed as the learner strives to organize his or her experiences in terms of pre-existing mental structure or schemas (Bodner, 1986). Differences in levels of intellectual development are reflected as qualitative differences in thought. Bodner also notes that maturation is an important factor in the quality of the knowledge construction.

Because the maturation of the nervous system is not completed until about the fifteenth or sixteenth year, it therefore seems evident that it does play a necessary role in the formation of mental structures, even though very little is known about that role ... the maturation of the nervous system does no more than open up possibilities, excluded until particular age levels are reached (Fox, 2001).

Following Piaget's developmental theory as it affects knowledge construction; some schools specify entry age to each grade level in schools (Blake & Hill, 1980:83).

2.2.2 Types of constructivism

As explained in subsection 2.2.1 above, Dewey and Piaget brought the Constructivism idea into the classroom. Today there are various forms of the Constructivism theory (Chiari & Nuzzo, 1996; Neimeyer & Raskin, 2001). Of these, Personal, Radical, Social and Contextual Constructivism are related to this study and are expounded below.

2.2.2.1 Personal constructivism

Personal Constructivism, otherwise known as *personal construct psychology*, originated from George Kelly's work of 1955 (Kelly 1991a, 1991b). The author postulated that people organized their experience by developing bipolar dimensions of meaning or personal constructs (Kelly, 1991a). These constructs are used to predict how the world and its people might behave. People construct meanings to account for events in the world, thereafter continually test and modify the accuracy of their constructs. In this sense, they rationally examine their experiences as a basis for improving their knowledge. That is, people learn by constructing meaning to their personal experiences as they interact with their environment. According to Piaget (1970), interaction with the environment implies making sense of the environment and using the new experience generated from this interaction to restructure existing knowledge structures. Consequently, for people to learn effectively, they must be exposed to experiences, which also impact on them.

Personal Constructivism was developed from what psychologists termed *constructive alternative*. The constructive alternative concept asserts that there

are infinite possibilities for conceptualizing events (Kelly, 1991a); whenever previous constructions were found faulty or lacking, people freely developed new dimensions of meaning to fit the required events. However, some constructs might have been regarded superior to others, because of their predictive utility or a better approximation of events in the world (Landfield, 1980; Steven, 1988). For example, the concept of a spherical earth displaced earlier beliefs in a flat earth. In the same vein, new concepts are being formulated to replace old ones, in order to attach improved meanings to events, as people continue to interact with their world.

2.2.2.2 Radical constructivism

The Radical Constructivists' view is that people operate in their own very private, self-constructed worlds. People use the understanding they created to help them navigate life, regardless of whether or not such understanding matches an external reality (Von Glasersfeld, 1995). Von Glasersfeld (1995), expanded on Piaget's configurative development theory and claims that human knowledge is a construction built through adaptation of cognition. He warns that adaptation does not necessarily imply adequation to an external world, but rather assist people to improve their equilibrium.

In addition, since cognition involves thinking, human beings keep thinking, until they arrive at a better interpretation of that reality. To a certain extent that means knowledge depends upon the conceptual structure of the knower. When this view is applied to learning the following suffices: learning will be more fruitful when learners are allowed to think about concepts and principles that were presented in the classroom and interpret them in a way that makes sense to them so that the concept is a reality in the learners' own world. To restructure learners' misconceptions, learners should engage in activities that involve thinking and reflecting on their own thoughts.

2.2.2.3 Social constructivism

Social Constructivism focuses on individual learning that takes place, because of learners' interaction within a group. Once learners properly grasp the understanding of a learning concept, they can effectively explain the concept to others (Duffy & Jonassen, 1992). Explaining to others, according to Duffy and Jonassen, is very important in the learning process. However, Lorschach and Tobin (1992) suggest that interaction with colleagues can create perturbation in both the explainer and the listener; furthermore individuals make adaptations in their understandings that fit their experiential world by resolving the perturbation, since knowledge can not be acquired passively. Nevertheless, in the social constructivism learning environment, teachers are not to leave learners to their own devices, but are to appraise what is important for true understanding of the material and move among the learners to assist with strengthening the quality of learners' constructs.

Indeed, social constructivism extends the view of constructivism by incorporating the role of other actors and cultures in the process of knowledge construction. It advocates that knowledge is socially and culturally constructed and not transmitted. As such, cultural and social interactions are fundamental aspects of cognitive activities (Borko & Putnam, 1998; Vygotsky, 1978). It places less emphasis on the individual and more on the learning context as well as the community of practice. The teacher's role is to support learners to make ideas and practices of the learning community meaningful at their respective individual levels.

2.2.2.4 Vygotsky's social constructivism

Vygotsky's theory main concern is about the role of social interaction and social context in cognitive development. Take for example a growing child, who

interact with the child from birth is very essential in the cognitive development of the child. Vygotsky, (1978) remarked that:

Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level: first, between people (inter-psychological) and then inside the child (intra-psychological). This applies equally to voluntary attention of concepts. All the higher functions originate as actual or slip between individuals.

Vygotsky also considered development of cognition. He believes that the potential for cognitive development depends upon what he called "zone of proximal development" (ZPD). That is, a level of cognition attained when children engage in social behaviour. This is vygotsky's view of intelligence. He measured intelligence by what a child can do with skilled help. That is, the range of skill that can be achieved with adult guidance or peer collaboration. By the help of adults, children can understand more than they can on their own. However, Daniels, (2001) and Wertsch, (1991) believe that ZPD is based on the idea that cognitive development is defined both by what a child can do independently and by what the child can do when assisted by an adult or more competent peer.

For classroom teaching, Karpord and Haywood (1998) suggested that Curriculum should be developmental, the teachers must engage learners in those activities that they can do individually and those activities they can learn with the help of others. However, it should be noted that it does not mean that anything can be given to a child to learn but only those things that belong to the child's ZPD. For example, a child who cannot differentiate between different numbers cannot learn addition or subtractions of numbers.

2.2.2.5 Contextual constructivism

Contextual Constructivism is concerned with the social construction of knowledge and the application of the knowledge. That is, it emphasizes meaning making and the application of the meaning in real life. Kuhn (1970) notes that true knowledge should aim at yielding calculations, which agree with the problems that the scientific community feels it should address, otherwise an alternative paradigm, which promises to solve those problems should be sought. The cognitive construct should be related to real life situations. For example, the teaching and learning in Mechanical Engineering, being a practical career, should aim at connecting theoretical concepts with real life field applications. Additionally, contextual constructivism also makes reference to the concept of situated cognition, which links learning to the activities used and the context in which they are used. Resnick and Hall (1998) remark that human beings have the ability to arrange perceptions on the basis of constructs, and this explains how individuals perceive different events in similar or different contexts, and how people construct similarities and identify differences in given situations.

2.3 CONSTRUCTIONISM

2.3.1 Origin and meaning

Constructionism postulates that learning is an active process in which learners construct mental models and theories of the world in which they live. It holds that children learn best when they are in the active roles of the designers and constructors (Papert, 1991). In addition, Papert (1993) states that this type of phenomenon occurs more felicitously in a context where learners are consciously engaged in constructing public entities, whether designing and constructing sand castles on the beach or formulating theories of the world.

Constructionism takes its root from Piaget's Constructivism learning theory and is pioneered by one of Piaget's students, Seymour Papert. While Piaget focused on knowledge construction, which takes place in the head; (i.e. mental construction), Papert concentrates more on the art of learning and on the significance of learners' drawing their own conclusions through creative experimentation and the making of social objects. Papert believes that learning happens more effectively when learners are active in making tangible objects in the real world. Furthermore, he is of the opinion that deep, substantive learning and enduring understanding occurs when public construct is added to mental construct.

Constructionism is not as popular as the constructivist learning theory and the education stakeholders are often confused by the two learning theories. The constructionism concept simply implies: "Take the constructivism ideology and add to it the reality demonstration of what is being constructed mentally for public discussion, examination, critique or admiration". This is what Papert referred to as *Concrete Construct*. The word *Concrete*, which Papert also called *Public Entity*, may also imply constructing abstract concepts in reality through constructing artifact molding, or creating computer programmes to demonstrate the understanding of the concept for and to share with others. The word *Concrete* may also mean explaining concepts that were taught to others: learners draw diagrams, think of the best ways to convey it to others and in the process, learn the concept even better.

The focus of engineering training is to enable students to apply theoretical concepts to solve real life situations competently. Therefore there is a need to enhance the teaching process to accelerate learning, so as to facilitate a good understanding of the concepts (Marek & Aleksander, 2005). Hence, the researcher believes that the constructionist learning strategy will suit the learning of the fluid mechanics module in engineering classes, the best because of the emphasis on the practical construction of knowledge.

2.3.2 Social constructionism

This is a learning theory that considers how social phenomena develop in a social context. Berger and Luckmann (1966) postulate that when people interact, they do so with the understanding that their respective perception of reality is related and as they act upon this understanding, their common knowledge of reality becomes reinforced. All knowledge is seen as being local and fleeting, it is negotiated among people within a given context and time frame.

In view of the above, learners should be given the opportunity to work together in small groups, to construct tangible objects like artifacts. In this sense, individual concrete constructs are combined to produce a common public entity that will be of more quality and less criticized than if learners work individually. In this social practice, the individual's weak mental and concrete constructs are strengthened during constructs' negotiation. Learners perform best when they learn in a community of social practice. Vygotsky (1978) and Bardural (1977) acknowledge that learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions, to inform them what to do.

2.3.3 Similarities and differences between constructivism and constructionism

Constructionism evolved from constructivism, so much so that there are similarities and differences between them.

2.3.3.1 Similarities

1. Both Constructivism and Constructionism view children as building their own knowledge structure when they interact with the world in

which they live. According to the two theories knowledge and the world are both constructed and constantly reconstructed through personal experiences (Piaget, 1970; Papert, 1991).

2. The two theories claim that knowledge is not to be transmitted or conveyed readymade to another person (Papert, 1993) as is the case in the traditional teaching and learning approach; where the teacher is a conduit of knowledge, and fills empty vessels. In the two learning theories, learners are part of the learning process.
3. The world gets progressively shaped and transformed through the child's interaction with the world, instead of the world is just out there waiting to be discovered (Piaget, 1967; Papert, 1993).
4. The theories also share the objective of how people can outgrow their current view of the world and construct deeper understanding about themselves and their environment (Papert, 1993).
5. Both theories also look at intelligence in the same paradigm of adaptation or ability to maintain balance between stability and change (Piaget, 1969; Papert, 1991).

2.3.3.2 Differences

1. Constructivism takes the form of a scientific approach (Piaget, 1967), while constructionism focuses on practice, the art of making (Papert, 1991; 1993).
2. Constructivism is based on mental knowledge construction (Piaget, 1967), while constructionism advocates concrete demonstration of

knowledge to reinforce the mental knowledge construction (Papert, 1993).

3. Constructivism is a philosophical theory that studies learning as a process. Constructionism investigates learning as a method of learning.
4. Constructivism phenomena are more concerned about internal stability, while constructionism is interested in the dynamics of change in learning.

The classroom application of both constructivism and constructionism are student-centre. They are characterized by classroom social interaction. Waite-Stupiansky (1997), noted that the context provided by social interactions among peers is a natural learning environment in which logical reasoning can develop. The feedback is usually immediate and the motivation to succeed is high. However, learners can only achieve best, academically, if proper instructional strategies are followed.

2.4 LEARNING, TECHNOLOGY AND INSTRUCTIONAL STRATEGIES

Gagne, Wager, Golas and Keller (2005) describe instruction as a set of events embedded in purposeful activities that facilitate learning. Formal learning and instruction strategies are inseparable. Yet, learning theories, some of which are discussed in section 2.3, only describe how learning occurs, but do not prescribe the specific methods and activities (Ornstein, 1990), to follow in order to accomplish the intended learning outcome. For example, a learning theory may describe the age at which a child ought to learn addition, but an instruction theory will provide guidelines on how to execute the teaching of addition. Therefore, Bruner (1960) suggests that there is a pertinent need for instructional theories.

Furthermore, Bruner (1964) and Hilgard (1980) call for instructional theories, which are able to translate the learning theories into instructional strategies. The instructional theories prescribe the series of steps the teacher should follow in the classroom, as supported by theory and research, to produce certain types of student learning. These series of steps are instructional strategies. Each of these steps comprise simple actions taken by the teacher, within the confines of the teaching strategies, these are called instructional tactics.

However, for learning to be effective, instructional tactics are supposed to produce most learning (Papert, 1993). Today, there are several instructional strategies, commonly used in the classroom. Additionally, new instructional strategies are being developed because of the advancement in research on the proper strategies to adopt, more especially in the science classroom. According to Ornstein (1990), the following are the four basic and traditional instructional strategies: (1) Direct Instruction; (2) Practice and drill; (3) Question; (4) Lecturing.

1. Direct Instruction

This is an instructional strategy for impacting basic knowledge or developing skills in a goal-directed classroom environment. The teacher comes to the class to deliver a well-structured lesson. The teaching strategy includes; the teacher defines the learning outcome, conveys new ideas and provides guided practice to students. This method of instruction does not allow the learners to use their initiatives as such. It may help the low-achieving students, but is not suitable for high achieving students, who prefer a classroom environment where they can utilize their initiatives.

Behaviourists like Thorndike and Skinner, belong to the movement, where the philosophy centres on breaking of behaviours and skills into component tasks as well as mastering each subcomponent, thus supporting direct instruction strategies. These behaviourists focus on modeling desired

behaviour in learners by using structured teaching (reinforcement) to guide learners towards the desired goal (response). Most classroom teachers in the 1970s and 1980s embraced this system of instructional strategy.

2. Practice and drill

This instructional strategy demands that learners memorize the teacher's lesson, or some basic skills or knowledge of some academic subject matter. The practice and drill method is often applied when teaching, say for example, counting from 1 to 20, or the multiplication table. For example, the researcher encountered the practice and drill method to learn the multiplication table in the mathematics' classroom. However, the use of the calculator in today's learning of mathematics has overtaken this learning method in the mathematics' classroom (Ruthven, 1998; Nyaumwe, 2006; Standing, 2006). This learning method is also used in learning definitions, proof and other concepts that must just be put down the way they were written for possible application in solving other problems.

The belief '*practice makes perfect*' as cited by Thorndike (1913), underpins this instructional practice. Thorndike's law of stimulus-response states that the more often a stimulus-response connection is made, the stronger it becomes. In addition, Skinner (1938) states that reinforcement of a response, increases the likelihood of its occurrence. These two learning theories provide support for the practice and drill instructional strategy.

Repetition is used to maximize correct responses and to prevent misconception. Continuous reinforcement is supplied by getting answers right. This type of instructional method neither stimulates students' imagination nor motivates them to search for new knowledge.

3. Questioning

In certain circumstances, teachers may involve a question method as part of the classroom activities, to bring about learning. Skillful questioning can arouse the students' curiosity, stimulate their imagination, and motivate learners to search out new knowledge and problems relating to the lesson. However, the type and sequence of the questions, and how students respond to them should be well structured.

This instructional method allows the learners to use their initiatives and to construct new knowledge. The questions are categorized according to the thinking processes involved in getting the answers. They are categorized as low or high level (Boom's taxonomy). Low-level questions emphasize memory and recall information, but high-level questions involve abstract and complex cognitive demand (Alan, 1990). Unlike the previous instructional strategies explained above, the questioning method improves the classroom dynamics; not only the interaction between teacher and students, but also among students.

4. Lecturing method

The lecturer presents a well-structured and goal-oriented lesson on the chalkboard, or as is done in today's classroom, by means of a computer PowerPoint presentation (William, 2010). Topics are introduced, concepts involved are explained and a specific problem or task relating to the concepts is given.

Lecturing method of classroom instruction neither encourages interaction between the lecturers and students, nor among students. Ornstein (1990) describes it as dull and a waste of time. Learners are to sit tight in their seats, while they listen to the lecturer. In this teaching environment, as it is generally perceived, students do not develop any understanding; they only copy notes, which they will regurgitate during tests or examinations.

However, this instructional method, like direct-instruction, allows the lecturer to cover as much of the scheme of work as he or she wants or needs to. It also allows the lecturer to structure a number of lectures to be covered at the prescribed pace. Students' understanding of the concepts is not paramount in this situation. Conversely, learning takes place when learners are cognitively engaged in thinking. Learners that sit down like empty vessels to be filled, learn very little afterwards. This type of learning environment does not encourage new knowledge constructs, and the students will not be able to apply the concept learned in another area.

The above discussed classroom instructional methods are traditional and teacher-centred. Only a limited amount, if any, of the students' thinking ability is engaged. Students work alone and learning is only achieved through repetition, the learning concepts are strictly in accordance with the syllabus and guided by the textbooks. The work of Dewey (1916) and Piaget (1970) brought about the student-centred instructional approach, designed to help students acquire higher cognitive levels and problem-solving skills.

In this contemporary time, the most popular student-centred instructional approach used in today's classroom is the constructivist instructional approach. The constructivist instructional approach is based on the constructivist learning theory (see section 2.2). It is about teaching the students how to learn, by training them to take initiatives for their own learning experiences. The approach is student-centred. However, many theorists and researchers have reviewed, reinterpreted and restructured the constructivist theory to suit modern classroom needs. However, studies (for example, Moreno & Mayer, 2007) have shown that technological instructional aides facilitate student-centre learning approach.

2.4.1 Use of technology as an instructional aid

Instructional aids are classroom resources that teachers can use to achieve effective learning. The present advanced technology offers opportunities for technological instructional aids, which facilitate teaching and enhance learning (Kadi, Yala & Crynes, 2000; Mayer & Moreno, 2003; Franze & Breit, 2005) as pointed out in subsection 1.1.2.

However, *American College Personal Association* (1996:118 in Engstron and Kruger, 1997) claims that the key to enhance learning and personal development is not simply only to teach more and better, but also to create conditions that motivate and inspire students to devote time and energy to purposeful educational activities, both in and outside the classroom. There are modern technologies that can be used in the classroom, which make learning more interesting, explorative and in the process facilitate teaching and learning. For example, bulletin boards make lecture presentations visually appealing and stimulating to students.

Previous generations' conceptualization of life has been twofold: the school age and the work years. The advent of modern learning technologies has made education a lifelong process. Nowadays, with the use of motivating learning technological materials, learning has become more fun, rather than the torture it was associated with when presented through the traditional teaching and learning methods. In the modern classroom, where the advantages of modern technology are fully harnessed, the teaching and learning approach is student-centred rather than the lecturer-centred approach found in the traditional classroom environment. Students are responsible for their own learning; learning and understanding is seen as a social act. The lecturer only acts as a resource and consultant in the classroom.

Furthermore, lately, technology has made an inordinate impact on teaching and learning. In some instances technology has even reduced the total dependence on textbooks when teaching. For learning, technology has made students learn by doing, inventing and creating through the use of technology (Papert, 1993). Papert (1996) warns that the scandal of education lies in the fact that every time you teach something using technology imprudently, you are likely to deprive a student the pleasure and benefit of self-discovery and creativity. On the other hand, technology, for example computers, can be handy to facilitate teaching and learning. It is this that the current study seeks to look into.

Some learning theories have evolved as a result of the use of technology in the classroom to facilitate learning, which nowadays form part of the modern learning theories. These theories are to guide the use of technology in the classroom to facilitate learning. The ones that are important to this study such as *cognitive-affective theory of learning with multimedia (CATLM)*, *Method-Affects-Learning* and *Multiple Representation Principle* are discussed below.

2.4.2 Cognitive-affective theory of learning with multimedia (CATLM)

CATLM is a multimedia learning theory, according to Mayer (1997), which proposes a learning environment scenario that combines verbal and pictorial information. The theory is conceptualised on the fact that learners possess a verbal information processing system; as well as a visual information processing system; such that narration goes into the verbal system, whereas animation goes into the visual system. It draws from:

- The dual coding theory (Clark & Paivio, 1991; Paivio, 1986);
- The working memory model (Baddeley, 1992);
- The cognitive load theory (Chandler & Sweller, 1991; Sweller, Chandler, Tierney & Cooper, 1990);
- The generative theory (Wittrock, 1989); and

- Cognitive-social learning (SOI) model (Meyer, 1996): Learning is knowledge construction through the following cognitive process: (a) Selecting relevant information, (b) Organizing incoming information, and (c) Integrating incoming information with exist knowledge

The CATLM theory, according to Moreno (2006), is based on the following assumptions:

1. Independent information processing channels (Baddeley, 1992).
2. Limited working memory capacity and virtually unlimited capacity long-term memory (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965).
3. Dual coding – the idea that learners can represent knowledge in verbal and visual codes (Paivio, 1986).
4. Active processing – the idea that meaningful learning occurs when the learners make a conscious effort in selecting, organising, and integrating new information with existing knowledge (Mayer & Moreno, 2003).
5. Affective mediation – the idea that motivational factors mediate learning by increasing or decreasing cognitive.
6. Metacognitive mediation – the idea that metacognitive factors mediate learning by regulating cognitive processing and engagement (Gottfried, 1990; Moreno et al., 2001), as well as affect (McGuinness, 1990; Morris, 1990).
7. Individual differences – the idea that differences in learners' prior knowledge (Kalyuga, Ayres, Chandler & Sweller, 2003; Moreno, 2004), and traits such as cognitive styles and ability (Plass, Chun, Meyer & Leutner, 1998; Moreno & Duán, 2004), may affect how much is learned with specific methods and media.

Figure 2.1 below, gives the illustrative diagram of the cognitive-affective theory of learning with medial (CATLM) (Moreno, 2005).

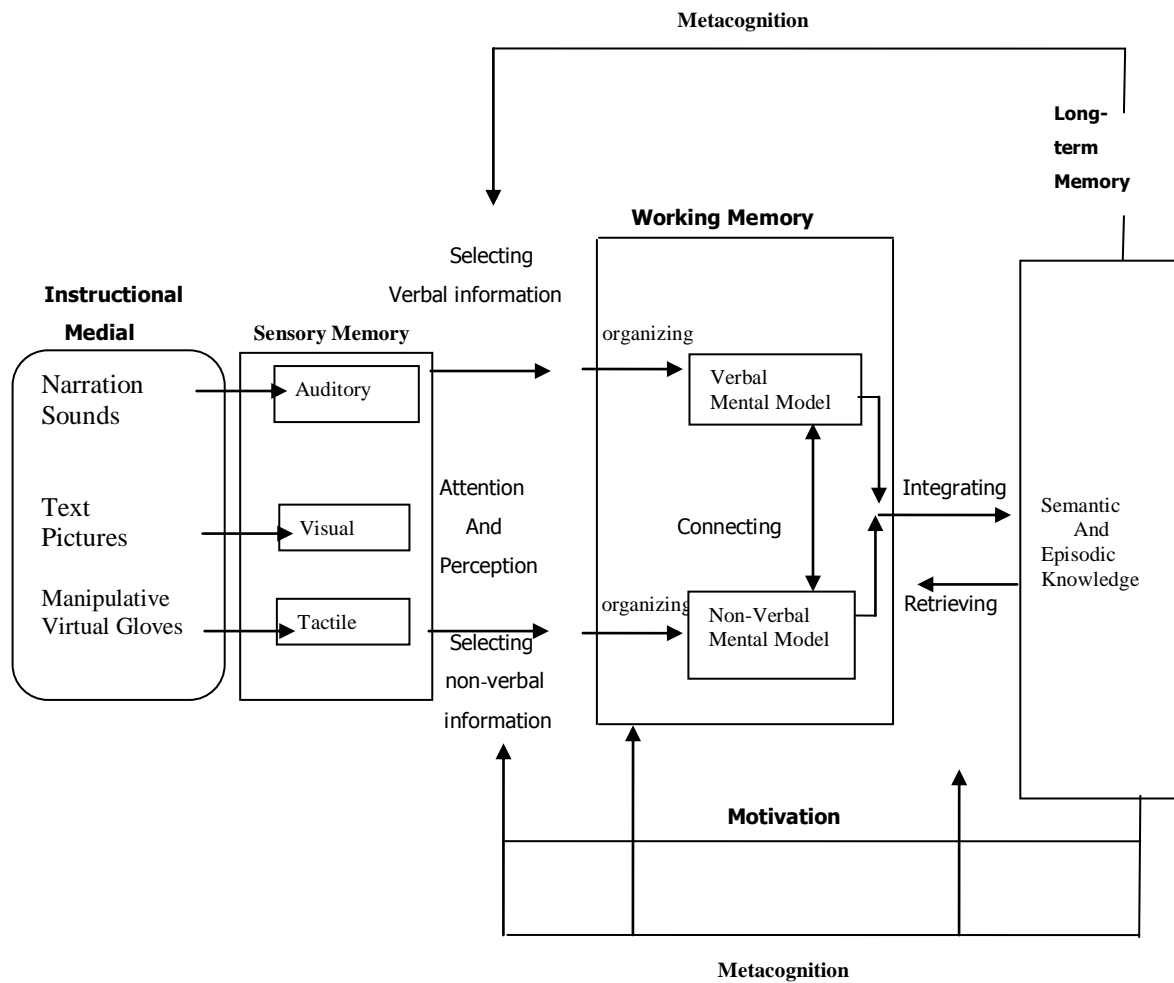


Figure 2.1 A Cognitive-affective model of learning with medial
(adapted from Moreno, 2005)

The instructional media consists of explanations entering via the learner's ears or eyes, depending on whether the explanations are presented with spoken or written words. Learners then need to select some of the words for further processing, organize the words into a model, and integrate this verbal model with their prior knowledge. In addition, the instructional media may include nonverbal representations of information such as tactile, acoustic, or visual representations of the content. Similarly, learners select some of the nonverbal information for further processing, organizing the information into a model, and integrating this nonverbal model with their prior knowledge. Corresponding verbal and nonverbal models are associated with referential connections (Paivio, 1986).

2.4.3 Multiple representation principle

The principle of multiple representation theory builds on the CATLM learning theory. It states that 'it is better to present an explanation in words and pictures than solely in words' (Mayer & Moreno, 1998). Mayer & Anderson (1991, 1992) explaining this learning principle claimed that:

students who listened to a narration on how a bicycle tire pump works while also viewing a corresponding animation generated twice as many useful solutions to subsequent problem-solving transfer questions than did students who listened to the same narration without viewing any animation (Mayer & Moreno, 1998: page 2)

Learning with multiple representation has, however, been recognized as a potentially powerful way of facilitating understanding (Ainsworth & Van Labeke, 2002). This principle implies that if the learning of fluid mechanics is facilitated with conceptual animation, the students may learn better than the present abstract, teacher-centre learning approach.

2.4.4 Media-Affects-Learning

Media-Affects-Learning hypothesis states that advanced instructional technologies promote deeper learning, (Moreno & Mayer, 2002). In support of this hypothesis, Moreno (2006) argues that this hypothesis is in line with the current efforts, in the education circle, to integrate newer technologies such as motion picture, radio, television, and computers, into education and is based solely on the assumption that state-of-the-art technologies are more effective learning tools than older technologies are. More especially, a practical but very technical subject like fluid mechanics needs to be supported with technology that can present the difficult-to-learn aspect of the subject in form of animation to facilitate learning. Mejia-Flores (1999) noted that visual representation made abstract concepts “easier to understand and internalised”

In view of the above learning theories, CCAIML learning model is proposed for learning fluid mechanics in mechanical engineering classes.

2.5 CONSTRUCTIONIST COMPUTER-AIDED-INSTRUCTION MODEL OF LEARNING (CCAIML)

2.5.1 Instructional model

From the pedagogical point of view, a model of teaching and learning is a representation of the sequence of teaching and learning activities or experiences designed with a view to attaining a set of intended learning outcomes. In particular it is a representation of how teaching should be carried out with clearly defined roles for both the lecturer and students to facilitate learning, which in the current study is on the mastery of aspects of fluid mechanics concepts.

The construction of a model is stimulated by a gap or a need in a learning area. For example, it was observed in the baseline study that the traditional method of teaching fluid mechanics constitutes learning difficulties in some complicated aspects of the module in some South African Universities. Briggs and Sonmefeldt (2003:38) remark that models of teaching are influenced by the prevailing culture of the education system as well as the generic and particular needs of the learner. The model constructed will be such that it satisfies the need for which it is constructed. However, in an attempt to satisfy this need, the explanations and observations derived from the model lead to propounding a theory, the purpose of which is to explain and predict behaviour, subject to modification (Dorin, Demin & Gabel, 1990). In addition, Xiaoyan (2003:57) advice that when introducing a new model; it is pertinent to integrate the new instructional method with the traditional instructional methods. There should also be a continuous review of the newly introduced instructional model so that necessary changes can be effected where required. Of paramount importance the instructional model should facilitate learning and make it much more meaningful particularly for those students whose learning histories are a cause for concern (Joyce & Weil, 1996).

2.5.2 Structure of CCAIML

Timothy and Richard (2006) remark that traditional classroom instruction, whereby instructors illustrate fluid mechanics concepts with only textbooks and blackboards as aids is inappropriate. A more effective learning strategy is, therefore, required: a learning strategy that will be able to facilitate fluid mechanics learning. Felder (1988, in Dwyer, 2010) informs that fluid mechanics students who, in some cases, also happen to be engineering students have four dimensions to their learning styles: (1) verbal learning, (2) visual learning (3) active learning and (4) reflective learning.

1. Verbal learners

Students, who belong to the verbal learning style, prefer and are comfortable when lectures that are presented in text or spoken explanations.

2. Visual learners

This group of learners will perform better if, in addition, the lecturer provides visual aids to demonstrate concepts, principles and processes.

3. Active learners

The active learners learn by trying or working things out.

4. Reflective learners

This group of learners wants to think things through, in addition to either audio or visual presentations of lecturers.

A learning model that will meet the four categories of learners described above, will actively engage all students in their academic pursuits. The constructionist learning theory proposes that learners engage pedagogical content as they construct their knowledge in relation to their environment. Therefore, the researcher in this study hypothesized as follows:

“If mechanical engineering students learn fluid mechanics by means of a technological learning aid, such as ACIA and following CCAIML learning model, such that students demonstrate their internal knowledge construction physically as they engage with their peers in a discussion; a sustainable conceptual deeper understanding will be inevitable”.

The CCAIML learning model is constructed in a way to implement the constructionist theory, the media-affects-learning hypothesis and the multiple representation principle discussed in sections 2.3 and 2.4. Figure 2.2 below reflects the structural description of CCAIML.

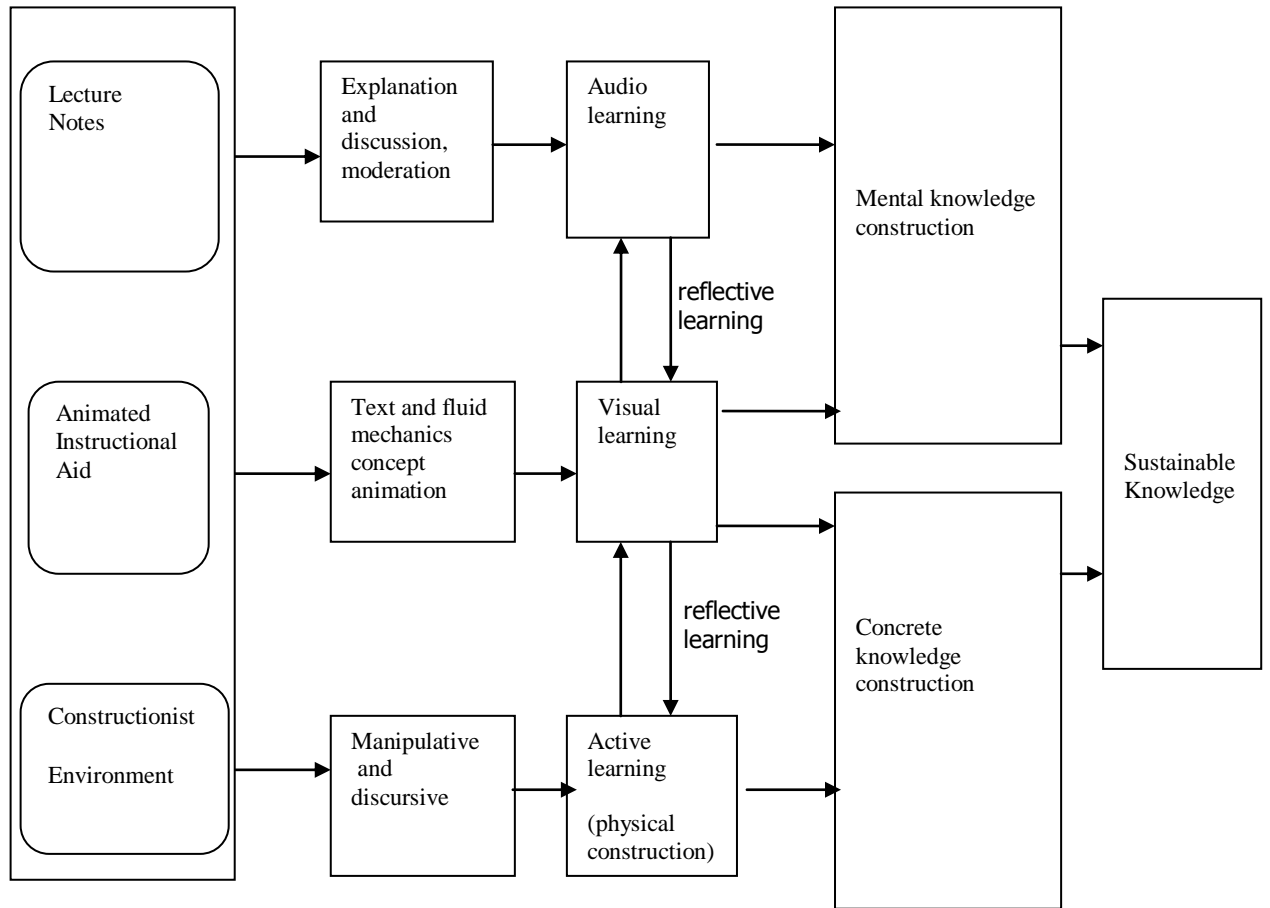


Figure 2.2 The structural description of CCAIML

Table 2.1 THE INSTRUCTIONAL STEPS IN CCAIML

Instructional phase	Lecturer's activities	Students' activities
Introduction	Presents the topic and the new concept on the white screen. Uses questioning to survey students' prior knowledge.	Students are seated in groups where they can freely discuss. Relate new concepts with previous ones.
Knowledge Construction	Explains briefly the main features of the new concept. Displays the computer animation of the new concept. Encourages cross-breeding of ideas, views and information. Moderates the lecture room dynamics.	Based on the new concept, form views and ideas from logical reasoning, utilize information to construct public entity of the concept. Give real-life representation of the constructs. Share views and ideas with other students.
Class Discussion	Allows each group or individual to present ideas, views and constructs to the whole class. Encourages comments and criticism from other students; makes a summary of the main ideas and constructs, such that these make logical sense.	Present individual or group views, ideas, and constructs to other students. Criticize each others' views and constructs. Keep track of the lecture. Comment, summarize and evaluate initial conception, using new constructs and ideas. Identify limitations of other people's opinion.
Problem Solving	Presents real life situations to be solved, to students. Moderates the answers or idea in an attempt to solve the problems.	Apply the concepts, ideas and new constructs to solve the problems posed.

The details of the teaching and learning activities involved in CCAIML are given in Table 2.1 above. Even though the model supports that computer animation should be made available to students to facilitate further engagement, learning is actually aided individually. This individual learning, when learners are by themselves, is not included in the instructional tactics described in Table 2.1 above.

The learning steps structured above focus on students being able to:

1. Represent the concept learned as a physical entity, open to peers' criticism;
2. Apply the concepts to solve real-life problems; and
3. Adapt the concepts to solve real life complex problems in other similar situations.

In the next chapter, the researcher reviews the current efforts of engineering education researchers to facilitate the learning of fluid mechanics and similar engineering subjects.

CHAPTER 3

REVIEW OF RELATED LITERATURE

Since the latter part of the twentieth century, numerous studies (for example Ngo and Lai, 2001; Steif and Naples, 2003; Hall, Philpot and Hubing, 2006; Cleghorn and Dhariwal, 2010) have been undertaken to address the various challenges facing the learning of engineering modules. The teaching of these modules has been getting increasingly more difficult due to:

- the growing number of students from varied cultural backgrounds;
- the necessity to move away from abstract concepts' illustration; and
- the need for multi-disciplinary teaching, in order to minimize teaching duplication and cost (Dearn, Tsolakis, Magaritis & Walton, 2010).

However, the quest for effective teaching strategies, which would facilitate learning in engineering classes, remains elusive. This chapter discusses related literature pertaining to the teaching and learning of engineering modules, particularly fluid mechanics, in mechanical engineering classes.

Kyza, Erduran and Tiberghien (2009) and Barnes (2009) postulate that different kinds of learning goals require different approaches to instruction and no single instructional method will be able to meet the learning needs of the large student numbers found in engineering classes, nowadays. In fact a set of instructional methods should be used and the current study looks into the use of one of those methods. Many studies have presented various instructional approaches, which are deemed good to facilitate learning in engineering classes.

In order to understand issues pertaining to the use of the instructional method being studied, related literature is being reviewed and has been categorized into:

- the use of technological aid, and
- the use of learning theories to facilitate the learning of engineering modules; more particularly in mechanical engineering class.

3.1 STUDIES ON INTERVENTION OF TECHNOLOGICAL AIDS IN LEARNING

In recent years, many engineering instructors have attempted to improve students' learning by incorporating computer-based instructions in their classroom teaching (see, for example, Bowe, Jensen, Feland, and Self, 2001; Reamon and Sheppard, 1999; Rhymer, Jensen, and Bowe, 2001; Ngo and Lai, 2001). However, there is evidence that computer-based instructional approaches are both more effective and efficient than conventional instructions (Akst, 1996; Kadiyala and Crynes, 2000).

Steif and Naples (2003) used computer courseware to address the problem of students' problem-solving skills. Steif and Naples concluded that in mechanics courses, students must learn to apply fundamental principles to ease understanding, problem solving and design. Hence, problem solving courseware modules were developed to facilitate this process. It is assumed that, by solving a number of similar but non-identical problems, students would be able to elucidate the underlying fundamentals more readily than if an independent method for solving each type of problem is memorized (Chi, Feltovich and Glaser, 1981). The developed courseware CDs were handed to students, who were expected to practice problem solving on their own. The courseware was also made available to students online. According to Steif and Naples (2003),

students found the courseware beneficial. Nonetheless, they warned that the courseware alone could not meet the learning needs of all the students.

One of the negatives of traditional teaching and learning is that students are expected to be fed with knowledge, with the supposition that it builds superficial understanding of the required knowledge in them. For example, this is evidence in Taraban et. al., (2004) which shows that, students in most cases, failed to connect the conceptual and procedural knowledge in a way that would lead to deeper understanding. In accordance with this view is Brandt (1993), who has found that students lack the capacity to take the knowledge learnt (fed with) and apply it appropriately in different settings. Thus, the researcher in this study feels that students should not be restricted to memorizing the problem solving procedures alone, but be taken through a learning approach that could help them foster deeper understanding of different engineering modules. Perhaps, a better result would have been obtained if the problem-solving skill concepts in the courseware were animated as in ACIA and the instructional strategy were student-centred as in CCAIML in this study.

However, in large lecture rooms, lecturers find it difficult to attend to the cognitive needs of each student. Learning materials, which can engage learners in new and empowering ways, while accommodating students' unique approach to learning, is imperative. Thinking in this direction, Hall, Philpot and Hubing (2006) developed educational software expounding the static, dynamic and mechanic components of materials with the objective that students would use these aids, during private study, to supplement classroom lectures. The project integrated the courseware with an active learning approach. The students were, after using the courseware individually, expected to demonstrate the new knowledge and skills gained from the courseware during lecture and tutorial classes.

Various assessments and evaluations of the study were carried out to measure the impact of this method on learning. According to Hall et al. (2006), the study proved to have impacted positively on the students' learning of the designated courses. This motivated the researcher to pursue a similar study in South African universities' engineering classes.

Wiske (1994) found that understanding grows through the exchange of ideas in the classroom. The researcher in this study thinks that many lazy students may not even open the courseware CD given to them, not to talk of learning the contents in it. The animation courseware would have been used in the class as proposed in CCAIML learning model, to motivate the students to use the CDs privately.

Hubing et. al. (2002), in search of effective instructional strategies, which can provide solutions to the problems in the learning of engineering modules, considered multimedia instructional aids to facilitate learning in the engineering classroom. The authors introduced the use of computer-based animated interactive learning materials for learning of the mechanics of materials course in mechanical engineering classes. These were introduced as classroom lecture supplements. It features animations, graphics, and interactivity designed to engage and stimulate students, to effectively explain and illustrate course topics as well as to build student problem-solving skills. The authors found that the use of the computer, as a medium for instruction, provides many learning capabilities that cannot be readily duplicated within the traditional lecture format. Computer animation presents engineering course concepts in three dimensional formats, making illustration easier.

In a more recent study on the use of multimedia to facilitate learning, Marek and Aleksander (2005), expounded that the teaching of manufacturing processes in the department of mechanical engineering are very complex and difficult to explain. In this type of situation, where the teaching is impaired, learning

becomes almost unattainable. The duo found the use of computer animation and simulation as a teaching aid, a more effective instructional strategy compared to the use of only the traditional teaching approach. They suggested that the lecture duration be reduced and found the students' performance improved by about 15%. In addition, they are of the opinion that animation helps to convey the intuition behind the phenomena, by permitting the presentation of complex processes, without the need of mathematical equations.

The studies by Hubing et al. (2002) as well as Marek and Aleksander (2005) are similar in approach. Though concept animation might have helped the students to overcome the abstract learning of the mechanics of materials course presented. Perhaps, the result would have been better, if the learning strategy was presented in a constructionist approach as was done in CCAIML learning model. Papert (1993) suggested that computer instructional aids should be used to support both mental and physical knowledge construction that can be discussed or criticized by colleagues.

Cleghorn and Dhariwal (2010) proposed and tried out the Multimedia Enhanced Electronic Teaching System (MEETS). According to Cleghorn and Dhariwal, MEETS has proved effective in the teaching of large core mechanical engineering undergraduate modules. MEETS uses two high definition document cameras, to project hand written notes, illustrate mechanical drawings as they are created, and demonstrate small mechanical systems. The advantage of this method over the previous traditional teaching and learning approach employed at the university the pair is associated with is that MEETS uses the advantage of a personal computer to facilitate the use of the conventional transparency role.

Comments from some of the students who participated in the study revealed that this instructional approach was preferred, because it assisted with conceptualizing and learning the mechanical engineering core modules with greater ease (Cleghorn and Dhariwal, 2010). The mechanical engineering

department of the university, where the study was carried out, has since adopted MEETS as its instructional method for teaching large classes (Cleghorn and Dhariwal, 2010). However, the researcher of this current study is of the opinion that the MEETS project was not fully evaluated. The study should have reported on the empirical facts elucidating to what extent MEETS has impacted students' learning, knowledge construction and performance in the examination.

The instructional aids used in the study by Cleghorn & Dhariwal (2010) only help to enlarge the lecturer's prepared notes. It facilitated lecturer's note copying but not directly learning. A better teaching and learning approach is needed to teach large classes aimed at by Cleghorn and Dhariwal. The CCAIML learning model is structured to meet the leaning needs of both small and large classes.

There are some schools of thought, that believe that spatial skills are imperative to engineering studies. One of the studies from these groups is that by Gerson, Sorby, Wysocki and Baartmans (2001) where they noted the importance of well-developed three dimensional spatial skills in scientific and technical careers, particularly in engineering classes (see also Maier, 1984; Smith, 1964). Therefore, Gerson et al., attempted to develop the spatial skills of engineering students through multimedia software. Students learn through the software and the workbook provided. The software proved effective in enhancing students' ability to view objects and instructions from a three dimensional point of view.

There is another group of engineering education researchers, for example, Rose and Meyer (2002) and Behrunann (2001), who belong to the school of thought, which favours that the curriculum be manipulated to facilitate learning. This group of thought explored the concept of Universal Design for Learning (UDL) to develop an interactive curriculum, which facilitates individual student learning. UDL is a theoretical framework that guides the development of curricular, which meets the needs of all students. One of the applications of UDL is the development of accessible interactive curriculum materials. Each learner can

manipulate and scaffold these learning materials based on the learners' individual need and cognitive style. In addition, Abel (2006) suggested that integrative technology, such as; digital text and hyperlinked glossaries could be added to the scaffolds to meet the students' learning styles. According to Abel, these aids will assist in meeting the needs of students' broader ability levels, while simultaneously addressing and engaging students' individual approach to learning.

A year later, Behrunann (2001) advocated the use of an instructional curriculum and material, in electronic format to meet students' individual learning styles. The focus here is not the curriculum itself, but rather the digital display of the curriculum. In this way, the curriculum can be altered through scaffolding as well as customized to meet the individual student's preferred approach to learning and unique ability level. Behrunann pointed out that with curriculum digital display, students can view and engage the curriculum content in a way that may not be possible with textbooks.

In all the studies reviewed above, in the researcher's view, the multimedia used were not properly applied to harness the full advantage of the technology. Much more efforts were been directed to helping students to acquire knowledge but not to help students construct or discover knowledge, as is the case with CCAIML learning model. Hence a study involving the CCAIML was pursued.

3.2 THE USE OF INNOVATIVE LEARNING THEORIES TO FACILITATE LEARNING

Some schools of thought, such as Cleghorn & Dhariwal (2010), that turn to modern technology for solutions to the emanating recent problems in the learning of engineering modules. Others concentrate on improving the existing learning and instructional theories to fit the present day situations in engineering classrooms, examples of which are presented below.

Taraban, Anderson, Definis, Brown, Weigold and Sharma (2007) built on prior research studies undertaken by Taraban, Hayes, Anderson and Sharma (2004 and 2005), which reported that students devoted more of their study time to developing problem-solving skills to the detriment of increasing conceptual knowledge. Taraban et al., believe that learning in a rich learning environment, in which students learn from visual, auditory and printed environments and solving problems using instructional software, promotes learning. Taraban et al. (2007) claim that “these kinds of learning materials were consistent with theories of skill development, which demand that students be provided with relevant factual knowledge and the means to transform that knowledge into skill through applications to problems”.

Among other findings from the study by Taraban et al. (2007), it became clear that students demonstrated striking individual differences in the way and extent every individual cognitively employs each of the learning materials. This finding corroborates the claim by Dwyer (2010) that engineering students learn in four different ways: verbal learning, visual learning, active learning and reflective learning. These four ways are termed a *rich learning environment* by Taraban et al. (2007). However, as against the core motive of Taraban et al. (2007), to provide the students with relevant factual knowledge, the CCAIML learning model encourages and motivates students to construct and discover their own knowledge.

Felder (1995) reported that one way of increasing active teaching time is by giving students more exercises; thus encouraging greater participation from students. Based on this claim She and Looney (2010) introduced a learning strategy to facilitate students’ active learning in mechanical engineering in the strength of material module. The new learning strategy, which is meant to facilitate active learning, involves mixing lecture and tutorial classes in a single

lecture time. The first 20 minutes of the two-hour lecture time is to be spent on lecturing, while the remaining 100 minutes were allocated to tutorials.

She and Looney elaborated that the lecture session instructional strategy was to encourage students' participation by questioning students, who in turn could pose questions of their own. The tutorial sessions involve grouping students into units of 3 or 4; who then attempt to solve tutorial questions step-by-step as a group. Group work encourages students to develop team skills, simultaneously building cooperative learning skills. According to She and Looney, students prefer this learning approach to the traditional lecturing and tutorial classes.

Cole and Spence (2010) showed how the challenges confronted in teaching a large first-year fluid mechanics course were overcome and how students' engagement in the classroom was encouraged. Cole and Spence proposed that normal traditional teaching be interspersed with active learning. This learning approach involves giving students short questions/puzzles to work out, with the aim of involving and promoting both thinking and learning skills during the lecturing process. Throughout the tutorials, students are divided into smaller groups of about 25 - 30 students; each tutorial class ends with a 10-minute test. The marks obtained from the test contribute 20% towards the final course mark. This approach proved successful.

The above described teaching approach is very similar to Skinner's *S-R Operant Conditioning* learning theory. The assessment was designed to encourage and maintain the students' involvement with the course. The students' target (response) was to perform very well in the test (stimulus) (see subsection 2.1.2.3).

Race (2006), stated that only 20% of students in mathematics lectures, actually follow what the lecturer is saying. Most students are simply copying notes. If this information is true, Dearn et al. (2010) argue that it is probably also true of

lectures in engineering classes. This means that standard lectures in mechanical engineering classes are relatively inefficient means of transferring knowledge. Thus, the best method of learning is to teach yourself (Carlson and Sullivan, 1999).

In view of the above and looking at the learning problems associated with large classes as well as the recent modularization in engineering courses, Dearn et al. (2010) developed a self-learning system called Student Centred Learning Groups (SCLG). SCLG involve giving specially prepared learning packages to students, dividing the students into groups, encouraging the students in each group to teach each other, while the department offers only tutorial classes to all students collectively. According to Dearn et al. the feedback from students revealed that this learning approach was favoured.

Brose and Kautz (2010) looked at changes in the instructional setting in engineering classes. The duo proposed that active learning techniques be combined with instructional materials developed on the basis of students' specific misconceptions and misunderstandings, in order to address these issues. The study entails identifying students' misconceptions and misunderstandings, developing worksheets that contain all the misconceptions and misunderstandings gathered from the students and lastly utilizing the worksheets in the collaborative group tutorials. Brose and Kautz are of the opinion that the use of the new learning material, in an active learning environment, showed signs of significantly improving student outcomes.

Joy and Dunne (2010) presented an interactive teaching method to the learning of Bioengineering and Biomaterials engineering modules, as opposed to the traditional approach that involve presentation of lectures; tutorials which are based on question sheets; and a standard examination that carries 100%. The new interactive teaching approach includes dividing the students into small groups. The students learn by practically handling and examining models of

human joints in their respective groups. The lecturer only acts as a facilitator. The lecturer allows peer learning within an encouraging and non-hierarchical setting (Kahn & Walsh, 2006). The assessment drive is project based rather than examination based. De Graaff and Kolmos (2007) informs that project based learning encourages deep learning rather than superficial learning. They also claim that the teaching approach introduced, facilitated the learning of bioengineering and biomaterials modules.

Campos and Queiroz (2010) proposed a student centred competence based learning. This, according to Campos and Queiroz, involves dividing the students into groups; each group is given a project to comprehend, critically analyze and suggest ways of improving such a project. They claimed that this learning approach, has impacted positively on the students' learning.

Adding to the list of suggested learning strategies in engineering classes, Petruska (2010) presents a Problem Based Learning (PBL) curriculum. This idea manifested when Petruska realized that the university was producing graduates who are incompetent in their various engineering careers. Prior to this innovative learning model, engineering students in the university where Petruska carried out his study, were taught through the traditional lecture presentation. Petruska believes that engineering students should learn through *learning by doing* and not *learning by hearing* only. Furthermore, engineering students should learn from specific complex tasks and not only from specific knowledge bulk. PBL leads students to apply the knowledge acquired to other situations outside the classroom environment. The PBL features learning as:

- student centred learning;
- learning occurs in small student groups and promotes collaborative learning;

- the lecturer is seen as a guide;
- a problem is seen as a vehicle for developing problem solving skills; and
- new information is acquired through self-directed learning.

Petruska is of the opinion that this learning approach has so far led to a deep change of the traditional view, where:

- the role of the lecturer was seen as an instructing authority;
- the student was perceived as a passive vessel to be filled; and
- education was regarded as a pre-fabricated process with a small proportion of individual creative contribution on both sides.

However, the efforts of engineering education researchers, some of which are discussed above, to facilitate learning of engineering modules, and improve the competency of engineering graduates to meet the standard of the industrial demands, are still lacking an instructional strategy. Such a strategy should proffer solutions to the multifaceted problems ravaging engineering education globally.

The CCAIML proposed in this study for the teaching of first year fluid mechanics module in mechanical engineering classes is pivoted on the ideas that engineering study should be characterized by *learning through doing* and not only *learning by hearing* (Petruska, 2010). In addition, it should be characterized by constructing knowledge that can be seen and critiqued to aid mental knowledge construction (Papert, 1993) with the help of modern technological learning aids. Engineering education, being more of a practical application of

theoretical concepts, should harness the potential of modern technology in knowledge construction (Mayer & Moreno, 2002).

CHAPTER 4

METHODOLOGY

This chapter discusses the research design, sampling, instrumentation, data collection procedures, and ethical issues.

4.1 RESEARCH DESIGN

The researcher carried out the study in two phases: the baseline study, which was conducted to provide data on how fluid mechanics was usually taught, and the main study. The baseline study followed a descriptive survey design, which involved classroom visits. The results of the analysis of data gleaned from the baseline study were used as guides in the main study (see subsection 5.2.1).

4.1.1 Baseline study

The aim of the baseline study was to investigate how fluid mechanics is normally taught in mechanical engineering classes in some South African universities and its implication on learning. This was to provide a proper footing for the main study.

At the onset of the baseline study, consultations were held with some of the lecturers in the field of engineering in most of the South African universities. There are 16 universities in the country, including the Universities of Technology. The researcher visited the mechanical engineering departments of the 16 universities and had consultations with the lecturers of fluid mechanics in each of them. From the various consultations held, the researcher gathered the following information:

- The fluid mechanics, apart from being a principal module in some of the engineering courses, it is one of the most difficult for engineering students.
- The curriculum of the Universities of Technology is structured to be more practically orientated compared to the traditional universities offering Bachelor of Engineering (B.Eng.) degrees.
- More students register for fluid mechanics module in mechanical engineering compared to other fields of engineering.

Based on the above information the baseline study was redirected to focus on the learning of fluid mechanics in mechanical engineering classes offering B.Eng. degrees. Only eight universities offer B.Eng. degrees in mechanical engineering, hence, the baseline study was carried out in those eight universities.

As previously mentioned in subsection 4.1, the baseline study followed a descriptive research design. The results of the analysis of the data gleaned from the baseline study were presented in conjunction with the results of the analysis of the data gleaned from the main study in chapter five.

4.1.2 Main study

The main study followed a mixed methods approach; involving a static group design (Washington, Parnianpour & Fraser, 1999) and a descriptive survey design. The mixed method approach combines the quantitative and qualitative methods of data collection and analysis, while the descriptive research design involves observing and describing the behavior of a subject without influencing it in any way. The former approach was meant to contrast the use of an Animated Computer Instructional Aid (ACIA) in a CCAIML learning environment, in enhancing students' achievements in the theoretical and practical applications of

fluid mechanics in the mechanical engineering classes, as opposed to the traditional method. This study was made up of both experimental and control groups:

- The experimental group consisted of nonrandomized mechanical engineering students, who used ACIA in their fluid mechanics' classes in CCAIML learning environment.
- The control group, comprised two consecutive, immediately preceding mechanical engineering student groups, who were taught fluid mechanics through the traditional lecturing method, which entailed static two-dimensional PowerPoint presentations, chalk and talk instructional approach, or, as was the case in some classes, a combination of both.

All the groups were taught the same material by the same lecturer in each of the participating universities. However, it is very important to note that in South Africa, the higher education curriculum review period, is a cycle of three years (Higher Education Quality Committee (HEQC), 2004). Therefore, the researcher had to ensure that the study was completed within a curriculum review cycle in each of the participating universities; thus, the motivation to use the immediately preceding two groups, within the curriculum review cycle, as control. In addition, the researcher considered a static group design appropriate for this study, mainly because the study was based at universities and not ordinary schools. Each university is autonomous and has its own practices, culture, rules and processes as well as distinctive curriculum and administrative arrangements. Cluster universities that offer the theoretical and practical applications of fluid mechanics as part of the mechanical engineering degree, could not be incorporated into the control and treatment groups. Instead, each of these universities was looked at individually; hence, the researcher's referral terminology to these as "cases".

The descriptive survey design, in the main study, entailed the use of open-ended questionnaires (see Appendix 4), and classroom observation checklist (see Appendix 5). The data obtained in this regard, presented details that helped to account for the test scores and provided an indication regarding the views of the participants about CCAIML and the way in which ACIA was used in the fluid mechanics' classes. However, the questionnaire, and classroom observation produced similar data; these supplied the researcher with convergent data validity.

4.2 SAMPLING

There are eight (8) universities in South Africa that have built the theoretical and practical applications of fluid mechanics into their curriculum for a degree in mechanical engineering. Since the study was intended to investigate the use of ACIA to teach and learn the theoretical and practical applications of fluid mechanics in CCAIML learning environment, the researcher requested all the universities to participate in the study. Only four universities were willing to participate and later the number dwindled to three, because the fourth university did not keep up with the schedule and was unable to perform research activities on the prescribed dates, though the few data collected on the fourth institution that dropped out is also reported. Nevertheless, the quality of the study was not compromised, given the type of its design (see section 4.1) combined with the fact that sufficient necessary data could still be gathered from the three remaining universities.

4.3 INSTRUMENTATION

The following instruments were used in this study:

- (i) Animated computer instructional aid (ACIA) package.
- (ii) Questionnaire.
- (iii) Classroom Test.

- (iv) End-of-semester examination paper (Post-test).
- (v) Past examination result.
- (vi) Classroom observation checklist.

4.3.1 Animated computer instructional aid package (ACIA)

4.3.1.1 Background

ACIA was used as an intervention instrument in this study. It was developed to assist the lecturers in illustrating the basic fluid mechanics' concepts more effectively and in their original 3-dimensional form with the aid of moving video clips: as if they were real-life situations. The ACIA contents covered major fluid mechanics' topics designed for learners who were studying fluid mechanics, as a subject, for the first time (see Appendix 12).

Since the study participants were first time fluid mechanics students, it was assumed that animating the fluid mechanics' basic concepts would help them to construct a learning framework, into which all other advanced fluid mechanics concepts could fit (Piaget, 1967). In addition, the choice of including "basic concepts of fluid mechanics" as the topics covered in the ACIA was to avoid the differences that could have arisen from the non-uniform fluid mechanics curricula across the four case studies. The basic fluid mechanics concepts, treated in ACIA, were topics that must be taught to first time fluid mechanics learners; hence, the tuition, in the fluid mechanics classes, of the four case studies.

Furthermore, flash programming was considered in developing ACIA; but it was discovered from the baseline study that lecturers involved in the study, used non-interactive Microsoft PowerPoint slides, to present their lecture notes. In addition, lecturers preferred ACIA to be prepared in Microsoft PowerPoint, so it would be easier, to integrate ACIA into lecture notes and if found useful, hoped

to continue with it. Based on these premises, ACIA was prepared in a Microsoft PowerPoint slideshow presentation.

4.3.1.2 Development of ACIA

ACIA was developed with the aid of Microsoft PowerPoint and animated photo clips. The animated photo clips, which were extracted from "Multimedia Fluid Mechanics" CD-Rom (Cambridge University Press) (permission duly sort and granted, see section 4.6 and Appendix 2), were infused into the Microsoft PowerPoint slides. At the top of ACIA, active buttons are provided to facilitate the navigation.

- Each new screen contained the same navigation structure and basic principle of interaction as the previous one. The motivation behind this was to provide a uniformity throughout the consecutive windows and stay with the on-screen constituents (for example, buttons or switches).
- Each concept was explained in writing and illustrated using photo clips. To view the interactive photo clips, one needed to click on the highlighted words, on the same page, explaining the concept.
- A photo clip window would pop up; this window had its own active buttons and switches to navigate it.
- When the play button in the pop-up window is clicked, it activate the photo clip that gives a moving illustration of the concept in question.
- The duration of each clip varied.
- While playing, it may be paused, stopped or restarted from the beginning.

- Each window may be repeated as many times as necessary.
- The photo clip window may be viewed in a larger window, by choosing a view button and selecting the view size required.
- To exit the photo clip window, one may click on the exit button at the right hand corner of the photo clip window, or navigate to the file icon at the top of the pop-up window and select exit.
- This selection would exit the pop-up window and go back to the initial screen.

The ACIA contains operational instructions, which will facilitate the use of the CD. In the instructions, the need for a QuickTime Player on the computer, on which the participants might want to play the ACIA's CD, was stressed. Hence, the ACIA's CD contains QuickTime Installer. Furthermore, study participants were warned that the ACIA does not replace the lecturer's note or lecture attendance.

4.3.1.3 Validity of ACIA as an intervention instrument

The ACIA, which is an intervention instrument, was content validated. To carry out content validation on an instrument, both sampling validity and item validity were determined. Sampling validity refers to how well the measuring instrument covered the content to be assessed; while item validity refers to the relevance and appropriateness of the instrument items to measure the content area to be assessed.

Therefore, ACIA was validated, by:

- Considering the extent to which the topics treated, covered the basic concepts of fluid mechanics (sampling validity).

- Considering the relevancy of each topic with the curriculum of the first-time learners of fluid mechanics in mechanical engineering (3rd year students).
- The relevance and appropriateness of the illustrations and definitions given in the package (item validity).

In view of the foregoing, the researcher prepared a validity-rating form (see Appendix 7). This form was distributed to ten selected judges; who were Fluid Mechanics lecturers, in different universities, in either Applied Mathematics or Engineering, to judge the instrument. The form consisted of three parts:

- The first part, introduced the project and rating tasks, to the selected judges.
- The second part, labelled Part A rated the extent, to which the topics treated in ACIA, covered the fluid mechanics basic concepts, expected to be learnt by first-time students of fluid mechanics.
- The third part was concerned with rating the relevance of each topic treated, to the curriculum of the first time students of fluid mechanics and the appropriateness of the illustrations and definitions given in ACIA.

Once the validity-rating forms were returned, the judging results were examined as it was done in Li et al., (2008). In Part A, there were three covered levels:

- 1 = not well covered;
- 2 = somewhat covered;
- 3 = very well covered.

The judging results provided 86.7 percent coverage. In light of the results, the interpretation was that more than three quarters of the judges rated the topics

treated in ACIA, between somewhat covered to very well covered fluid mechanics basic concepts, expected to be studied by first-time students of fluid mechanics as a module. In addition, on grounds of result suggestions, made by the judges, two new topics were added to the content of ACIA.

In Part B, there were three relevance levels:

- 1 = not relevant/low relevance;
- 2 = somewhat relevant;
- 3 = highly relevant.

Topics with a relevance ≥ 66.7 percent (this implies that 66.7 percent or more of the judges awarded a rating to the topic as somewhat relevant or highly relevant to the scheme of work for first time learners of fluid mechanics), were included among the final contents of ACIA.

In addition part B also had three appropriateness levels:

- 1 = not appropriate;
- 2 = somewhat appropriate;
- 3 = very appropriate.

The definitions and/or illustrations with appropriateness mean score ≤ 2 implied that the judges felt that the definitions or illustrations were not appropriate or somewhat appropriate. Many of the definitions and illustrations had a mean equal to or below 2. The affected definitions and illustrations were restructured, while some illustrations were replaced. For example, the animated illustration for 'Pathlines', was replaced as suggested by six of the judges.

4.3.1.4 Reliability of ACIA

The internal consistency reliability of ACIA had to be considered. This involved consistency of objectives among the ACIA contents as well as the matching of

these objectives with the content objectives of the fluid mechanics modules under review. Inter-judges reliability test was carried out on the instrument. Three of the judges who participated in the validating process of ACIA, were asked to help with the reliability evaluation of the instrument. A reliability coefficient of 0.79 was obtained by calculating the scores agreement percentage. This implied that the judges rated the ACIA content reliable.

4.3.2 Questionnaire

A questionnaire is a collection of questions which all the research participants are asked to respond to (Gay, 2003). These questions should be clear, concise, and straight-forward, in the simplest possible language. The arrangement of the questions should be in a logical sequence, such that the respondents are led through a subject area without a break in the train of thought. Lemon (1973:66) suggests that the general principle governing the order, in which questions are asked in a questionnaire, is that the respondent should be led through the area to be answered, in a coherent way. The questions are in the form of statements; these statements are known as items.

In this study, this instrument was used to gather data on the feelings of the study participants on the learning in CCAIML environment and using ACIA as a learning aid. As mentioned in subsection 4.1.2, this was meant to corroborate data from the other method of data gathering in this study.

In the development of the questionnaire items, a two-in-one (double-barrel) statements should be avoided. Likert in Fishbein (1967:90) warns that none of the questionnaire statements should involve double negatives or other wordings that will make them confusing. Dividing any double-barrel statement into two, is preferable. If a statement is double-barrelled, a respondent may want to react favourably to one part and unfavourably to the other part, leaving the respondent confused about how to respond to such items.

Questionnaires may be administered through mail, e-mail, telephone, or self-administration. In a self-administered questionnaire, the researcher has the opportunity to explain any unclear items. Moreover, the self-administered questionnaires guarantee a higher return rate compared to other methods of questionnaires' administration, because the researcher will be available to collect the questionnaires as soon as the respondents have completed them. In research it is generally accepted that the more the data, the more reliable the result. Therefore, in data collection, the self-administered questionnaires' method is more efficient, especially when the respondents are close at hand.

A questionnaire in the form of a 5-point Likert type scale was used to collect data. Each respondent was expected to indicate the extent of his/her agreement to an item. For example, a respondent may be asked if he/she:

"strongly agrees" = 5,

"agrees" = 4,

"is undecided" = 3,

"disagrees" = 2, or

"strongly disagrees" = 1.

Each of the agreement levels carried a weight ranging from 5 = strongly agrees to 1 = strongly disagree for a positive statement and 1 = strongly agrees to 5 = strongly disagree for a negative statement.

In this study, a questionnaire was used to collect data on the participants' perspectives toward the use of ACIA as a learning aid in the fluid mechanics module, used in carrying out this study. To this end, there was a need to collect responses from every study participant. Questionnaires are comparatively better instruments to use in achieving this goal, more so, because the respondents, in each of the case studies, were all together in one class. The questionnaires were

administered during the lecture period and were collected at the end of the lecture.

4.3.2.1 Items generation

To design a good instrument that will measure the participants' perspectives toward the use of ACIA, as a teaching and learning aid, in the fluid mechanics module used in carrying out this study, a thorough literature review in the relevant area was carried out. Based on the literature review and in view of the research questions, the questionnaire items were generated.

4.3.2.2 Validity of the questionnaire instrument

The questionnaire was constructed by the researcher and thus the need to validate it. The content validity-rating form used by Li et al. (2008), was adapted and used to validate the questionnaire. Ten judges were selected from the field of education as well as science education and statistics, to validate the questionnaire. The judges were to report on the "Sureness" and "Relevance" of each item.

There were three "Sureness" levels:

- 1 = not very sure;
- 2 = pretty sure;
- 3 = very sure.

There were also three "Relevance" levels:

- 1 = low/not relevant;
- 2 = somewhat relevant;
- 3 = very relevant.

Analysing the responses from the judges, items with a "Sureness" mean score ≥ 2 (implied the judges were, at least, "pretty sure" about the item) and the "Relevance" mean score $\geq 66\%$ (was interpreted as; most judges rated the item "somewhat" or "very relevant" to what it was intended to measure), were retained.

4.3.2.3 Factor analysis

During the rating process, some items were taken out, while a few were added, as suggested by the judges. Therefore, the instrument had 18 items at the end of the rating process. These eighteen variables were identified from the 18 items. The 18 variables in one instrument are a fairly large number to contend with, in data analysis, of only one research. Factor analysis was performed, to remove redundant information or variables that did not contribute to the dimension of the questionnaire and to represent the original variables with a smaller set of derived variables, called factors. The derived factors contained virtually all the information inherent in the original larger variables.

From the original instrument, 18 variables were identified. Data were generated for the factor analysis, by giving ACIA software to 10 final year mechanical engineering students, to use for one week and thereafter, they were asked to respond to the questionnaires. Data generated from this exercise were used to compute the original data matrix.

The original data matrix was used to compute the matrix of correlations among the variables. Factor extraction was carried out by grouping together the variables that were highly correlated among each other, but lowly correlated with other variables. This exercise resulted in a three-factor solution. The eigenvalue for each extracted factor was computed, as suggested by Kaiser (1991), see the Appendix 11. Once again it was observed that the communities for the variables as a whole, were between 0 and 1. This implied that the

variables were moderately correlated with each other, as suggested by Thompson & Zamboanga (2004).

Finally, variables with a loading of at least 0.4 on the relevant factor and a loading not higher than any other factor, were retained for the revised instrument as done in Li et al., (2008). The revised instrument had 15 items. See table 4.1 below, for the rotated component matrix and table 4.2, gives the communalities of the items.

Table 4.1: Factor analysis (rotated component matrix)

	Component		
	Learning facilitation	Interest Perception	Navigation
Q1. The software is not difficult to comprehend.	.148	.025	<u>.834</u>
Q2. I found the software easy to navigate.	.006	.278	<u>.721</u>
Q3. I have easy access to the software.	.106	.132	<u>.853</u>
Q4. It provides better visualisation than explanation on paper.	.042	.483	<u>.518</u>
Q5. It presents a clearer presentation of fluid mechanics basic concepts in 3-D.	.192	<u>.815</u>	.199
Q6. The animation of basic fluid mechanics concepts contained in the software...dimension to my learning of fluid mechanics.	.229	.230	<u>.511</u>
Q7. It helps me to visualize the fluid mechanics basic concepts in its 3-D form.	.172	<u>.851</u>	.199
Q8. It helps to reinforce an understanding of fluid mechanics topics.	.247	<u>.692</u>	.363
Q9. The animated movies make me to be more interested in fluid mechanics.	.518	<u>.576</u>	.030
Q10. I understand the fluid mechanics concepts in illustrative movies better than reading from textbooks or lecture notes.	<u>.642</u>	.138	.097
Q11. The software is a good learning aid.	<u>.665</u>	.252	.177
Q12. The animated movies were fascinating.	<u>.865</u>	.048	.117
Q13. I think the time spent using the software was a worthwhile use of my study time.	<u>.784</u>	.342	.032
Q14. I enjoy using the software.	<u>.884</u>	.033	.026
Q15. The software is educating.	<u>.834</u>	.211	.254

Table 4.2: Factor analysis communalities

	Initial	Extraction
Q1. The software is not difficult to comprehend.	1.000	.718
Q2. I found the software easy to navigate.	1.000	.596
Q3. I have easy access to the software.	1.000	.756
Q4. It provides better visualisation than explanation on paper.	1.000	.504
Q5. It presents a clearer presentation of fluid mechanics basic concepts in 3-D.	1.000	.740
Q6. The animation of basic fluid mechanics concepts contained in the software...dimension to my learning of fluid mechanics.	1.000	.366
Q7. It helps me to visualize the fluid mechanics basic concepts in its 3-D form.	1.000	.794
Q8. It helps to reinforce an understanding of fluid mechanics topics.	1.000	.672
Q9. The animated movies make me to be more interested in fluid mechanics.	1.000	.602
Q10. I understand the fluid mechanics concepts in illustrative movies better than reading from textbooks or lecture notes.	1.000	.441
Q11. The software is a good learning aid.	1.000	.537
Q12. The animated movies were fascinating.	1.000	.764
Q13. I think the time spent using the software was a worthwhile use of my study time.	1.000	.733
Q14. I enjoy using the software.	1.000	.783
Q15. The software is educating.	1.000	.805

The three factors that emerged were used to measure different components of the study, as discussed below.

A. Learning Facilitation Scale

This scale was used to measure the learning facilitation component of the study. The subset of the questionnaire items that made up this scale were q₁₀, q₁₁, q₁₂, q₁₃, q₁₄, and q₁₅ (the reader should note that small letter, 'q', was used to indicate questionnaire items, while capital letter, 'Q', was used to indicate research questions). A high score rating indicated that the study participants perceived that the use of the software facilitated the learning of fluid mechanics. The reliability analysis for this scale showed that the Cronbach's alpha was 0.88. This indicated a high homogeneity among item responses.

B. Interest Scale

This scale was used to measure the interest component of the study. The subset of the questionnaire items that made up this scale were q₅, q₇, q₈, and q₉. A high score rating indicated that the study participants perceived that the use of the software arouse their interest in the learning of fluid mechanics. The reliability analysis for this scale showed that the Cronbach's alpha was 0.65. This indicated that the item responses were homogeneous.

B. Navigation Scale

This scale was used to measure the software navigation component of the study. The subset of the questionnaire items that made up this scale were q₁, q₂, q₃, q₄ and q₆. A high score rating indicated that the study participants agreed that it was not difficult to navigate: to move from one section of the software to another, or even use the software. This component was used to ensure easy and itch free navigation of the software. It was included to ensure that the study participants were not hindered in any way while using the software during the intervention. The reliability analysis for this scale showed that the Cronbach's alpha was 0.76. This indicated that the item responses were homogeneous.

4.3.2.4 Reliability of the questionnaire instrument

The reliability of the three scales derived from the revised questionnaire that were explain above were calculated using Cronbach alpha as given above. However the researcher still calculated the reliability of the whole revised questionnaire items, put together, as explained below:

Since it was a prerequisite for the questionnaire respondents to have used the ACIA software for at least one week before answering the questionnaire successfully, the Split-half method of testing reliability was considered the best option to certify the level of reliability of the questionnaire. It involved breaking the instrument in half.

The 15 items on the revised list were divided in half, with eight odd numbered in one half and the other seven even numbered items in the other. The two half instruments were administered at two different times to 10 respondents; they were the same set of students, who were previously engaged to assess the validity of the instrument. Each of the two item sets, were treated as a separate scale and the two different scores were correlated. The coefficient of reliability was calculated, according to Rulon's formula (William & Zimmerman, 1968) as 0.69.

4.3.3 Classroom knowledge test instrument

According to Alias (2005), an assessment test involves systematic gathering of evidence to judge students' demonstration of learning. It may be in the area of cognitive, affective or psychomotor learning domain. The cognitive learning domain assessment comprises activities, such as, memorizing, interpreting, applying knowledge, solving problems, and critical thinking. The affective learning domain involves feeling, attitudes, values, interests and emotions. The

psychomotor learning domain includes physical activities and actions, in which students must manipulate objects, such as, pencils or a computer mouse.

An educator may want to know if his or her learners have learned what they were expected to learn, by gathering valid and reliable information through different kinds of assessment test methods. The learning domain that the educator is interested in will dictate the kind of assessment test method to be used.

In this study, there was a need to measure the level of understanding attained, in the learning of fluid mechanics module used in carrying out this study, as a result of the use of ACIA in a CCAIML learning environment, as a teaching and learning aid. To this end, a cognitive assessment test was administered in the form of a classroom test. For the purpose of this study, a classroom test refers to a set of questions that was specifically designed, by the study participant fluid mechanic lecturers, to measure the level of understanding attained in the module under review by the students.

4.3.3.1 Development of classroom knowledge test

The researcher and module's lecturers jointly developed the classroom test items (questions) used in each case study. The classroom test comprised supply-items (essay type questions). The aim of using this type of method was to assess the ability of the students to present their skills, thoughts and ideas, gained after an exposure to ACIA, as a teaching aid in the lecture room in a CCAIML learning environment, tutorial class and during individual studies. Furthermore, the test was aimed at determining their ability to apply the skills gained to real-life situations, which were neither discussed in the textbooks nor in the classroom during lectures.

To ensure that the objectives to be tested were adequately covered, a table of specifications, which is a two-way table with the cognitive emphasis on the first row and contents in the first column (Alias, 2005), was constructed. It matched the contents the lecturer had taught with the level at which he or she expected the students to perform.

Table 4.3: Table of specification for a one-hour knowledge test on fluid mechanics

Topic: Flow Patterns	Cognitive Emphasis		
Content	Comprehension	Application	Total
1. Name and define	4	6	10
2. Describe the nature of the flow pattern	4	6	10
3. Problem solving	8	12	20
Total (Cognitive Emphasis)	16	24	40

Table 4, above, guided the construction of the test items. The language used in the construction of each item, was simple and non-ambiguous. Three essay-type items were constructed in each case study.

4.3.3.2 Validity of classroom knowledge test

The validity of a test depends on whether the information obtained from the test permits the lecturer to make an appropriate decision about how successful a student's learning activity was (Airasian, 2005). A valid test, measures to a large extent, what it is supposed to measure. A valid mathematics test should measure the students' ability in mathematics; not their grammatical or reading ability.

According to Alias (2005) there are two validity tests that are most common to classroom tests: face validity and content validity. Face validity is a rudimentary type of validation; it gives the notion that a classroom test appears to measure what it is supposed to measure. Content validity involves affirmation from experts that the test contents cover the test objectives, which in turn are a representation of the syllabus.

In this study, the classroom test validation was achieved in two stages. The first dealt with the test construct. The table of specification that was prepared listed what was taught and how many items on a test would cover those topics to ensure that the test measured what it was supposed to measure. The second stage was validity testing. Colleagues from the same department, teaching other fluid mechanics modules, different from the module used in carrying out this study, taught by each lecturer; scrutinized the test to render a second opinion. The lecturer's colleagues checked if the class test covered the test objectives; in view of the objectives of the module's curriculum. This was also in line with the HEQC (see subsection 4.1.2) policy in South Africa, which stipulates that every higher education institute must have effective procedures, which facilitate the quality of the internal and external moderation of its assessment procedures and results, in order to ensure their validity and reliability.

4.3.3.3 Reliability of classroom knowledge test

The reliability of a test instrument is a measure of the consistency of the test in measuring what it is supposed to measure. A reliable, consistent test instrument that measures a student's achievement should not in any way be influenced by factors, such as, whether the test was taken in the morning or afternoon, one day or the next.

Black (1999) informs that there are three types of reliability that are most common to a classroom test: internal consistency, inter-scorer reliability, and intra-scorer reliability.

- Internal consistency refers to the consistency of objectives among the items of a test.
- Inter-scorer reliability refers to the consistency between the marks given by different lecturers.
- Intra-scorer reliability is the measure of consistency in the marks given by the same lecturer on different occasions.

The reliability of the classroom test was assessed using the intra-scorer reliability method. The 10 final year mechanical engineering students, who were used in the process of validating the questionnaire and who had already taken the module used in carrying out this study in the past, were asked to take this test. The same test was administered twice (T_1 , T_2): T_2 was administered 2 weeks after T_1 . The reliability of the test was determined by the correlation between scores of T_1 and T_2 . A reliability coefficient of 0.76 was obtained.

4.3.4 End-of-semester examination paper

The end-of-semester examination paper, was used to measure the achievement attained by each of the study participants. The results were attributed to the use of ACIA in a CCAIML learning environment, as a learning aid in the fluid mechanics module used in carrying out this study in the intervention group.

4.3.4.1 Development of the examination instrument

Each of the lecturers in charge of the fluid mechanics module under review collaborated to set the post-test examination. These lecturers had been teaching and setting this examination for at least three years; hence, all the examination papers in each of the case studies were set in the same format as before.

However, it should be noted that, the fluid mechanics under review was taught together with thermodynamics course as a single module. The two courses were allocated 50% each, to make the 100% examination marks for the module. The marks considered in this study, are the marks the study participants got only in fluid mechanics course. The marks were later converted to percentage.

4.3.4.2 Validity and reliability of the examination instrument

In view of the HEQC policy on assessment (see subsection 4.1.2) second examiners, both internally and externally, were appointed by the departmental authorities. This was necessary to ratify the fluid mechanics post-test questions and to moderate the marked scripts.

4.3.5 Classroom observation checklist

An observation checklist was used to collect data during the classroom observation. A series of classroom visits were carried out in each of the case

studies to ensure the proper use of ACIA in a CCAIML learning environment, in the class and to triangulate the data gleaned from the static group design (see section 4.1.2).

4.3.5.1 Development of observation checklist

The observation checklist instrument developed by Gadsden education was accessed online and modified so that it could be used to collect the required data in this study (see, <http://www.gadsdenstate.edu/ie/faculty/Classroom%20Observation%20Checklist.pdf>).

4.3.5.2 Validity of the observation checklist instrument

The checklist contents needed to meet the objectives for which the instrument was constructed to be able to measure what it was supposed to measure. Hence, the instrument was face validated. The instrument was validated by five experts in the field of education. This exercise resulted in reconstructing some of the instrument items; while other items were removed.

4.3.5.3 Reliability of the observation checklist instrument

Internal consistency reliability was used to measure the reliability of the instrument. This involved the consistency of objectives among the items in the checklist, matching it with the overall objective for constructing the instrument. The same five experts in the field of education, who validated the instrument, were also employed to check its reliability. A reliability value of 0.68 was calculated by finding the scores agreement percentage.

4.3.6 Past examination records

The records of the past-examination-results in the module that was used to carry out the study and which was examined by the same lecturer in the same curriculum content were obtained in each of the case studies. These records were used to show that the achievement attained by the study participants in the post-test was due to the intervention. The immediately preceding two years' examination results records were used for this purpose. The reason for making use of two years' record was stated in section 4.1.2.

Again, as mentioned in subsection 4.3.4.1, the fluid mechanics that was used to carry out this study was taught together with thermodynamics course as a single module. The marks for fluid mechanics, in the past fluid mechanics/thermodynamics examination marks, were extracted and converted to percentage to be appropriate for this study.

4.4 PILOT STUDY

The pilot study is the last and very important stage in the construction of a measuring instrument. Bailey (1987), described this stage as a pretesting point in the construction of a measuring instrument. At this stage, the instrument is tried out on a small scale, in order to identify any unanticipated problems or issues that may compromise the results of the study.

The ACIA, questionnaire, interview and classroom checklist were the instruments used in this study. The pilot study was carried out utilizing mechanical engineering students, who enrolled for fluid mechanics offered by a School of Engineering, attached to a distance teaching model, where contact sessions were held regularly or per arrangement. It was during these contact sessions that the researcher tested the above mentioned instruments. This afforded the

researcher the opportunity to perfect his interview skills and to make necessary modifications on the questionnaire and classroom checklist.

4.4.1 Administration of ACIA and other instruments

The lecturer who participated in the pilot study was given the CD that contained ACIA a week prior to the commencement of the pilot intervention. The lecturer had been presenting his lectures in Microsoft PowerPoint even before the pilot intervention. In preparation, he was able to infuse the necessary parts of the ACIA CD contents into his lecture notes. However, he encountered some problems infusing the animated photo clips of the ACIA, into his lecture notes.

In addition, students were given the ACIA CDs as a learning aid during their private studies. The students were also advised neither to think that the ACIA CD could replace the lecturer's notes nor should it keep them from attending classes; rather the CD should be seen as a supporting medium that could help them understand what was taught in the classroom.

Two classroom observations per month were carried out throughout the semester: that is a period of four months. The classroom observation checklist instrument was used to collect the observed data. During the second classroom visit, students were given questionnaires to complete and the lecturer was interviewed.

4.4.2 Results of the pilot study

Results from the pilot study provided an indication of what would have happened during intervention if the trial study was not conducted. Many unforeseen events that had the ability of compromising or stalling the study out rightly, manifested.

The lecturer initially had a problem with integrating the animated ACIA photo clips into his PowerPoint lecture notes; it took about two weeks for the lecturer and researcher to resolve this problem. Once again, the lecturer discovered that he spent more time than the normal lecturing time, when using ACIA. In addition, the students could not initially use the ACIA CDs given to them, because they did not have the Quick Time application programme, which enables the playing of videos on their computers. The researcher had to retrieve the first set of the ACIA CDs and prepare another set, which included QuickTime, before the students could use the ACIA during their private studies. However, the questionnaire and the classroom checklist instruments were found good enough to generate the required data, but some of the interview items were not appropriate and had to be restructured.

4.4.3 Implications of the pilot study results

Based on the results that emanated from the pilot study, the researcher had to reconsider appropriate means of conducting the intervention. To this end, the researcher met with each of the lecturers (individually) in the three case studies, to discuss the results obtained from the pilot study as well as how best to conduct the intervention in their respective fluid mechanics classes. A solution was reached that each lecturer should receive the ACIA CD at least one month prior to the commencement of the intervention (which was the beginning of the semester). This was to allow the lecturers to perfect the best way to incorporate the software without any hitches and still keep to the expected normal lecturing time.

Furthermore, the ACIA was restructured to include the QuickTime application programme on the CD. The new version was also more fascinating and user friendly as well as easier to navigate. The ultimate aim was to encourage students to use the ACIA package during their private studies.

4.5 DATA COLLECTION

In each case study, the main study intervention started from the beginning of the semester and continued to the end of the semester. In two of the case studies, the intervention came up in the first semester, while it was carried out in the second semester in the remaining one. This was due to the fact that in the latter institution fluid mechanics was only taught in the second semester. This however, did not compromise the study since the participating institutions were considerably far apart. The intervention time was a question of when the module that was used to carry out the study was taken in an academic year in each case study.

The methods of data collection in the three case studies were similar; hence, the general discussion of data collection approaches. Data were collected using questionnaires, a classroom test, end-of-semester-examination (post-test) results, previous examination results, and a classroom observation checklist.

4.5.1 Past examination results

At the onset of the intervention, the researcher collected the immediately preceding two years' examination results in each case study. These data was used to measure the academic achievement of the control groups in each case study.

4.5.2 Classroom observation approach

In all case studies, the intervention lasted for a whole semester. A total of ten classroom observations were conducted in each case study. The classroom visits were not pre-scheduled. The observation checklist was used to collect relevant data. The class visits were also meant to monitor the use of ACIA during lecture times.

4.5.3 Classroom knowledge test

In all the case studies, a mid-semester class-test was normally administered. During the particular academic session when the research was conducted, the mid-semester class test was structured to collect data on whether or not the intervention (ACIA) had any impact on the study participants' understanding of the fluid mechanics module that was used to carry out the study.

The test was administered six weeks from the beginning of the intervention in all the case studies. By this time, the semester lectures were already half-way, most of the basics of fluid mechanics should have been covered and in addition, the lecturer and the study participants were already familiar with the CCAIML environment, in particular the use of ACIA in the learning of fluid mechanics. The duration of the test was one hour. After the test had been written, the study participants' scripts were marked by the lecturer and the results were made available to the researcher.

4.5.4 Questionnaire

The questionnaire was administered four months into the intervention. In each case study, a particular day, which had been announced to all the study participants, was scheduled for completing the questionnaire. The questionnaires were distributed to the study participants, while the lecture was in progress; they completed and returned these to the researcher, before the end of the day's lecture.

4.5.5 Examination

At the end of the semester, which also marked the end of the intervention, an examination was written. The results were made available to the researcher by each of the lecturer.

4.6 Ethical Issues

At the onset of the study, separate official letters were sent to each of the Heads of the Department of Mechanical Engineering in each of the eight universities, which offer B.Eng. degrees in South Africa. A copy of the letter inviting these departments to participate in the study is contained in Appendix 1.

Four universities agreed to participate in the study. Assurance was given that all identities of participating universities, lecturers as well as students would remain confidential.

In addition, the animated photo clips used in developing ACIA were taken from "Multimedia Fluid Mechanics" CD-Rom (Cambridge University Press). Hence, permission to extract and use the photo clips was duly sought and approval was granted by the publisher (see Appendix 2).

CHAPTER 5

DATA ANALYSIS AND PRESENTATION OF RESULTS

In Chapter 4, the description of the research approach and method of data collection were discussed. In this chapter, the techniques for data analysis and the results are presented.

As mentioned in section 4.2 of the study, research was conducted in four distinct case studies. The results are presented, case study by case study, in accordance with the research questions and hypotheses that guided the study. A similar approach was also used in the studies by Mapolelo (2003) and Malone (1996). The presentation of results in each of the case studies starts with the profile of the case study and that includes the profile of the respective fluid mechanics lecturer in each case study, followed by the intervention results. The intervention results include the descriptive statistics, inferential statistics as well as the analysis of the qualitative data.

5.1 DATA ANALYSIS STRATEGIES

As mentioned in subsection 4.1.2, this study followed a mixed methods approach: static group and descriptive survey design. Data from the static group design were analysed through quantitative data analysis techniques, while the data gleaned from the descriptive survey design were analysed using qualitative data analysis techniques.

5.1.1 Quantitative data analysis strategies

The quantitative data collected were captured in SPSS. Exploratory and inferential statistical analysis techniques were used to study descriptive

attributes, performance and perceptual trends, as well as relationships of the data as pertaining to the effect of the intervention programme.

5.1.1.1 Exploratory data analysis strategies

In each of the case studies, exploratory analyses were used in the initial exploratory comparison of the means, standard deviation, skewness, and kurtosis of the performance and perception measurements in both the control and intervention groups. Line plots (Turkey, 1977) were also used to illustrate trends and tendencies in this regard.

5.1.1.2 Inferential data analysis strategies

Inferential statistical analyses were performed on the examination scores (see subsection 4.3.4 for detail) of both the control and intervention groups as well as on the test scores of the intervention groups; including on the surveyed learning facilitation perception data and the interest stimulating perception data. The inferential strategies applied included:

- The Pearson correlation tests were performed on: (1) the interest perception rating and intervention examination marks; and (2) the classroom knowledge tests marks and intervention examination marks. This strategy was followed to establish whether a relationship exist between the interest perception rating and intervention examination marks; and the classroom knowledge tests marks and intervention examination marks. If established, whether the trend pattern of the examination and classroom knowledge test marks agreed or whether they differed in some respect.
- Composite one way frequency tables with associated mean and standard deviation were computed on facilitation of learning perception items; as

well as on interest stimulating perception items of the survey data. The strategy was followed to investigate response patterns (or perception trends) and identify elements within the two perception aspects, which elicited different response patterns (or perception trends) in study participants.

- Scale reliability tests, on the above two perception components of the survey data, to validate the reliability of derived summative perception scores and to act as respondent perception measures of the two components. The internal consistency reliability test of the subset of questionnaire items used was calculated using Cronbach's alpha formula. Alpha coefficient ranges from 0 to 1. A value falling between 0.7 and 1.0 indicates high reliability (Cronbach, 1951; Cronbach, 1990). However, the subset of questionnaire items that was used to measure learning facilitation (q_{10} , q_{11} , q_{12} , q_{13} , q_{14} , and q_{15}) and the subset of questionnaire items that was used to measure the interest component (q_5 , q_7 , q_8 , and q_9), gave alpha values of 0.88 and 0.65 respectively, see subsection 4.3.2.3. These alpha values show that the subset of questionnaire items that were used to measure learning facilitation strongly correlated with each other, while those items used to measure the interest component of the study showed fairly weak correlation with each other, but, yet acceptable because the measurement value of 0.65 was very close to the acceptable value of 0.7. In fact, 0.65 is 0.7 to one decimal place. All the subset of questionnaire items were determined through factor analysis (see subsection 4.3.2.3)
- An analysis of Covariance (ANCOVA) was performed on the classroom tests and examination performance scores. In addition, Bonferroni Multiple Comparisons of means tests was used for the purpose of the analyses, to investigate the significance of the impact of the intervention programme on students' performance in fluid mechanics and to describe

the nature of the impact. Associated with the analyses of covariance results are ANCOVA data compliance assumptions that ensure reliable analyses results which were carried out in each of the case studies. The assumptions, as suggested by Dimitrov and Rumrill (2003) were tests of linear relationship between the covariates and the dependent variables, and the homogeneity test of the regression slopes.

The analysis strategy had to accommodate the nature of the data set in this study (see subsection 4.1.2) such as inherent differences in each group and the unequal group sizes of the groups. The ethical confidentiality clause of the institutions did not allow study participants' student numbers to be included in the research data provided to the researcher. Each of the study participants' responses and performances were coded to facilitate data analysis. The procedure on how the analysis strategy was designed to accommodate this restriction will be discussed in each analysis results' section. For each case study, the frequency-trend for the classroom test and examination marks was then illustrated in a scatter plot.

Analyses results are presented on the basis of each research question and per hypothesis. The hypotheses tested are as stated in subsection 1.2

5.1.2 Qualitative strategy

The qualitative data in this study were the data gathered from classroom observations as well as the background information of the specific institution. The data were meant to evaluate the classroom dynamics in the CCAIML learning environment and to corroborate the quantitative results.

The collected data were structured on a spreadsheet. Data analysis in this instance included an in-depth look at classroom organisation, the application of ACIA used in the classroom, the instructional tactics of the lecturer as well as

classroom participation of study participants throughout the progression of the lectures. In addition, the nature and cognitive level of the questions raised by the study participants, plus the level of interaction among the study participants, and between the lecturer and the study participants were noted. The meanings drawn from the data were used in supporting the claims in the quantitative results.

5.2 PRESENTATION OF RESULTS

5.2.1 Presentation of the baseline results

The purpose of presenting the baseline results here is to allow the reader the ability to compare the results of the qualitative data analysis on the learning of fluid mechanics before intervention to the results of the intervention qualitative data analysis on the learning of fluid mechanics during the intervention. The baseline study was carried out in 2007 in all the four case studies. Case studies one and four took place during the second semester, and case studies two and three took place during the first semester. Questionnaire surveys (see Appendix 3) and observation checklist (see Appendix 5) were used to collect data.

Similar questions (seven items) were presented to students and lecturers as separate questionnaires. The questions were couched to determine how fluid mechanics was taught and learned. The objective of effectively using two questionnaires (one for students and another for lecturers) was to collect convergence data. Two rounds of scheduled classroom observations were conducted in each of the four case studies. During the classroom observation relevant events were recorded using the observation checklist; furthermore, field notes were taken. The results of the four Case Studies are similar and thus are presented compositely.

Both questionnaire and classroom observation data on the teaching method used, revealed that the teaching of fluid mechanics conformed to the traditional approach in all the participating universities: in three of the universities, lecturers taught with the aid of PowerPoint presentation and data projection, but without interactive animation. In one institution the chalkboard and overhead projector were used as basic teaching aids: the overhead projector was used to display diagrams prepared on transparencies. Data from the observed items revealed an average student population of 82 per classroom, and most of the classrooms were spacious and reasonably furnished with equipment that facilitated teaching (like computers and electronic communication peripherals).

The results from the classroom observation also showed that during lecture and tutorial sessions, students struggled to understand the basic fluid mechanics concepts, and there was not any significant interaction between the students and lecturers in the class. The students were always quiet throughout the lecturing periods and hardly answered the lecturers' questions correctly. The lecturers had to revise important concepts repeatedly, even previously taught concepts, relevant to the topics under discussion.

An observed lecture on control volume, is cited here as an example. This was noted in Case Study 2. In this particular lesson, the lecturer commenced by explaining the resolution of a problem relating to control volume. The problem dealt with a plate set up parallel to a flowing stream. After displaying the PowerPoint slide on which the problem was written, the lecturer, without any students' engagement, proceed to solve the problem on the chalkboard, 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 $V = U_0 i$ ". The lecturer 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 in his hand. The lecturer continued, *"The slowly moving particles retard their neighbours above them so that at the end of the plate there is a significant retarded sheer layer, or boundary layer of thickness $y = \delta$ ".* Then the lecturer 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"*. While explaining and writing on the board, the lecturer pointed to the diagram, which was displayed on the PowerPoint screen. The lecturer instructed the students, *"Make an integral analysis and find the drag force D in terms of the flow properties ρ , U_0 , δ and the plate dimensions L and b "*. He later solved the problem on the chalkboard and gave a related problem to students to solve as homework. The lecture was completed in 40 minutes.

Survey results, furthermore, revealed that students found some aspects of fluid mechanics difficult. A total of 305 students and four fluid mechanics lecturers participated in the survey. The four lecturers sent in their responses, while only 180 students' responses were collected. Thus, the students' response rate was 59.02%.

The results of the data analysis of the data gathered from the lecturers indicated that, the four lecturers lectured in a traditional approach by using PowerPoint computer package to present their lecture notes and used the blackboard to explain and work examples. It also emerged from the results of the data collected from the lecturers that students found some of the topics in fluid mechanics very difficult and that the students looked at fluid mechanics as a very difficult subject.

The results of the data analysis of students' responses were in line with that of the lecturers. There were 177 (58%) students who indicated that, 'they find some of the aspect of fluid mechanic very difficult'. This corroborates the

classroom observation result, which indicated that students struggled to understand fluid mechanics. Again, 261 (86%) of the students indicated that 'computers were used in teaching them'. These set of students might be referring to the PowerPoint display of the lecturer's notes. Also, 290 (95%) indicated that 'no computer animation was used during fluid mechanics classes'. In describing their normal fluid mechanics class, 182 (60%) indicated that 'it is usually abstract, which makes it boring, while 158 (52%) felt that, they usually copy note and memorize the copied notes later'. Perhaps, that was why, as was indicative in the classroom observation data, the lectures repeated the basic fluid mechanics concepts often.

5.2.2 Presentation of the intervention results

The intervention in each of the case studies, involved the use of ACIA in a CCAIML learning environment, in the learning of fluid mechanics. The teaching and learning instructional strategies followed were as described in subsection 2.5.2, the CCAIML instructional steps. Between six to seven weeks into the intervention, a classroom knowledge test (see subsection 4.3.3) was administered. As explained in subsection 4.3.4.1, fluid mechanics was taught together with thermodynamics, as a single module. The intervention ended, when the fluid mechanics aspects of the module were completed. The intervention period in each of the case studies were given in the section that dealt with the profile of each case study.

As mentioned at the beginning of this chapter, the results presented in this section shall start from case study 1 and end with case study 4.

5.2.2.1 Case Study 1

(i) Profile of case study 1

In case study 1, the students' admission into the University was based on the new national curriculum for the Further Education and Training Phase and the institution's Access Tests score (ATs). The results of the ATs account for 40% and the results of the National Senior Certificate (NSC) 60% of a candidate's admission requirement.

However, the minimum admission requirement into the Faculty of Engineering stipulates that a candidate:

- Must write ATs in Mathematics, Physical Science, and Academic Literacy (Afrikaans & English language).
- Must have obtained an aggregate of at least 60% for the NSC, made up as follows:
 - Mathematics 5 points (60 – 69%);
 - Physical Sciences 5 points (60 – 69%);
 - English (Home language) 3 points (40 – 49%); OR
 - English (First additional language) 5 points (60 – 69%); OR
 - English (First additional language) 4 points (50 – 59%); in conjunction with Afrikaans (Home language) 3 points (40 – 49%), or Afrikaans (First additional language) 5 points (60 – 69%).

In this case study, the fluid mechanics module investigated was offered in second semester. Instruction was through the medium of English. The middle-age lecturer is a Senior Lecturer in the Department of Mechanical Engineering with over ten years' lecturing experience, of which four years included lecturing experience in fluid mechanics.

(ii) Results of the analysis of the intervention data in case study 1

In this case study, the control groups were the students who offered the fluid mechanics under investigation in 2007 and 2008 academic years. The intervention group was the group students who registered for the fluid mechanics module used for investigation in 2009 academic year. As mentioned in subsection 4.1.2, both the control and intervention groups were taught the same material by the same lecturer.

As indicated at the beginning of this chapter, the results of the intervention data analysis were presented in accordance with the research questions and hypothesis that guided the study.

1. Research Question One

Does the use of ACAI facilitate the teaching of fluid mechanics in the mechanical engineering classes?

The frequency table (Table 5.1) below presents the response distributions of study participants on the questionnaire items that probed the learning facilitation component of the intervention. The subset of questionnaire items (q_{10} , q_{11} , q_{12} , q_{13} , q_{14} , and q_{15}), used to measure learning facilitation, were gotten from the factor analysis (see subsection 4.3.2.3).

Table 5.1: Results of the learning facilitation in case study 1

Composite one-way frequency table: Software package intervention and learning facilitation						
Questionnaire item	frequencies per rating category					Total
Frequency Row Pct	Strongly disagree	disagree	undecided	agree	Strongly agree	
Q10. I understand the fluid mechanics concepts in illustrative movies better than reading from textbooks or lecture notes.	1 2.33	3 6.98	10 23.26	18 41.86	11 25.58	43
Q11. The software is a good learning aid.	0 0.00	1 2.33	7 16.28	25 58.14	10 23.26	43
Q12. The animated movies were fascinating.	0 0.00	1 2.33	7 16.28	17 39.53	18 41.86	43
Q13. I think the time spent using the software was a worthwhile use of my study time.	0 0.00	1 2.38	10 23.81	18 42.86	13 30.95	42
Q14. I enjoy using the software.	0 0.00	1 2.33	11 25.58	21 48.84	10 23.26	43
Q15. The software is educating.	0 0.00	0 0.00	5 11.90	18 42.86	19 45.24	42
Total	1	7	50	117	81	256
Frequency Missing = 2						

Note. In the above table, some of the cells have two figures: the upper number represents the frequency of a particular response, while the other number is the percentage of the response compared to the total number of expected responses (43).

The total frequencies of responses for each agreement rating level, indicated in the last row of table 5.1 are 1, 7, 50, 117, and 81, which represents responses for strongly disagree, disagree, undecided, agree, and strongly agree respectively. It should be noted, that the total frequencies in the 'agree' and 'strongly' agree columns are in the majority, they formed 45.70% and 31.64% of the total responses respectively. These agree and strongly agree perception proportion of the total responses can be taken to represent the general perspective of the respondents. Therefore, it can be deduced, that the respondents were generally positive, that the ACIA facilitated the learning of fluid mechanics taught. Thus, this gives an impression that ACIA facilitated the learning of fluid mechanics in this case study.

The above deduction is based on the frequencies of a number of questionnaire items. The need to derive, a single summative learning facilitation perception measurement, of the visualization impact of the intervention on fluid mechanics

subject is apparent. Therefore, Table 5.2 below, reports on the mean and the spread of the study participants' perception, of the learning facilitation component of the study.

Table 5.2: The mean scores and standard deviations of questionnaire items that address learning facilitation in case study 1

Dimension	items	Perception mean	Standard Deviation	n
facilitate learning	Q ₁₀ , Q ₁₁ , Q ₁₂ , Q ₁₃ , Q ₁₄ , Q ₁₅	4.03	0.51	43

Table 5.2 reports a mean learning facilitation perception rating of 4.03 with a standard deviation of 0.51. A standard deviation of 0.51, indicates a fair homogeneity in the dispersion of the learning facilitation rating frequencies around the mean. That is, most of the study participants' learning facilitation perception ratings fell into 0.51 brackets of the mean (3.52 – 4.54) or approximately within 4.0 and 5.0 perception rating range. Since the questionnaire rating scale allocates a point of 4 and 5 to agree and strongly agreed perception respectively, it follows that the majority of the study participants were positive that ACIA facilitated the learning of the fluid mechanics taught. The analysis results of research question four, which reports on the classroom observation, corroborated this quantitative result. The two results are discussed together in chapter six.

2. Research Question Two

Does ACIA, as a learning aid, arouse students' interest in fluid mechanics in an CCAIML learning environment?

The frequency Table 5.3 below, presents the distributions of the participants' responses on the subset of the questionnaire items, that probe the interest perception level of the study participants, in ACIA as a learning tool in CCAIML

learning environment. The questionnaire items (q₅, q₇, q₈, and q₉) that were used, to measure the interest perception rating, were gotten from the factor analysis (see subsection 4.3.2.3).

In Table 5.3 below, the total frequencies of responses for each agreement rating level, indicated in the last row of Table 5.3 are 0, 2, 13, 80, and 77 which represent total responses for strongly disagree, disagree, undecided, agree, and strongly agree respectively. Again, it is noted that the total frequencies in the 'agree' and 'strongly' agree columns are in the majority, they formed 46.51% and 44.77% of the total responses respectively. The implication of this result is that, the respondents had general positive perception, that ACIA arouse their interest in learning the fluid mechanics module under review.

Table 5.3: Result of the interest perception rating in case study 1

Table Composite one-way frequency table re raised levels of interest in Fluid Mechanics						
Questionnaire item	Agreement rating levels					Total
Frequency Row Pct	Strongly disagree	disagree	undecided	agree	Strongly agree	
Q5. It presents a clearer presentation of fluid mechanics basic concepts in 3-D.	0 0.00	0 0.00	1 2.33	15 34.88	27 62.79	43
Q7. It helps me to visualize the fluid mechanics basic concepts in its 3-D form.	0 0.00	0 0.00	3 6.98	21 48.84	19 44.19	43
Q8. It helps to reinforce an understanding of fluid mechanics topics.	0 0.00	1 2.33	6 13.95	24 55.81	12 27.91	43
Q9. The animated movies make me to be more interested in fluid mechanics.	0 0.00	1 2.33	3 6.98	20 46.51	19 44.19	43
Total	0	2	13	80	77	172

Note. In the above table, some of the cells have two figures: the upper number represents the frequency of a particular response, while the other number is the percentage of the response compared to the total number of expected responses (43).

A single summative interest perception measurement, of the visualization impact of the intervention on fluid mechanics learning, is given in Table 5.4. The table reports on the mean and the spread, of the study participants' perception of the arouse interest component of the study.

Table 5.4: The mean scores and standard deviations of the interest perception in case study 1

Dimension	items	Perception mean	Standard Deviation	n
Interest perception	q ₅ , q ₇ , q ₈ , and q ₉	4.22	0.59	43

The mean interest level value of 4.22 was calculated, with a standard deviation of 0.59. As indicated in subsection 4.3.2, the perception rating ranges from 1 (strongly disagree) to 5 (strongly agree). Further analysis on the mean of 4.22 and 0.59 standard deviation indicated a fair homogeneity in the dispersion of the interest rating frequencies around the mean. That is, most of the study participants' interest perception ratings fell into 0.59 brackets of the mean (3.63 – 4.81) or approximately within 4.0 and 5.0 perception rating range. This gives the impression that the majority of the study participants were positive that ACIA arouse their interest in the learning of the fluid mechanics module that was used to carry out the study.

Test of ANCOVA assumptions

As mentioned in subsection 5.1.1.2, the ANCOVA assumptions of linearity of the relationship between the covariate and the dependent variables, and the homogeneity of the regression parallelism, were carried out.

(A) Test of linearity and significance of relationship between the covariate and the dependent variables

H₀: There is no statistical significant linear relationship between the covariate and the dependent variable.

H₁: There is a statistical significant linear relationship between the covariate and the dependent variable.

Pearson correlation was used to determine the correlation between the covariate and the dependant variable in each group. The results are given in Tables 5.5, 5.6, and 5.7 below.

Table 5.5: Correlations in 2007 group in case study 1

			Test	Examination
Test	Pearson Correlation		1	0.818**
	Sig. (2-tailed)			0.000
	N		88	88
Examination	Pearson Correlation		0.818**	1
	Sig. (2-tailed)		0.000	
	N		88	88

**Correlation is significant at the 0.05 level.

Table 5.6: Correlations in 2008 group in case study 1

			Test	Examination
Test	Pearson Correlation		1	0.633**
	Sig. (2-tailed)			0.000
	N		86	86
Examination	Pearson Correlation		0.633**	1
	Sig. (2-tailed)		.000	
	N		86	86

** Correlation is significant at the 0.05 level.

Table 5.7: Correlations in 2009 group in case study 1

			Test	Examination
Test	Pearson	Correlation	1	0.568**
		Sig. (2-tailed)		0.000
		N	79	79
Examination	Pearson	Correlation	0.568**	1
		Sig. (2-tailed)	0.000	
		N	79	79

** Correlation is significant at the 0.05 level.

Tables 5.5, 5.6, and 5.7 above showed the observed correlation coefficient, r , between the covariate and the dependant variable to be 0.818, 0.633 and 0.568 for the 2007, 2008 and 2009 groups respectively. The associated p-values in each of the tables were found to be less than 0.05, ($p < 0.05$), hence the null hypothesis is rejected. This implies that there is a significant linear relationship between the covariate and the dependent variable in this case study.

(B) Test of homogeneity of the regression parallelism

H_0 : There is no statistical significant similar relationship between the covariate and the dependent variable across all groups.

H_1 : There is a statistical significant similar relationship between the covariate and the dependent variable across all groups.

Table 5.8: The relationship between the residuals across the groups in case study 1

Source	Type I sum of squares	df	Mean square	F	Sig.
Treatment * Test	14158.086	2	7079.043	56.121	0.000

Table 5.8 gives a p-value of 0.000. The null hypothesis is rejected since $p < 0.05$ level. Hence, there is similarity in the regression lines across the three groups.

3. Hypothesis One

H_0 : There is no statistical significant difference in the study participants' intervention examination achievement marks in the fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the examination achievement marks in the control groups.

H_1 : There is statistical significant difference in the study participants' intervention examination achievement marks in the fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the examination achievement marks in the control groups.

Table 5.9 below, shows that the intervention, as the main effect, is significant on the study participants' achievement in the fluid mechanics learnt at 0.05 level. This is because the observed $F_{\text{observed}}(2, 245) = 16.134$ and $p = 0.000$, where $p < 0.05$. Hence, the null hypothesis was rejected. It, therefore, means that the CCAIML learning model enhances the study participants' achievement in the learning of the fluid mechanics taught.

Table 5.9: Summary of the ANCOVA on the effect of the use of CCAIML learning approach on the examination achievements in 2007, 2008, and intervention (2009) groups (case study 1)

Source	Type I sum of squares	df	Mean square	F	Sig.
Corrected Model	38001.720 ^a	5	7600.344	60.254	0.000
Intercept	927516.191	1	927516.191	7353.120	0.000
Test	19773.339	1	19773.339	156.758	0.000
Treatment	4070.295	2	2035.148	16.134	0.000
Treatment * Test	14158.086	2	7079.043	56.121	0.000
Error	30904.088	245	126.139		
Total	996422.000	251			
Corrected Total	68905.809	250			

a. R Squared = 0.552 (Adjusted R Squared = 0.542)

The Post Hoc analysis shed more light on the nature of the differences noted in Table 5.9. Table 5.10 below, the Bonferroni Multiple Comparisons of means tests, is used to show and explain the nature of the differences in the means.

Table 5.10: Post Hoc Analysis: Multiple Comparisons of Means of examinations in the control and intervention groups in case study 1

(I) Year (J) Year		Mean difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2007	2008	3.42257	2.40428	0.467	-2.3722	9.2174
	2009	-8.73375*	2.45756	0.001	-14.6570	-2.8105
2008	2007	-3.42257	2.40428	0.467	-9.2174	2.3722
	2009	-12.15631*	2.47104	0.000	-18.1120	-6.2006
2009	2007	8.73375	2.45756	0.001	2.8105	14.6570
	2008	12.15631	2.47104	0.000	6.2006	18.1120

* The mean difference is significant at the 0.05 level.

Table 5.10 shows that there is a statistical significant difference when comparing the achievements in 2008 (control) and the 2009 (intervention), and 2007 (control) and 2009 (intervention) groups. But, there is no statistical significant difference between the achievements of 2007 (control) and 2008 (control). However, Figure 5.1 below compares the achievement means across the groups.

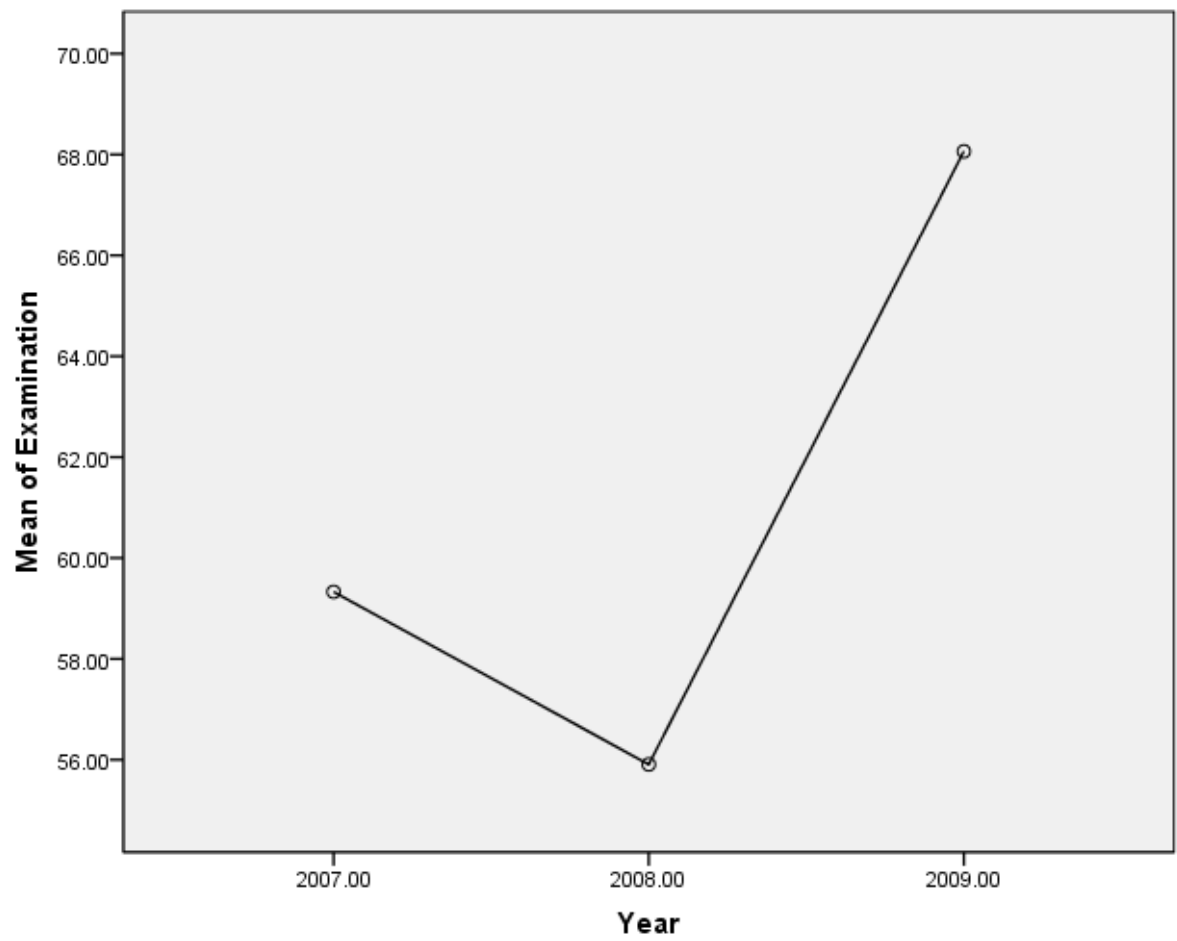


Figure 5.1: The mean plot of the examination performance in case study 1

From Figure 5.1, the researcher observed that the intervention group (2009) gained the highest achievement in fluid mechanics.

In view of the above results, the study participants who were exposed to CCAIML learning approach performed better than those that were taught in the traditional approach.

4. Hypothesis Two

H_0 : There is no statistical significant relationship between the study participants' intervention examination achievement score and the achievement score of the Classroom knowledge test.

H_1 : There is statistical significant relationship between the study participants' intervention examination achievement score and the achievement score of the Classroom knowledge test.

In this case study, seven weeks were allocated to learning fluid mechanics and about the nine weeks are for learning thermodynamics and examinations (see subsection 4.3.4.1). Intervention started during, the first week of the second semester. A fluid mechanics concept knowledge test was conducted six weeks into the intervention, to assess whether the study participants understood the basic fluid mechanics concepts as they were learning with the aid of ACIA in CCAIML learning environment. Table 5.11 below gives the mean and standard deviation of the study participants' performance in the knowledge test.

Table 5.11: The Mean Scores and Standard Deviations of Classroom knowledge test in case study 1

Analysis Variable : test							
year	N Obs	Mean	Std Dev	Maximum	Minimum	Skewness	Kurtosis
2009	79	62.47	11.80	87.00	28	-0.42	0.60

The Pearson correlation test was used to find out the relationship between the intervention examination marks and the classroom knowledge test marks. The result is given in the table below.

Table 5.12: Pearson correlation of the intervention examination and classroom knowledge test marks in case study 1

		Test	Examination
Test	Pearson Correlation	1	0.568**
	Sig. (2-tailed)		0.000
	N	79	79
Examination	Pearson Correlation	0.568**	1
	Sig. (2-tailed)	0.000	
	N	79	79

**Correlation is statistically significant at the 0.05 level

Table 5.12 above shows the observed correlation coefficient, ($r=0.568$) between the intervention examination marks and the classroom knowledge test marks. The $p = 0.000$ is less than 0.05 confidence level, ($p < 0.05$). Therefore, the null

hypothesis is rejected. This implies that, there is a significant relationship between the intervention examination mark and the classroom knowledge test. The trend is graphically depicted in the line graph which follows.

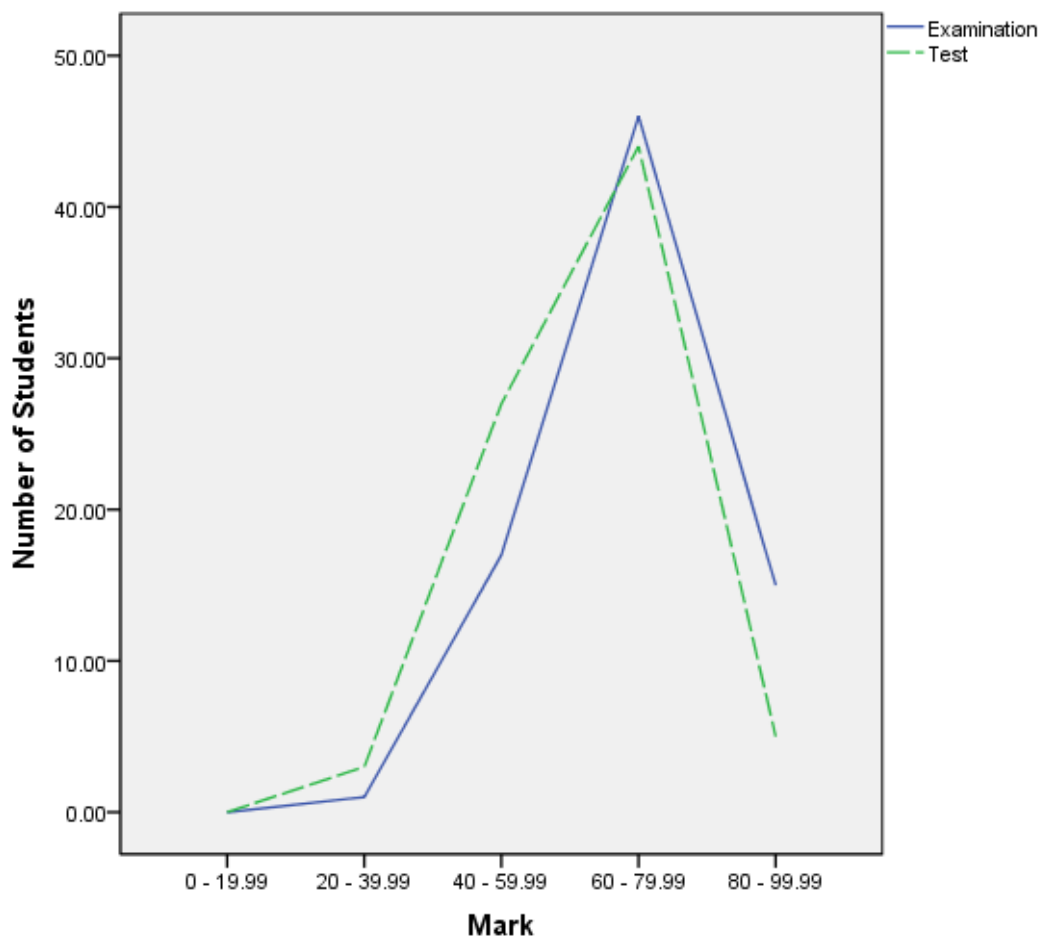


Figure 5.2: Classroom test & examination marks in case study 1

Figure 5.2 above shows a relationship between the class test and the post-intervention examination. The relationship can be described as a trend with similarities but also significant differences: for both classroom test and examination marks, the frequency of student performance increased in the 60-80 mark category and decreased in the 80-100 performance mark category. The trends differed significantly from each other in that examination performance outnumbered the test performance in the 70-100 mark category but a higher proportion of students performed poorly in the classroom test (0-40 performance mark) and also in the 40-60 % test performance category.

5. Hypothesis Three

H_0 : There is no statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and the achievement marks in the intervention examination.

H_1 : There is a statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and the achievement marks in the intervention examination.

Pearson correlation test was used to find the relationship between the intervention examination marks and the study participants' interest perception.

In Table 5.13 below, the correlation coefficient, r , between the examination marks and the interest perception rating is given as $r = 0.97$ with a corresponding p -value of 0.471. It is noted that $p > 0.05$ level, the null hypothesis is accepted. Hence, the correlation between the examination marks and the interest perception rating is not significant. This implies that the interest perception is not a factor to be considered in the study participants' intervention examination achievement.

Table 5.13: Pearson correlation between the intervention examination marks and the study participants' interest perception in case study 1.

		Examination	Mean rating
Examination	Pearson Correlation	1	0.097
	Sig. (2-tailed)		0.471
	N	78	57
Mean rating	Pearson Correlation	0.097	1
	Sig. (2-tailed)	0.471	
	N	57	57

6. Research Question Three (Classroom Observation Result)

Does CCAIML learning approach encourage instructor-students and students-students interactions?

The classroom observation was structured to answer the classroom dynamic component of the study. The intervention in this case study materialised in the second semester of 2009 academic session. It was from 12th July, to 19th November, 2009. Each of the lecture's duration was a period of one hour. Six different unscheduled classroom observations were conducted. The average number of study participants, observed on each occasion, was 71.

An observation checklist, as indicated in subsection 4.3.5, was used to collect relevant data. None of the classroom observation was pre-scheduled. In addition, from the beginning of the intervention, the lecturer advised the study participants to always be seated in groups of threes or fours to facilitate discussion among them. It was observed that the study participants complied with this instruction throughout the intervention period. Relevant events were also recorded, using field notes. The data collected were coded and processed as explained in subsection 5.1.2. Emerging themes in the six observations were compared (Mapolelo, 2003; Day, 1996; Malone, 1996).

The results of the data analysis revealed that the classroom resources were rich; animated teaching aid (ACIA), overhead projector, computer, textbooks and whiteboard, in addition, on some occasions physical model were used. It also emerged that as soon as the lecturer displayed a topic on the screen, the study participants already had an idea about it (since each study participant was given the ACIA CD to use during their private study), and would start interactive discussion. After a brief introduction of the topic, the lecturer displayed the animation related to the topics concerned, to illustrate the concepts involved in the topic of the day.

The lecturer directed leading questions to study participants resulted in inquiries. The lecturer allowed the study participants to construct individual meanings of the new concepts. After about ten minutes, the lecturer requested each group to verbally respond to the questions asked earlier on. The study participants were allowed to present the group's reasoning to the class, while other participants contributed and the lecturer moderated the discussion. The study participants explained or demonstrated individual understanding of the new concepts. The study participants sometimes drew diagrams on the board or used objects to demonstrate cognitive understanding of the required concepts. This took about ten minutes.

The lecturer displayed a problem of the day's topic on the white screen and allowed study participants to address the problem in individual ways. The lecturer moved among the groups, to monitor how each group was solving the problem. Any group could be called upon to present the group's finding to the class. To round up the lecture, the lecturer requested the study participants to suggest other possible application of the concepts learnt in real life situations.

The lecture observed on August 26th, 2009 at 12.00 pm to 1.00 pm is cited here as an example. The lecture was on the Reynolds number (Re). The lecturer started by displaying the topic on the white screen. He proceeded to introduce the topic to the student.

"In the last lecture, we learnt about the three basic laws of analysis in fluid mechanics", He quickly went to the blackboard to write the laws. As he was mentioning the laws one after the other, he was writing,

"(1) Law of conservation of mass (m)

$$\frac{dm}{dt} = 0$$

This implies that m is constant.

(2) Law of conservation momentum

$$F = ma$$

$$F = \frac{d(mv)}{dt}$$

a is the acceleration and v is the velocity of the moving fluid

(3) Law of angular momentum

$$M = \frac{dH}{dt}$$

Where

$H = \sum (\mathbf{r} \times \mathbf{v}) \delta m$ is the angular momentum of the system about its centre of mass"

He came near the white screen which is at the other end of the classroom, continued explaining and gesticulating with his hand as he was moving. *"To use control volume analysis approach to solve problems in fluid flow system, we have to convert our mathematics to apply to region rather than individual mass."* He paused a little, kept quite, as if he wanted the study participants to say something. He continued *"We need to relate the time derivative of a system property to the rate of change of that property within a certain region."* Again, he pause and then continue, *"this conversion is called"*, he directed the laser pointer in his hand to the topic, *"the Reynolds transport theorem"*. He quickly went to his computer to display the animated illustration of Reynolds number. The class was quiet until this time, when the study participants started watching the animation. One can notice the murmuring started, even some pointing at the animation.

The lecturer continued *"in five minutes, how best can you describe Reynolds numbers"*. Each group started interacting while watching the illustrative animation of Reynolds number. The lecturer went round to listen to discussion of the six groups at the front row of the class. After about seven minutes, *"o.k"*, he shouted, he stopped the study participants' interaction and pointed at a group. *"Can you present your answer to the class"*.

One of the study participants (a man) from the selected group stood up and explained that *"Reynolds number is comparing the inertial to viscous"*.

"That is good but there are some things missing, who can contribute to that"? He asked. Members of other groups raised up their hands. The lecturer called on one of them.

"It is the ratio of inertial effect to viscous forces" the called study participant answered.

"Do we agree with this"? The lecturer went on *"how do inertial and viscous affect fluid flow?"*

Each group started interacting among themselves again, watching the animation that was kept running. The lecturer went to each group, listened to them, and made some contribution. After about ten minutes, the lecturer requested answers. Members of each group raised their hands, *"Let us hear from you"*, he pointed to a group.

A lady answered, from the group that was pointed to, *"From the animation, Reynolds number is all about how thick a fluid is, if we pour water (a fluid) on the floor of this class now, and see how it spreads, we can compare its spread to when we pour paint on the floor. The water immediately spreads out while the paint spreads cover a little space. The inertial influence on water molecules is more than that of the paint, that is, paint is more viscous"*.

Another study participant (a lady) contributed, *"We can compare tea in a cup and prepared bread flour kept in a bowl. If you rotate the cup of tea gently, the tea in the cup does not rotate with the cup, but if you rotate the bowl that contains the flour, the flour rotates with the bowl. This is the experiment that I carried out when I was preparing for this lecture, yesterday, trying to understand Reynolds number from the animations in the CD we were given"*, she paused a little to allow comments from other study participants. Then she continued *"in the case of the tea, $Re > 1$, since its inertia is high but $Re < 1$ in the case of the flour, since its viscous property is high"*.

"Thank you". The lecturer replied.

The lecturer pointed at the animation, *"Let us consider the two different fluids in the two tanks as shown in the animation,"* and using the laser pointer in his hand to highlight what he was talking about continued, *"the fluid in tank 1, coloured red, is 1000 times more viscous than the fluid in tank 2, coloured purple. When the two tanks are rotated separately, the fluid in tank 1, rotates immediately with the tank, just as she found out with the mixed flour in a bowl,"* he pointed at the lady, who related the example of the flour in a bowl. The

lecturer continued, *"In the case of tank 2, it was only the fluid adjacent to the moving boundary that was set in motion, the fluid in tank 1 is dominated by its viscous effect, as you all have mentioned before, it has a high viscosity and consequently its $Re < 1$. The fluid in the tank 2 has a small viscosity, hence its $Re > 2$ ".* He moved to the chalkboard and started writing on it while verbalizing what he was writing, *"In a simple form, Re may be seen as follows:*

$$Re = \frac{\delta VoL}{\mu}$$

Where:

δ is the density of the fluid

Vo is the characteristic speed

L is the characteristic length

μ is the viscosity of the fluid

and

$$Re = \frac{VoL}{\nu}$$

Where:

$$\nu = \frac{\mu}{\delta} \text{ is called the kinematic viscosity".}$$

"Now let us apply of Reynolds number in control volume, the desired conversion formula differs slightly according to whether the control volume is fixed, moving, or deformable". He noticed a group of students standing outside and wanting to come into the class, then he realised that the lecture time was over, *"we shall apply the Reynolds number to solve problems in the next class"* the lecturer said. The lecture ended at 1.02 pm.

In addition, the method of assessment was also aligned with the instructional method. The assessment was structured such that it tested the study participants' ability in practical applications of concepts as against questions, which favoured memorizing concepts and problem solving procedures.

The questionnaire data analysis complemented these results. Item 16 on the questionnaire allowed the study participants to state their overall evaluation of the software as a learning tool. Some of the responses offered by the respondents were extracted and are reflected, unchanged, below:

"It is a great way to help me understand the work, because you actually see what's happening."

"It was easy accessing it and helped me get a better view of the work, however, I feel you should first read through your work to first comprehend and understand what you are seeing, because the video goes quite quickly through the concepts."

"It is very interesting to see what we learned in actual real life, see the theory practically being applied in reality."

"It helps you understand the basic concepts better than the book".

"Helps visualisation of flow".

"It helps to understand the different subjects dealt with in the class".

5.2.2.2 Case study 2

5.2.2.2(i) Profile of case study 2

The institution represented by case study 2 was a multi campus public institution. The institution has a high international status. In addition, various world ranking have consistently ranked it as one of the top five educational

institutions in South Africa. The enrolment figure of the institution is approximately 39 000 as at 2009 academic session, with seven campuses and nine Faculties. One of these Faculties houses the School of Engineering. The Department of Mechanical Engineering, where this study was carried out, is one of the seven departments that constitute the School of Engineering. The School of Engineering has uniform admission requirements for the entire seven departments comprising it. The admission requirements are as follows:

- A valid National Senior Certificate (NSC) with university admission.
- Write and pass the institution's bench mark test.

In addition to the above admission criteria, for a Four Year Programme in the School of Engineering, a candidate must meet all the subject minimum requirements set out below:

- Afrikaans or English (60 – 69%) - 5 points;
- Mathematics (70 – 79%) – 6 points;
- Physical Science (60 – 69%) – 5 points; and
- A total admission points score (APs) of 30.

However, for a Five Year Programme, in the case a candidate who did not meet the subject minimum requirements set for a Four Year Programme as stated above, then the admission will be based on :

- Faculty selection;
- The result of the institution's bench mark test;
- The NSC result;
- Achievement of a 5 points in mathematics and a 4 points in physical science as well as a 4 points in Afrikaans or English; and
- A total admission points score of 25.

The fluid mechanics module used to carry out the study, was offered in the first semester and the intervention was carried out in 2010 academic session. The classroom teaching in the department was normally through medium of Afrikaans or English. However, the fluid mechanics module, used to carry out the study, was taught through the medium of English. The lecturer was a young man, currently appointed at lecturer level, with about four years' lecturing experience, all of which was spent lecturing fluid mechanics.

(ii) Results of the analysis of the intervention data in case study 2

In this case study the control groups, were the students who offered the fluid mechanics module used to carry out the study, in 2008 and 2009 academic years. The intervention group, were the students who offered the fluid mechanics under investigation, in 2010 academic year. As mention in subsection 4.1.2, both the control and intervention groups were taught the same material by the same lecturer.

Again, the results of the intervention data analysis are presented in accordance with the research questions and hypotheses that guided the study.

1. Research Question One

Does the use of ACAI facilitate the teaching of fluid mechanics in the mechanical engineering classes?

The frequency table (Table 5.14) presents the response distributions of the study participants on the questionnaire items that probed the learning facilitation component of the intervention. As mentioned in case study one, the subset of questionnaire items that was used to measure learning facilitation, was gotten from the factor analysis (see subsection 4.3.2.3).

Table 5.14: Result of the learning facilitation in case study 2

Composite one-way frequency table: Software package intervention and learning facilitation						
Questionnaire item	frequencies per rating category					Total
Frequency Row Pct	Strongly disagree	disagree	undecided	agree	Strongly agree	
Q10. I understand the fluid mechanics concepts in illustrative movies better than reading from textbooks or lecture notes.	0 0.00	4 5.48	22 30.14	23 31.51	24 32.88	73
Q11. The software is a good learning aid.	0 0.00	2 2.74	17 23.29	31 42.47	23 31.51	73
Q12. The animated movies were fascinating.	0 0.00	6 8.22	22 30.14	24 32.88	21 28.77	73
Q13. I think the time spent using the software was a worthwhile use of my study time.	1 1.37	7 9.59	19 26.03	31 42.47	15 20.55	73
Q14. I enjoy using the software.	0 0.00	4 5.48	24 32.88	25 34.25	20 27.40	73
Q15. The software is educating.	0 0.00	2 2.74	12 16.44	35 47.95	24 32.88	73
Total	1	25	116	169	127	438
Frequency Missing = 0						

Note. In the above table, some of the cells have two figures: the upper number represents the frequency of a particular response, while the other number is the percentage of the response compared to the total number of expected responses (73).

The total frequencies of responses for each agreement rating level indicated in the last row of Table 5.14 are 1, 25, 116, 169 and 127 which represent responses for strongly disagree, disagree, undecided, agree, and strongly agree respectively. It should be noted that the 'agree' and 'strongly' agree were 38.58% and 29.00% of the total response frequencies, respectively. These agree and strongly agree perception levels indicated strong positive responses. It gives an impression that ACIA facilitates the learning of fluid mechanics in this case study.

Furthermore, Table 5.15 gives a single summative learning facilitation perception measure of the visualization impact of the intervention on Fluid Mechanics learning.

Table 5.15: The mean scores and standard deviations of questionnaire items that address learning facilitation in case study 2

Dimension	items	Perception mean	Standard Deviation	n
facilitate learning	q ₁₀ , q ₁₁ , q ₁₂ , q ₁₃ , q ₁₄ , q ₁₅	3.94	0.71	73

Table 5.15 reports a mean learning facilitation perception rating of 3.94, with a standard deviation of 0.71. A standard deviation value of 0.71 indicates that the interest perception rating frequencies fluctuated around the mean. That is, most of the study participants' interest perception ratings fell into 0.71 brackets of the mean (3.23 – 4.65) or approximately within 3.0 and 5.0 perception rating range. Since the questionnaire rating scale allocated a point of 3 and 5 to undecided and strongly agreed perception respectively, it followed that the majority of the study participants' interest perception rating was between undecided and strongly agreed. But Table 5.14, shows the total agree and strongly agree column frequency as 67.58% of the total frequencies. Thus, majority of the study participants agreed that ACIA arouse their interest in the learning of the fluid mechanics module under review.

2. Research Question Two

Does ACIA, as a learning aid, arouse students' interest in fluid mechanics in an CCAIML learning environment?

The frequency table 5.16 below presents the response distributions of the participants, on the questionnaire items that probed the interest perception level of the study participants, in ACIA as a learning tool in CCAIML learning environment. Similar to what was reported in Case Study 1, the subset of the questionnaire items (q₅, q₇, q₈, and q₉), that were used to measure the interest

perception rating were derived from the factor analysis performed in subsection 4.3.2.3.

Table 5.16: Result of the interest perception in case study 2

Table Composite one-way frequency table re raised levels of interest in Fluid Mechanics						
Questionnaire item	Agreement rating levels					Total
Frequency Row Pct	Strongly disagree	disagree	undecided	agree	Strongly agree	
Q5. It presents a clearer presentation of fluid mechanics basic concepts in 3-D.	0 0.00	3 4.11	16 21.92	31 42.47	23 31.51	73
Q7. It helps me to visualize the fluid mechanics basic concepts in its 3-D form.	0 0.00	4 5.48	12 16.44	35 47.95	22 30.14	73
Q8. It helps to reinforce an understanding of fluid mechanics topics.	0 0.00	3 4.11	16 21.92	37 50.68	17 23.29	73
Q9. The animated movies make me to be more interested in fluid mechanics.	1 1.37	5 6.85	18 24.66	26 35.62	23 31.51	73
Total	1	15	62	129	85	292
Frequency Missing = 0						

Note. In the above table, some of the cells have two figures: the upper number represents the frequency of a particular response, while the other number is the percentage of the response compared to the total number of expected responses (73).

Table 5.16 reports the total frequencies of responses for each agreement rating level in the last row as 1, 15, 62, 129, and 85 which represent responses for strongly disagree, disagree, undecided, agree, and strongly agree respectively. It should be noted that the 'agree' and 'strongly' agree were 44.18% and 29.1% of the total response frequencies, respectively. The implication of this result is that, majority of the respondents agree that ACIA arouse their interest in learning the fluid mechanics module under review.

A single summative interest perception measurement of the visualization impact of the intervention on Fluid Mechanics learning is given in Table 5.17 below. The table reports on the mean and the spread of the study participants' perception of the arouse interest component of the study.

Table 5.17: The mean scores and standard deviations of the interest perception in case study 2

Dimension	items	Perception mean	Standard Deviation	n
Interest perception	q ₅ , q ₇ , q ₈ , and q ₉	3.96	0.68	73

Table 5.17 shows a mean interest perception level of 3.96, with a standard deviation of 0.68. A standard deviation of 0.68 indicates that the interest perception rating frequencies fluctuate around the mean. That is, most of the study participants' interest perception ratings fell into the 0.68 brackets of the mean (3.28 – 4.64) or approximately within 3.0 and 5.0 perception rating range. Since the questionnaire rating scale allocates a point of 3 and 5 to undecided and strongly agreed perception respectively, it follows that the majority of the study participants' interest perception was between undecided and strongly agreed. But from Table 5.16, the agree and strongly agreed column frequency is 73.29% of the total frequencies. Thus, the majority of the study participants are positive that ACIA arouse their interest in the learning of the fluid mechanics module that was used to carry out this study.

Test of ANCOVA assumptions

As mentioned in subsection 5.1.1.2, the ANCOVA assumptions of homogeneity of the regression parallelism and linearity of the relationship between the covariate and the dependent variables were carried out.

(A) Test of homogeneity of the regression parallelism

H_0 : There is no significant difference in the variance associated with each mean of the pre and post intervention scores.

H₁: There is a significant difference in the variance associated with each mean of the pre and post intervention scores.

Pearson correlation was used to establish the correlation between the covariate and the dependant variable in each group. The results are given in Tables 5.18, 5.19, and 5.20 below.

Table 5.18: Correlations in 2008 group in case study 2

		Test	Examination
Test	Pearson Correlation	1	0.610**
	Sig. (2-tailed)		0.000
	N	111	111
Examination	Pearson Correlation	0.610**	1
	Sig. (2-tailed)	0.000	
	N	111	111

** Correlation is significant at the 0.01 level.

Table 5.19: Correlations in 2009 group in case study 2

		Test	Examination
Test	Pearson Correlation	1	0.669**
	Sig. (2-tailed)		0.000
	N	102	102
Examination	Pearson Correlation	0.669**	1
	Sig. (2-tailed)	0.000	
	N	102	102

** Correlation is significant at the 0.01 level.

Table 5.20: Correlations in 2010 group in case study 2

		Test	Examination
Test	Pearson Correlation	1	0.656**
	Sig. (2-tailed)		0.000
	N	111	111
Examination	Pearson Correlation	0.656**	1
	Sig. (2-tailed)	0.000	
	N	111	112

** Correlation is significant at the 0.01 level.

Tables 5.18, 5.19 and 5.20 above show the observed correlation coefficient, r , between the covariate and the dependent variable to be 0.610, 0.669 and 0.656, for the 2008, 2009 and 2010 groups, respectively. Each of the p values were found to be less than 0.05, ($p < 0.05$), hence the null hypothesis is rejected.

This implies that there is a significant relationship between the covariate and dependent variable in this case study.

(B) Test of homogeneity of the regression parallelism

H_0 : There is no statistical significant similar relationship between the covariate and the dependent variable across all groups

H_1 : There is a statistical significant similar relationship between the covariate and the dependent variable across all groups

Table 5.21: The relationship between the residuals across the groups in case study 2

Source	Type I sum of squares	df	Mean square	F	Sig.
Treatment * Test	6481.386	2	3240.693	37.314	0.000

Table 5.21 gives a p-value of 0.000. The null hypothesis is rejected since $p < 0.05$ level. Hence, there is similarity in the regression lines across the three groups.

3. Hypothesis One

H_0 : There is no statistical significant difference in the study participants' post intervention mean achievement score in the fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the mean achievement score in the control groups.

H₁: There is a statistical significant difference in the study participants' post intervention mean achievement score in the fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the mean achievement score in the control groups.

Table 5.22: Summary of the ANCOVA on the effect of the use of CCAIML learning approach on the examination achievements in 2008, 2009, and intervention (2010) groups (case study 2)

Source	Type I sum of squares	df	Mean square	F	Sig.
Corrected Model	28173.258 ^a	5	5634.652	64.878	0.000
Intercept	1047148.238	1	1047148.238	12056.951	0.000
Test	15037.545	1	15037.545	173.144	0.000
Treatment	6654.327	2	3327.164	38.309	0.000
Treatment * Test	6481.386	2	3240.693	37.314	0.000
Error	27531.504	317	86.850		
Total	1102853.000	323			
Corrected Total	55704.762	322			

a. R Squared = 0.506 (Adjusted R Squared = 0.498)

Table 5.22 shows that the intervention, as the main effect, is significant on the study participants' achievement in the fluid mechanics that was used for this study at 0.05 level. This is because the observed $F_{\text{observed}}(2, 314) = 2.279$ and $p = 0.000$, where $p > 0.05$. Hence, the null hypothesis is rejected. It, therefore, means that the CCAIML learning model enhances the study participants'

achievement in the learning of the fluid mechanics that was used to carry out this study.

Table 5.23, the Bonferroni Multiple Comparisons of means tests, is used to show and explain the nature of the differences in the means.

Table 5.23: Post Hoc Analysis: Multiple comparisons of means of examinations in the control and intervention groups in case study 2

(I) Year	(J) Year	Mean difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2008	2009	-.33916	1.43429	1.000	-3.7909	3.1125
	2010	-4.97957*	1.40052	0.001	-8.3500	-1.6091
2009	2008	.33916	1.43429	1.000	-3.1125	3.7909
	2010	-4.64041*	1.43122	0.004	-8.0847	-1.1961
2010	2008	4.97957	1.40052	0.001	1.6091	8.3500
	2009	4.64041	1.43122	0.004	1.1961	8.0847

*The mean difference is significant at the 0.05 level.

Table 5.23 indicates there is a significant difference when comparing the achievements in 2008 (control) and the 2010 (intervention), and 2009 (control) and 2010 (intervention) groups. But, there was no significant difference between the achievements of 2008 (control) and 2009 (control) groups. Figure 5.3 below compares the achievement means across the groups.

From Figure 5.3 below, the researcher observed that the intervention group (2010) gained the highest achievement in fluid mechanics.

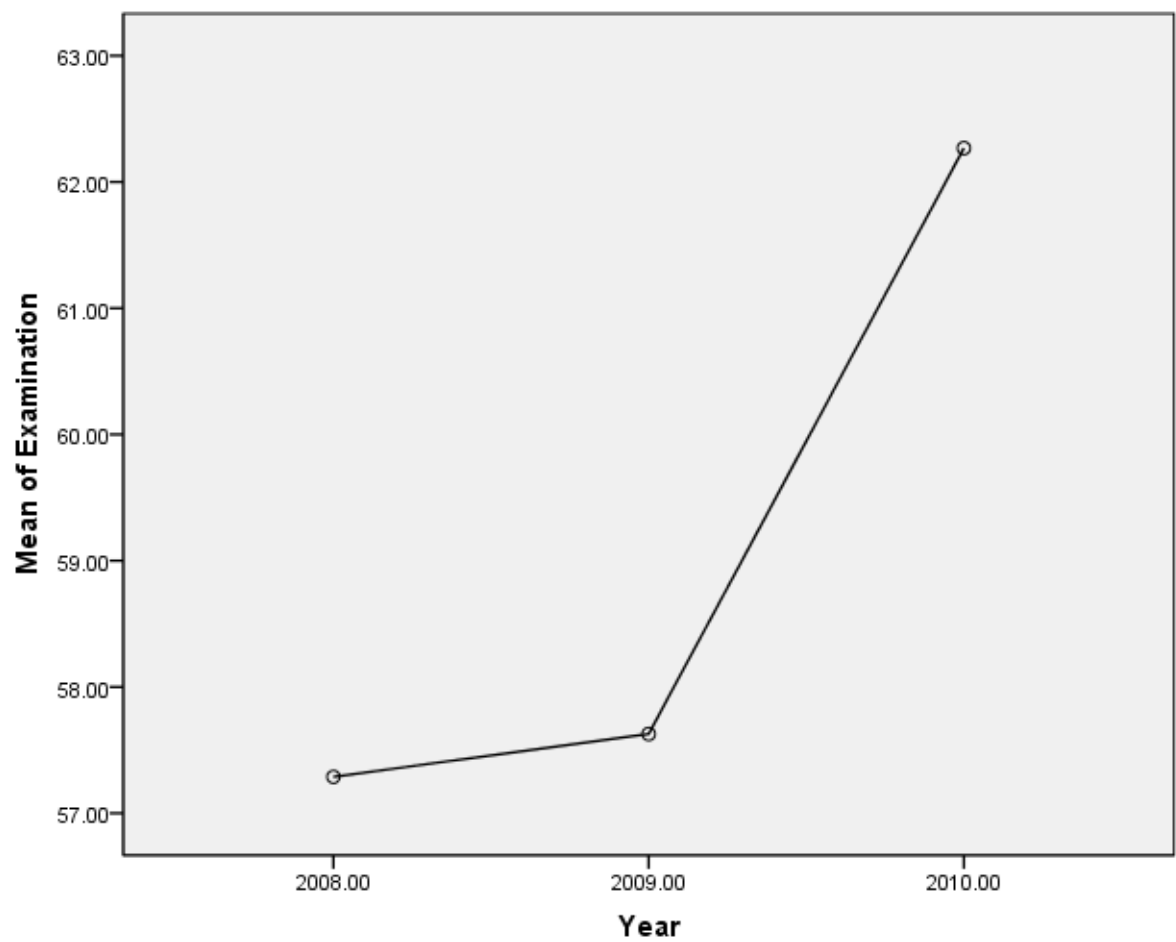


Figure 5.3: The mean plot of the examination performance in case study 2

In view of the above results, the study participants who were exposed to CCAIML learning approach performed better than those that were taught in the traditional approach.

4. Hypothesis Two

H₀: There is no statistical significant relationship between the study participants' intervention examination achievement marks and the mean achievement score of the classroom knowledge test.

H₁: There is a statistical significant relationship between the study participants' intervention examination achievement score and the achievement marks of the classroom knowledge test.

In this case study, eight and a half weeks were allocated to the learning of fluid mechanics. The remaining nine weeks, out of seventeen and a half weeks that made up the second semester in which the fluid mechanics that was used for this study was taught, was left for thermodynamics course (see subsection 4.3.4.1). Intervention started in the first week of the semester. Knowledge test was conducted four weeks into the intervention. Table 5.24 below gives the mean and standard deviation of the study participants' performance in the knowledge test.

Table 5.24: The mean scores and standard deviations of classroom knowledge test in case study 2

Analysis Variable : test							
year	N Obs	Mean	Std Dev	Maximum	Minimum	Skewness	Kurtosis
2010	111	62.50	12.15	90.00	26.00	-0.16	0.26

The Pearson correlation test was used to find out the relationship between the intervention examination marks and the classroom knowledge test marks. The result is given in the Table 5.25 below.

Table 5.25: Pearson correlation of the intervention examination and classroom knowledge test marks in case study 2

		Test	Examination
Test	Pearson Correlation	1	0.656**
	Sig. (2-tailed)		0.000
	N	111	111
Examination	Pearson Correlation	0.656**	1
	Sig. (2-tailed)	0.000	
	N	111	112

** Correlation is significant at the 0.05 level (2-tailed).

Table 5.25 above shows the observed correlation coefficient ($r=0.656$) between the intervention examination marks and the classroom knowledge test. The $p = 0.000$ is less than 0.05, ($p < 0.05$). Therefore, the null hypothesis is rejected. This implies that, there is a significant relationship between the intervention examination mark and the classroom knowledge test. The trend is graphically depicted in the Figure 5.4, which follows.

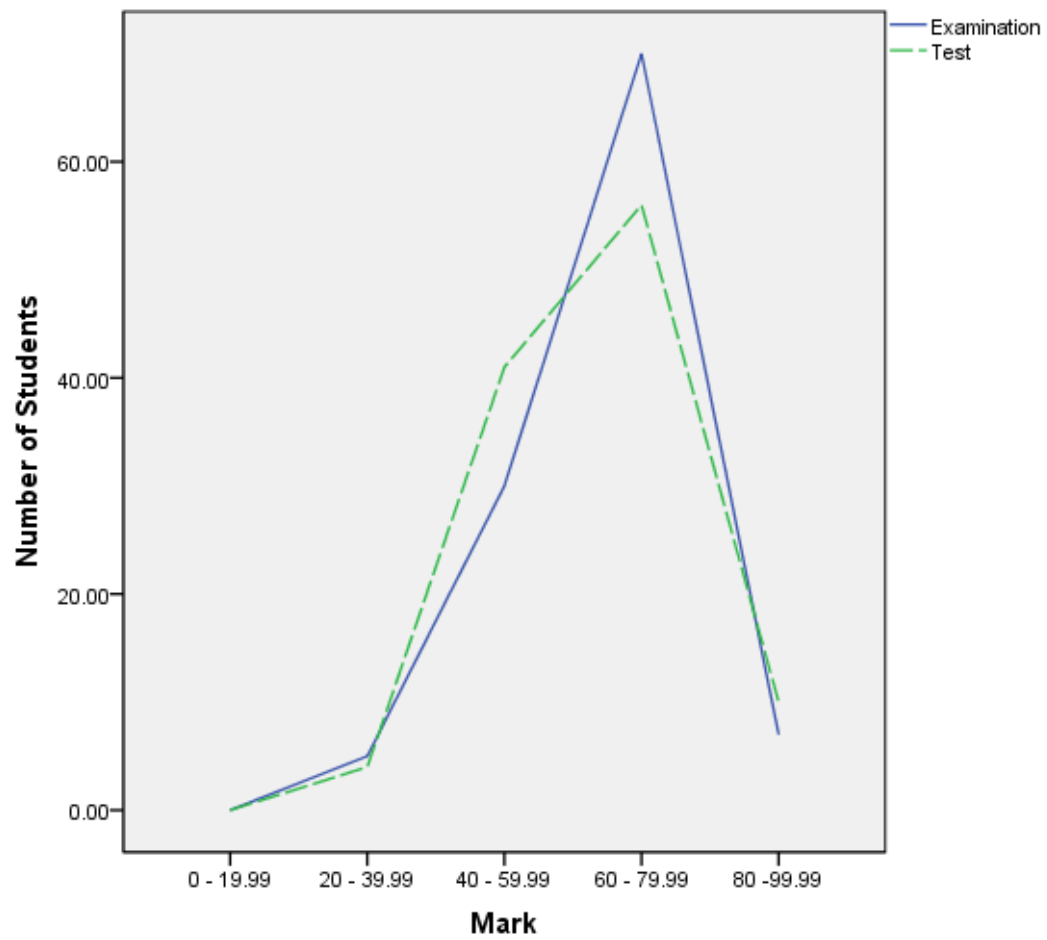


Figure 5.4: Classroom knowledge test & examination marks in case study 2

The relationship can be described as a trend with similarities but also significant differences, as can be observed in Figure 5.4, comparing the classroom knowledge test and examination marks, the frequency of student performance in both the classroom test and examination marks increased in the 70-80 mark category and decreased in the 80-100 performance mark category. The trends are also comparable in the 40-60 mark categories. The results gave the impression that the knowledge of the fluid mechanics basic concepts demonstrated in the test (research question 2 referred) was sustained and strengthened in the examination.

5. Hypothesis Three

H_0 : There is no statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and the achievement marks in the intervention examination.

H_1 : There is a statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and the achievement marks in the intervention examination.

Pearson correlation test was used to find the relationship between the intervention examination marks and the study participants' interest perception.

Table 5.26: Pearson correlation between the intervention examination marks and the study participants' interest perception in case study 2

		Examination	Mean rating
Examination	Pearson Correlation	1	0.145
	Sig. (2-tailed)		0.241
	N	67	67
Mean rating	Pearson Correlation	0.145	1
	Sig. (2-tailed)	0.241	
	N	67	67

In Table 5.26, the correlation coefficient, r , between the examination marks and the interest perception rating is given as $r = 0.145$ with a corresponding p-value of 0.241. It is noted that $p > 0.05$ level, the null hypothesis is accepted. Hence, the correlation between the examination marks and the interest perception rating is not statistically significant. This implies that the interest perception is not a factor to be considered in the study participants' intervention examination achievement.

6. Research Question Three (Classroom Observation Result)

Does CCAIML learning approach encourage instructor-students and students-students interactions?

The intervention in this case study occurred in the first semester of the 2010 academic session. It started on January 27th, 2010 and ended on May 18th, 2010. The lectures were on Tuesdays, 7.30 – 8.30 a.m and Fridays, 7.30 – 9.30

a.m in the same venue. In each of the lectures observed, there was an average of 85 study participants in attendance.

The study participants were advised to sit in groups of three to four during lecturing times, to facilitate classroom discussions and group learning. Eight classroom observations were conducted within the twelve weeks of the intervention. As was the case in the first case study, observation checklist and field notes were used to collect data on each observation scenario.

Results of the data analysis showed that lectures were presented with animation learning aid (ACIA), computer, textbooks and whiteboard. On the average, the lecturer started the lectures by posing a few questions related to the concepts learnt in the previous class and this was followed by writing the new topic on the board. A brief introduction about the new topic was given, stating the underpinning concepts that would be learnt in the topic; usually about ten minutes procedure. At this stage, the study participants were already engaged in interactive discussion about the topic. The lecturer displayed the animated illustration of the new concepts on the screen posing questions, starting with an imperative verb like "*describe*", or with an interrogative word like "*how*" et cetera, which would guide study participants into thinking, construction of knowledge and discussion. All these activities took place, while the lecturer moved through the class to moderate the study participants constructs. Study participants' construction of individual knowledge was aided by the concurrent watching of the animated illustration. After about five minutes, the lecturer requested an open response from any of the groups. In responding to the questions, the study participants drew diagrams or mould objects to demonstrate individual knowledge constructs. The answers were criticized, rejected or moderated by the whole class. However, this spanned a twenty minutes time slot.

The lecturer then displayed typical applications of these concepts in form of a problem to be solved on the screen; the study participants once again commenced group discussions on ways to solve the problem, utilizing the conceptualised underpinning concepts. The animation was still running as a guide. The lecturer once again moved through the class to contribute to the study participants' knowledge constructs. After another twenty minutes, the lecturer called on any of the groups for presentation of the solution on the board. These solutions were also contested or accepted by other groups.

The lecturer usually ended the lecture by asking the study participants for other real life situations where the concepts could be applied to aid in solving problems. The lecturer added his own experiences to the various real life situations mentioned.

The learning method introduced was also reflected in the method of assessment. The assessment was structured such that it tested the study participants' ability in practical applications of concepts as against questions that favoured memorizing concepts and problem solving procedures.

Furthermore, item 16 on the questionnaire survey required the study participants to furnish their overall evaluation of the ACIA as a learning aid. Stated below are unedited extracts of some of the results that emerged from the survey data analysis:

"It makes the studying much better and interesting because studying with visuals makes the work easier to understand and less time to study."

"The software helps visualise fluid mechanics and overall helps with a better understanding of the topic."

"Great idea – more fields of study need to visualise what is being taught, if we are learning about flow in a textbook the picture needs to move! Thank you for doing that."

"It aids were the book is not clear and give you a perfect imagination of the situation."

"I'm prepared to pay top dollar for such a learning aid. Point out types of questions that can be expected at each chapter. Great experience."

5.2.2.3 Case study 3 results

5.2.2.3(i) Profile of case study 3

The institution called case study 3 was a multi-campus university. It operates from three campuses. The three campuses have fifteen academic Faculties, which in turn consisted of more than 50 schools. One of these Faculties are the Faculty of Engineering which housed the School of Mechanical Engineering where this study was carried out. The official medium of instruction is Afrikaans as well as English.

The institution admission requirement was a National School Certificate (NSC) achievement of

- 40-49% (3 points), in three subjects (one of which is an official language at Home Language level)
- 30-39% (2 points), in three other subjects, provided that a portfolio of evidence in the school-based assessment (CASS) component is submitted in the (seventh) subject failed.

The School of Engineering admission policy was, in addition to the above requirement that a candidate must have achieved:

- Mathematics level 6 (70-79%); as well as
- Physical Sciences level 5 (60-69%); and
- Afrikaans or English level 5 (60-69%).

APs score of 31 was required. The results obtained in four Designated Subjects and two NSC subjects were used in the computation of the APS score.

The lecturer of the fluid mechanics module that was used to carry out this study is a well-experienced lecturer, with about twenty-three years lecturing experience. As at the time of the intervention, this lecturer had been lecturing the fluid module that was used to carry out this study for about seven years. The language of instruction for the module was in Afrikaans, but it was translated into English simultaneously.

5.2.2.3 (ii) Results of the analysis of the intervention data

As mentioned at the beginning of this chapter, the results are presented according to the research questions and the hypotheses that guided the study.

1. Research Question One

Does the use of ACAI facilitate the teaching of fluid mechanics in the mechanical engineering classes?

The frequency table (Table 5.27) below presents the response distributions of the study participants on the questionnaire items that probe the learning facilitation component of the intervention. The subset of the questionnaire items that were used to measure learning facilitation (q_{10} , q_{11} , q_{12} , q_{13} , q_{14} , q_{15}) were derived from the factor analysis performed in subsection 4.3.2.3 on the questionnaire items.

Table 5.27: Results of the learning facilitation in case study 3

Composite one-way frequency table: Software package intervention and learning facilitation						
Questionnaire item	frequencies per rating category					Total
Frequency Row Pct	Strongly disagree	disagree	undecided	agree	Strongly agree	
Q10. I understand the fluid mechanics concepts in illustrative movies better than reading from textbooks or lecture notes.	1 1.12	3 3.37	14 15.73	27 30.34	44 49.44	89
Q11. The software is a good learning aid.	0 0.00	2 2.25	9 10.11	40 44.94	38 42.70	89
Q12. The animated movies were fascinating.	0 0.00	3 3.37	14 15.73	43 48.31	29 32.58	89
Q13. I think the time spent using the software was a worthwhile use of my study time.	1 1.12	3 3.37	21 23.60	30 33.71	34 38.20	89
Q14. I enjoy using the software.	1 1.12	2 2.25	13 14.61	40 44.94	33 37.08	89
Q15. The software is educating.	0 0.00	0 0.00	8 8.99	27 30.34	54 60.67	89
Total	3	13	79	207	232	534

Note. In the above table, some of the cells have two figures: the upper number represents the frequency of a particular response, while the other number is the percentage of the response compared to the total number of expected responses (89).

Table 5.27 reports the total frequencies of responses for each agreement rating level indicated in the last row as 3, 13, 79, 207, and 232, these represent responses for strongly disagree, disagree, undecided, agree, and strongly agree respectively. It noted that the 'agree' and 'strongly' agree frequency distribution were 38.76% and 43.45% of the total responses. This result gave an impression that ACIA facilitated the learning of fluid mechanics in this case study.

Furthermore, Table 5.28 below gives a single summative learning facilitation perception measure of the visualization impact of the intervention on Fluid Mechanics learning.

Table 5.28: The mean scores and standard deviations of questionnaire items that address learning facilitation in case study 3

Dimension	items	Perception mean	Standard Deviation	n
facilitate learning	q ₁₀ , q ₁₁ , q ₁₂ , q ₁₃ , q ₁₄ , q ₁₅	4.22	0.47	89

Table 5.28 reports a mean learning facilitation perception rating of 4.22 and a standard deviation of 0.47. A standard deviation of 0.47 indicates high homogeneity in the dispersion of the learning facilitation rating frequencies around the mean. That is, most of the study participants' learning facilitation perception ratings fall into 0.47 brackets of the mean (3.75 – 4.69) or approximately within 4.0 and 5.0 perception rating range. Since the questionnaire rating scale allocates a point of 4 and 5 to agree and strongly agreed perception respectively, it follows that majority of the study participants are positive that ACIA facilitate the learning of the fluid mechanics module under review.

2. Research Question Two

Does ACIA, as a learning aid, arouse students' interest in fluid mechanics in an CCAIML learning environment?

The frequency Table 5.29 below presents the participants' responses distribution on the subset of the questionnaire items that probed the interest perception level of the study participants in ACIA as a learning tool in CCAIML learning environment. The subset of questionnaire items (q₅, q₇, q₈, and q₉) that were used to measure the interest perception rating were derived from the factor analysis performed on the research questionnaire (see subsection 4.3.2.3).

Table 5.29: Results of the interest perception rating in case study 3

Table Composite one-way frequency table re raised levels of interest in Fluid Mechanics						
Questionnaire item	Agreement rating levels					Total
Frequency Row Pct	Strongly disagree	disagree	undecided	agree	Strongly agree	
Q5. It presents a clearer presentation of fluid mechanics basic concepts in 3-D.	0 0.00	1 1.12	12 13.48	38 42.70	38 42.70	89
Q7. It helps me to visualize the fluid mechanics basic concepts in its 3-D form.	0 0.00	1 1.12	13 14.61	40 44.94	35 39.33	89
Q8. It helps to reinforce an understanding of fluid mechanics topics.	0 0.00	2 2.25	18 20.22	39 43.82	30 33.71	89
Q9. The animated movies make me to be more interested in fluid mechanics.	0 0.00	4 4.49	12 13.48	33 37.08	40 44.94	89
Total	0	8	55	150	143	356

Note. In the above table, some of the cells have two figures: the upper number represents the frequency of a particular response, while the other number is the percentage of the response compared to the total number of expected responses (89).

Table 5.29 reports the total frequencies of responses for each agreement rating level indicated in the last row as 0, 8, 55, 150, and 143 which represent responses for strongly disagree, disagree, undecided, agree, and strongly agree respectively. However, the 'agree' and 'strongly' agree were 42.13% and 40.17% of the total response frequencies, these were in the majority. This result gives the impression that the respondents were positive that, ACIA arouse their interest in learning the fluid mechanics module taught.

A single summative interest perception measure of the visualization impact of the intervention on Fluid Mechanics learning is given in Table 5.30. The table reports on the mean and the spread of the study participants' perception of the interest component of the study.

Table 5.30: The mean scores and standard deviations of the interest perception in case study 3

Dimension	items	Perception mean	Standard Deviation	n
Interest perception	q ₅ , q ₇ , q ₈ , and q ₉	4.22	0.48	89

The mean interest level value of 4.22 was calculated as shown in Table 5.30, with a standard deviation of 0.48. A low standard deviation, 0.48 indicated the homogeneity in the dispersion of the interest rating frequencies distribution around the mean. That is, most of the study participants' interest perception ratings fell into 0.48 brackets of the mean (3.74 – 4.70) or approximately within 4.0 and 5.0 perception rating range. Since the questionnaire rating scale allocated a point of 4 and 5 to agree and strongly agreed perceptions respectively, it followed that the majority of the study participants were positive that ACIA arouse their interest in the learning of the fluid mechanics module that was used for this study.

Test of ANCOVA assumptions

As mentioned in section 5.1.1.2, the ANCOVA assumptions of homogeneity of the regression parallelism and linearity of the relationship between the covariate and the dependent variables were carried out.

(A) Test of linearity and significance of relationship between the covariate and the dependent variables

H₀: There is no statistical significant relationship between the covariate and the dependent variable.

H₁: There is statistical significant relationship between the covariate and the dependent variable.

Pearson correlation was used to establish the correlation between the covariate and the dependent variable in each group. The results are given in Table 5.31, 5.32 and 5.33 below.

Table 5.31: Correlations in 2008 group in case study 3

		Test	Examination
Test	Pearson Correlation	1	0.769**
	Sig. (2-tailed)		0.000
	N	119	119
Examination	Pearson Correlation	0.769*	1
	Sig. (2-tailed)	0.000	
	N	119	119

** . Correlation is significant at the 0.05 level.

Table 5.32: Correlations in 2009 group in case study 3

		Test	Examination
Test	Pearson Correlation	1	0.876**
	Sig. (2-tailed)		0.000
	N	89	89
Examination	Pearson Correlation	0.876**	1
	Sig. (2-tailed)	0.000	
	N	89	89

** Correlation is significant at the 0.05 level.

Table 5.33: Correlations in 2010 group in case study 3

			Test	Examination
Test	Pearson	Correlation	1	0.790 ^{**}
		Sig. (2-tailed)		0.000
		N	117	117
Examination	Pearson	Correlation	0.790 ^{**}	1
		Sig. (2-tailed)	0.000	
		N	117	118

^{**} Correlation is significant at the 0.05 level.

Tables 5.31, 5.32 and 5.33 above show the observed correlation coefficient, r , between the covariate and the dependent variable to be 0.769, 0.876 and 0.790 for the 2008, 2009 and 2010 groups, respectively. Each of the p – value are found to be less than 0.05 ($p < 0.05$), hence the null hypothesis is rejected. This implied that there was a significant relationship between the covariate and the dependent variable in this case study.

(B) Test of homogeneity of the regression parallelism

H_0 : There is no significant similar relationship between the covariate and the dependent variable across all groups.

H_1 : There is significant similar relationship between the covariate and the dependent variable across all groups.

Table 5.34: The relationship between the residuals across the groups in case study 3

Source	Type I sum of squares	df	Mean square	F	Sig.
Treatment * Test	4657.474	2	2328.737	28.119	0.000

Table 5.34 gives a p-value of 0.000. The null hypothesis is rejected since $p < 0.05$ level. Hence, there is similarity in the regression lines across the three groups.

3. Hypothesis One

H_0 : There is no statistical significant difference in the study participants' post intervention mean achievement score in the fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the mean achievement score in the control groups.

H_1 : There is statistical significant difference in the study participants' post intervention mean achievement score in the fluid mechanics, after following CCAIML approach in the learning of fluid mechanics as compared to the mean achievement score in the control groups.

Table 5.35 below shows that the intervention, as the main effect, was not significant on the study participants' achievement in the fluid mechanics learnt at the 0.05 level of confidence. This is because the observed $F_{\text{observed}}(2, 314) = 28.119$ and $p = 0.104$, where $p > 0.05$. Hence, the null hypothesis was

accepted. It, therefore, means that the CCAIML learning model enhances the study participants' achievement in the learning of the fluid mechanics learnt.

Table 5.35: Summary of the ANCOVA on the effect of the use of CCAIML learning approach on the examination achievements in 2008, 2009, and intervention (2010) groups (case study 3)

Source	Type I sum of squares	df	Mean square	F	Sig.
Corrected Model	10122.065 ^a	5	2024.413	24.444	0.000
Intercept	1111797.013	1	1111797.013	13424.545	0.000
Test	5087.115	1	5087.115	61.425	0.000
Treatment	377.475	2	188.738	2.279	0.104
Treatment * Test	4657.474	2	2328.737	28.119	0.000
Error	26004.923	314	82.818		
Total	1147924.000	320			
Corrected Total	36126.988	319			

a. R Squared = 0.280 (Adjusted R Squared = 0.269)

The Bonferroni comparison analysis, Table 5.36 below, shed more light on the where significance occurred.

Table 5.36: Post Hoc Analysis: Multiple comparisons of means of examinations in the control and intervention groups in case study 3

(I) Year	(J) Year	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2008	2009	-0.00113	0.09908	1.000	-0.2396	0.2373
	2010	0.08403	0.09165	1.000	-0.1365	0.3046
2009	2008	0.00113	0.09908	1.000	-0.2373	0.2396
	2010	0.08517	0.09908	1.000	-0.1533	0.3236
2010	2008	-0.08403	0.09165	1.000	-0.3046	0.1365
	2009	-0.08517	0.09908	1.000	-0.3236	0.1533

Table 5.36 shows that there was no significant difference when comparing the achievements in 2008 (control) and the 2010 (intervention), 2009 (control) and 2010 (intervention), and 2008 (control) and 2009 (control) groups. Figure 5.5 below compares the achievement means across the groups.

Figure 5.5 below, shows that the intervention group performed not quite as good, compared to the 2008 and 2009 which were control groups. The results from the classroom observation support this result.

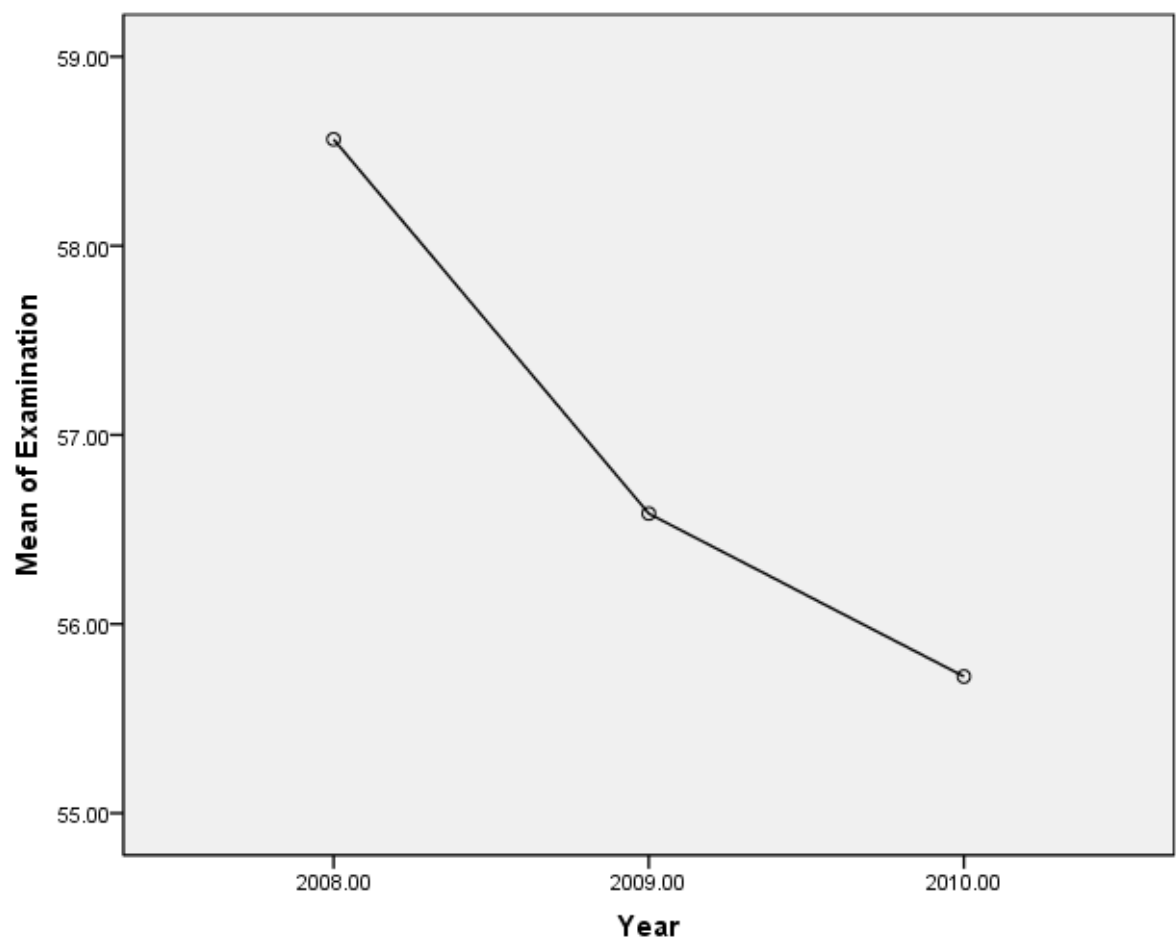


Figure 5.5: The mean plot of the examination performance in case study 3

In summary, the above results suggest that the study participants who were exposed to CCAIML learning approach did not perform better than those that were taught in the traditional approach.

4. Hypothesis Two

H₀: There is no statistical significant relationship between the study participants' intervention examination achievement marks and the achievement marks of the classroom knowledge test.

H₁: There is a statistical significant relationship between the study participants' intervention examination achievement marks and the achievement marks of the classroom knowledge test.

The knowledge test was conducted six weeks into the introduction of the intervention activities to assess whether the study participants understood the basic fluid mechanics concepts they were learning with the aid of ACIA in CCAIML learning environment. However, in this case study, ten weeks were allocated to the learning of fluid mechanics. The remaining ten weeks, out of twenty weeks that made up the second semester in which the fluid mechanics module learnt was taught was left for thermodynamics course (see subsection 4.3.4.1). Intervention started in the first week of the semester. Table 5.37 below gives the mean and standard deviation of the study participants' performance in the knowledge test.

Table 5.37: The mean scores and standard deviations of classroom knowledge test in case study 3

Analysis Variable : test							
year	N Obs	Mean	Std Dev	Maximum	Minimum	Skewness	Kurtosis
2010	118	59.31	14.09	87.00	21.00	-1.40	2.56

The Pearson correlation test was used to find out the relationship between the intervention examination marks and the classroom knowledge test marks. The results were given in the Table 5.38 below.

Table 5.38: Pearson correlation of the intervention examination and classroom knowledge test marks in case study 3

			Test	Examination
Test	Pearson Correlation		1	0.790**
	Sig. (2-tailed)			0.000
	N		117	117
Examination	Pearson Correlation		0.790**	1
	Sig. (2-tailed)		0.000	
	N		117	118

** Correlation is significant at the 0.05 level.

Table 5.38 above shows the observed correlation coefficient, ($r=0.790$) between the intervention examination marks and the classroom knowledge test. The $p = 0.000$ is less than 0.05 ($p < 0.05$). Therefore, the null hypothesis is rejected. This implies that, there is a significant relationship between the intervention examination mark and the classroom knowledge test. The trend is graphically depicted in the Figure 5.6 which follows.

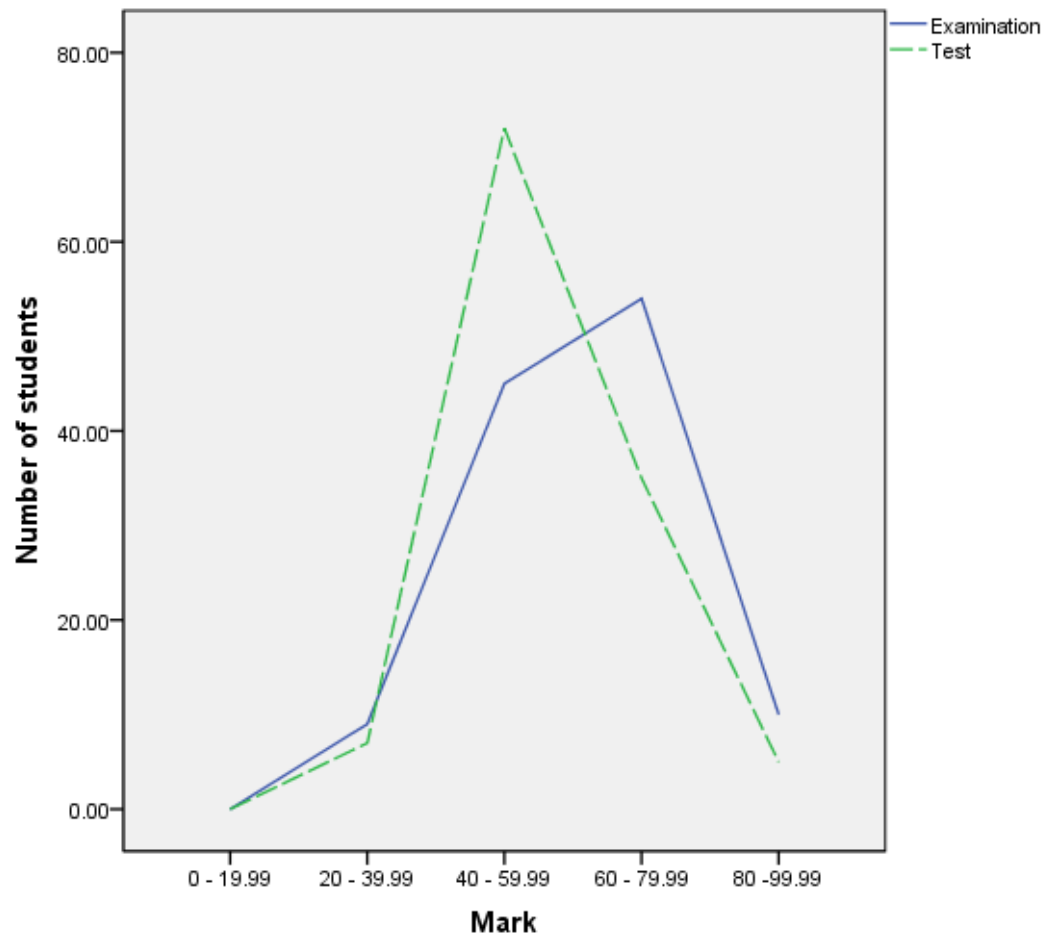


Figure 5.6: Classroom test and examination marks in case study 3

From Figure 5.6, the researcher noted that the relationship could be described as a trend with similarities but also significant differences: for the classroom knowledge test, the majority of the frequency of student performance were in the 50-60 mark category, while in the examination more of the frequency of students' performance were in the 60-80 mark category. In both knowledge test and examination, the performance frequency decreases in the 80-100 performance mark category.

5. Hypothesis Three

H_0 : There is no statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and the achievement marks in the intervention examination.

H_1 : There is a statistical significant relationship between the study participants' interest perception in the use of ACIA in CCAIML learning approach and the achievement marks in the intervention examination.

The Pearson correlation test was used to find the relationship between the intervention examination marks and the study participants' interest perception.

In Table 5.39 below, the correlation coefficient, r , between the examination marks and the interest perception rating is given as $r = -0.104$ with a corresponding p-value of 0.331. It is noted that $p > 0.05$ level, the null hypothesis is accepted. Hence, the correlation between the examination marks and the interest perception rating was not significant. This implied that the interest perception is not a factor to be considered in the study participants' intervention examination achievement.

Table 5.39: Pearson correlation between the intervention examination marks and the study participants' interest perception in case study 3.

		Examination	Mean rating
Examination	Pearson Correlation	1	-0.104
	Sig. (2-tailed)		0.331
	N	89	89
Mean rating	Pearson Correlation	-0.104	1
	Sig. (2-tailed)	0.331	
	N	89	90

6. Research Question Five (Classroom Observation Results)

Does CCAIML learning approach encourage instructor-students and students-students interactions?

As mention before, the classroom observation was structured to answer the classroom dynamic component of the study. Four different classroom observations were carried out during the eighteen weeks intervention to assess the effectiveness of the proposed CCAIML learning model of fluid mechanics. Intervention started 1st of February and ended on the 12th of May, 2010. On the average, about 91 study participants attended the observed lectures. Lectures were one hour period in duration and presented in Afrikaans with occasional explanation of concepts in the English language. The observation checklist was used to collect data and field notes of important events, during the lecture, were also recorded.

Data from the observation checklist were gathered and organised, including data from field notes. A spreadsheet was created to analyse the data. The data analysis included an in-depth look at the fluid mechanics learning procedures, the classroom dynamics as well as how applicable and facilitative was the proposed CCAIML learning model, in the learning of fluid mechanics.

The results of the data analysis showed that the study participants were always excited when watching the illustrative animation of the fluid concepts of the day and immediately engaged in interactive discussion. As soon as a new topic as well as the illustrative animation was displayed, the study participants demonstrated interest in the topic and became inquisitive. Usually, the lecturer displayed the topic of the day and gave a brief explanation of the underpinning concepts. The lecturer also took some time to explain in Afrikaans, the animated illustration displayed from the ACIA CD.

While watching the illustrative concept animation, the study participants, who were sitting in groups of three or four engaged in discussion and tried to conceptualise the application of the concepts to solve problems. The lecturer asked questions, which always demanded the study participants to express or demonstrate the individual understanding of the concepts.

Thereafter, the lecturer displayed a problem, which required the knowledge of the new concept to be solved, while the illustrative animation was still running. Each group discussed and solved this problem in their groups. The lecturer moved through the class to moderate the study participants' activities. After about twenty minutes the lecturer called on any of the groups to present answers to the class. The answers were criticised or accepted by other groups.

The lecturer ended the lecture with a discussion of the application of the concepts in solving real life problems. The study participants expressed personal views which sometimes involved practical demonstration of the application. An

extract of unabridged responses of the study participants, to the questionnaire item 16, which required the participants to provide an overall evaluation of the ACIA as a learning aid are cited below:

"The software aided me significantly in the visualisation of fluid mechanics and thereby helped me in understanding the basic concepts of the subject."

"Nice one, but needs more interactive programs, which you can input values and see the results thereof. Plus more detailing on the formulas."

"It is a good idea to use modern presentation of difficult concepts, but still needs a more colourful presentation to keep your attention fixed on the work."

"The software can be helpful to people struggling to understand fluid mechanics."

"Was a great learning tool. Easy to use and gave me a better understanding of the subject of fluid mechanics."

5.2.2.4 Case study 4

5.2.2.4(i) Profile of case study 4

The institution designated to case study four was one of the South Africa's oldest universities, and was one of Africa's leading teaching and research institutions. Over 23 500 students enrolled at this institution in 2009 and nearly half of this student population were black. Of these, more than 15 800 were undergraduates working on a first degree or undergraduate diplomas and certificates, and over 6 700 were doing a postgraduate qualification

(postgraduate diplomas all the way to doctoral studies). The institution has seven Faculties including the Faculty of Engineering & the Built Environment. The disciplines within the Faculty of Engineering & the Built environment comprised the following departments: Architecture, Planning and Geomatics, Civil Engineering, Construction Economics and Management, Chemical Engineering, Electrical Engineering and Mechanical Engineering. Lectures were offered through medium of English.

The institution's general admission requirements were as follows:

- obtain the NSC endorsed for degree studies;
- satisfy specified subject requirements; and
- obtain the required number of admission points.

The admission requirements for Mechanical Engineering, where the case study was carried out, were as follows:

- Mathematics 6 points (70%-79%);
- Physical Science 5 points (60%-69%); and
- 32 admission points.

The lecturer was a middle-aged man with about eleven years lecturing experience. He is currently a Senior Lecturer in the Department of Mechanical Engineering.

As mentioned in section 4.2 the fourth case study did not keep up with the schedule, rendering the researcher unable to perform research activities on the prescribed dates. Unfortunately this prohibited this case study's intervention.

5.2.3 Summary of findings

Below is the summary of all the major findings:

- ACIA facilitated the learning of the fluid mechanics module taught in the class, in the CCAIML learning environment;
- ACIA arouse the study participants' interest in the learning of fluid mechanics module learnt in the class;
- The study participants understood fluid mechanics module learnt in the class better, in the CCAIML learning environment, and were able to demonstrate this in the post intervention examination ;
- The CCAIML learning approach encouraged classroom interaction, group and individual knowledge construction, practical demonstration of understanding of concepts and consequently improved classroom dynamics;
- The study participants achieved more in the fluid module learnt in the class at the post intervention examination, by using CCAIML learning approach compared to the traditional approach;
- A relationship was established between the level of study participants' interest in the Software used to aid learning and the study participants' post-intervention achievement; and
- If the language medium of the instructional aid was different to that of the classroom medium of instruction, then the learners' achievements were affected.

The above finds are discussed in the next chapter.

CHAPTER 6

SUMMARY, DISCUSSION, IMPLICATIONS, CONCLUSION AND RECOMMENDATIONS

This chapter discusses the summary of the study and also the results presented in Chapter 5. The summary of the findings as enumerated in subsection 5.2.3, are discussed in light of the research questions and hypotheses. In addition, the limitations, implications of the researcher's findings, conclusion and suggestions for further research are also discussed.

6.1 SUMMARY OF THE STUDY

This study was carried out to investigate the effect of introducing Animated Computer Instructional Aid (ACIA) in the learning of fluid mechanics. It was also intended as a means to evaluate the CCAIML learning model, which was developed and proposed for learning fluid mechanics. CCAIML included the use of ACIA as a learning aid. Three theories underpinned CCAIML learning model: the Constructionist learning theory, Media-Affects-learning hypothesis and Multiple representation principle.

The study participants were the intact classes of first-time fluid mechanics students in Mechanical Engineering in four South African universities, who award Bachelor of Engineering degrees in Mechanical Engineering. The study followed a mixed method approach: involving a static group design and a descriptive survey design. The control groups were the two consecutive, immediately preceding intact groups, who were taught fluid mechanics through the traditional lecturing method. The intervention groups were the non-randomized mechanical engineering students, who were taught by the same lecturer, who taught the control groups the same course material through a traditional

approach, but taught the intervention group using the CCAIML learning approach.

A number of statistical tools like, Pearson correlation tests, composite one way frequency tables with associated mean and standard deviation, Cronbach's alpha scale reliability test, ANCOVA and Bonfferoni multiple comparison of means, were used to analyse data obtained in the study. The findings of the study showed that:

- ACIA facilitated the learning of the fluid mechanics module taught, in CCAIML learning environment;
- ACIA aroused the study participants' interest in the learning of fluid mechanics module taught in the class;
- The study participants understood the fluid mechanics module taught in the class better, in CCAIML learning environment, and were able to demonstrate this in the post intervention examination;
- CCAIML learning approach encouraged classroom interaction, group and individual knowledge construction, practical demonstration of understanding of concepts and consequently improved classroom dynamics;
- The majority of the study participants achieved higher scores in the fluid module taught in the class in the post intervention examination, by using CCAIML learning approach compared to the traditional approach;
- No relationship was established between the level of study participants' interest in the software used to aid learning ACIA and the study participants' post-intervention achievement; and

- Where the language medium of the instructional aid was different to that of the classroom medium of instruction, the learners' achievement was affected negatively.

6.2 DISCUSSION

As mentioned above, the outcomes of the study shall be discussed in view of its research questions and hypotheses. Therefore, the following sub-headings were used:

- The effect of the intervention on the study participants' post intervention achievements;
- The effect of the intervention on classroom dynamics;
- The effect of the intervention on the study participants' level of understanding of the fluid mechanics taught during intervention;
- Study participants' interest in learning fluid mechanics in CCAIML learning environment; and
- The relationship between the medium of classroom instruction and the language, in which instructional aid is compiled.

6.2.1 The effect of the intervention on study participants' post intervention achievements

One of the major results of this study was the findings that there were marked differences in achievements when comparing the marks obtained in the control groups and the marks obtained by the study participants in the intervention groups.

In case studies 1 and 2, the F-value of the test of null hypothesis, which probed the achievement level, were statistically significant (see Table 5.9 and 5.22 respectively). The p-value in both cases was less than 0.05 levels. This implies that there was a statistically significant difference in the achievement level of the study participants, who learnt fluid mechanics with the aid of ACIA in CCAIML learning approach, compared to the marks obtained by the students in the control groups, who learnt the same fluid mechanics material through a traditional approach and were taught by the same lecturer. Thus, CCAIML learning model may have enhanced the study participants' achievement in the fluid mechanics module used to carry out this study in case studies 1 and 2. This conformed to the findings of Mayer and Anderson (1992), which claimed that when pictures and words were used in instruction, it enhanced the students' achievement. Furthermore, Alper (2009) and Ogbonnaya (2010) also indicated that the use of technology in the learning of mathematics enhanced students' achievement. Thus, in case study 1, the mean examination mark, in the intervention group, was 68% compared to the 57.28% and 56% mean marks for 2007 and 2008 respectively, which were the control groups (see Figure 5.1). Moreover, in case study 2, the mean examination mark, in the intervention group, was 62.40% compared to the control groups' mean mark of 57.28% and 57.63% for 2008 and 2009 respectively (see Figure 5.3).

Furthermore, the results from the classroom observations, showed that the study participants in case studies 1 and 2 were always very active in the class, answering and asking questions, bringing materials to the lecture room to demonstrate fluid mechanics concepts physically, and proffering new ideas. Therefore, it may be deduced that they were probably enthusiastic about fluid concepts, because of an improvement in their learning of fluid mechanics (as against the uninspiring traditional teaching method reported in the baseline study, see subsection 5.2.1), due to the use of CCAIML - see subsection 6.2.4 (Yushau, Mji, & Wessels, 2003). Moreover, this result conformed to Skinner's (1950) *Operant Conditioning* result reviewed in subsection 2.1.2.3, which stated

that when a participant learns, responses increase and when unlearning occurs, the rate of responding falls. Skinner preferred this qualitative measure of learning to the quantitative results reported above because, according to Skinner, it provides an orderly and continuous record of behavioural change, free of arbitrary criteria.

However, in case study 3, there was no statistically significant difference between the achievement level of the study participants, who learnt fluid mechanics in CCAIML learning approach using ACIA, and the control group, who learnt the same fluid mechanics material through a traditional approach and were taught by the same lecturer. In this case study, learning fluid mechanics in CCAIML approach did not have any statistically significant effect on the study participants' achievement in fluid mechanics. The mean examination mark, for the intervention group, was 55.80% compared to the 58.50% and 56.50% mean marks for 2008 and 2009 respectively (see Figure 5.5).

The results from the classroom observations revealed that the study participants in case study 3 displayed a different attitude. Instead of being enthusiastic, like their fellow students in the other case studies, they generally asked questions which indicated that they were not enjoying and following the lectures. One may then consider this observation to be in line with the principle of Skinner's *Operant Conditioning*. Perhaps, their difficulty in following the lectures may be as a result of the fact that ACIA CD was compiled in English language. As was mentioned in subsection 5.2.2.3, this set of students were natural Afrikaans speaking people and the lectures were mainly in Afrikaans.

Furthermore, also emanating from case study 3 during a different lecture, some students were overheard when they stated they were not enjoying the class, because they always wanted to copy and memorize the lecturer's notes. However, CCAIML approach encouraged them to work on their own. The results suggest that CCAIML approach enable the students to learn on their own, thus

constructing or discovering knowledge by themselves. Reeder (2007) noted that the ability to memorize facts does not necessarily imply understanding of content. Though, the majority of these study participants passed very well in the knowledge test, it was noted that they wrote the test while the intervention was still on. One might say that, the study participants memorized the contents just to pass the knowledge test or had a superficial, yet not deep understanding of the fluid mechanics concepts tested. Reeder further remarked that at some point, learners' grasp of the concepts become deep or sophisticated enough that they can use their knowledge in practical ways. Perhaps, since the majority of the study participants, in this case study, could not follow the lessons that probably facilitated gaining a deeper understanding of the concepts, they were therefore unable to solve new problems in the examination. The difference in the medium of instruction was indicted as a factor for the non-achievement results obtained in this case study. These results, further gave credibility to the outcomes of this study, in that all the conditions in case studies 1, 2 and 3 were the same, except for the medium of instruction, discussed here.

In view of the above, CCAIML learning approach might have enhanced the learning of the fluid mechanics module used to carry out this study, more than the present traditional approach, with which fluid mechanics is taught in South African universities. Technology facilitates the learning of mathematics, (Naatanen, 2007). Hence, CCAIML hypothesis, stated in subsection 2.5.2, has been proved. These results conform to the remark made by:

- Papert (1993) that deep, substantive learning and enduring understanding occurs when the public construct, which in this case was ACIA, is added to mental construct;
- Bandura (1977) that learners perform best when they learn in a community of social practice; as well as
- Mayer and Moreno (1998) that the principle of multiple representations implies that students learn better when they are taught both in words and pictures.

All these learning approaches were built into CCAIML:

- to make one learning model,
- to meet the significance of the study,
- to promote active learning,
- to improve the quality of graduating engineering students, and
- to encourage more learners into engineering fields, as stated in section 1.3.

6.2.2 The effect of the intervention on classroom dynamics

The approach to teaching during the intervention in case study 1, 2, and 3 followed the proposed CCAIML learning model. The four learning phases that made up the instructional steps in CCAIML learning model were followed, see subsection 2.5.2.

The results of the qualitative research method informed that, in lectures, the study participants were divided into groups of three or four, to facilitate classroom discussion among them. Repeatedly, it was evident that as soon as the animation was displayed on the screen, the study participants in the different groups would start murmuring, gesticulating and pointing to the running animations. The discussions in each group were always guided by a leading question from the lecturer, such as, "*How would you describe.....?*" or "*Explain.....*". The animation was kept running throughout the duration of the lecture. This aided the study participants' deliberations and knowledge construction. The lecturer moved round the class and visited each group to moderate their discussions.

After deliberations in each group, the group/s selected by the lecturer supplied answers to the lecturer's question, as a way to indicate to the remaining members of the class, the level of knowledge construction achieved by the individual and/or group. For example, in one of the lectures observed, in case

study 2, a student demonstrated the concept of laminar flow by pouring a glass of water on the smooth floor of the classroom, to show how the layers of the water molecules moved smoothly until they came to a stop. She related this demonstration to the animation. It was very interesting for me to observe this.

The researcher wishes to emphasize here that, CCAIML instructional steps encouraged building knowledge structures through progressive internalization of actions, (Papert, 1991) and that learning takes place in a community of social practice. This learning process is capable of fostering deeper conceptual understanding. This is what is needed to connect the classroom theory with the engineering field practices (see subsection 5.2.2.1, for the full demonstration of CCAIML learning approach).

The activities narrated above are contrary to the findings obtained from the baseline study (subsection 5.2.1), where the students usually kept quiet and copied notes, while the lecturer discussed his prepared notes without any students' engagement. However, Vygotsky (1978) acknowledged the role of other actors and culture in the process of knowledge construction, and advocated that knowledge is socially and culturally constructed and not transmitted. When students learn through the traditional learning approach, they often memorize the contents to pass examinations (Reeder, 2007). Ramsdeen (1992) concurred when he noted this weakness in students and remarked that in general students only concentrate on obtaining their degree rather than gaining knowledge. However, as mentioned in section 1.1.1, engineering practice entails solving practical, real life problems. Therefore, engineering students are required to have the ability to apply theoretical concepts in solving practical problems.

Students need to learn for themselves, rather than shape their ideas on some other authorities. The researcher noted from literature (Papert, 1993) that constructionist learning theory, which is one of the learning theories that underpins this study, is not popular amongst engineering educators and

engineering education researchers. However, the researcher in the present study believes that the principle of constructionist learning approach is the needed learning approach that could address most of the recent emanating difficulties (such as, teaching ever growing large engineering classes, students' understanding of difficult to learn areas in fluid mechanics and students' failing to connect theoretical concepts to field practices) in engineering classes today. CCAIML encouraged classroom dynamics and provided a conceptual link between engineering practice and fluid mechanics' theoretical concepts. In addition, it allowed the study participants to construct knowledge individually and try out what was constructed publicly.

CCAIML learning approach has proved more effective compared to the normal current traditional learning approach of fluid mechanics as mentioned earlier and may be a better option to the "normal traditional teaching to be interspersed with active learning" approach proposed by Cole and Spence (2010), which they hope could solve the problem of teaching large engineering classes. In CCAIML learning approach, the lecturer must not only stand in front of the class, while trying to reach the whole class but move around provide the 'zone of proximal development' when necessary. After a brief introduction of the topic, the lecturer in CCAIML learning environment, should display the illustrative animation, to provide the students with the required "zone of proximal development" in the process of knowledge construction and allow the students to engage in individual construction and discovery of knowledge, in their different groups. CCAIML was structured to produce the most learning for the least teaching (Papert, 1993). Case studies 1 and 2, had large classes: an average of 104 students, and yet learning proved facilitated and very successful.

The results of the analysis of the questionnaire data also supported the qualitative results discussed above, in that the study participants were generally pleased with CCAIML learning approach. The results of the research question on learning facilitation were positive. The study participants generally agreed that

ACIA used in CCAIML learning approach facilitated or assisted them to learn the fluid mechanics taught during intervention easier than the traditional learning approach. This result agreed with Leung, Lu and Lu (2008), who remarked that good teaching and learning context, influences the learning process and determines the learning outcome.

In case study 1 (Table 5.1), 77.34% of the questionnaire respondents agreed that the use of ACIA in CCAIML learning approach facilitated the learning of the fluid mechanics taught during intervention. This is an indication that the respondents were generally positive in their opinion. The mean rating of the respondents' learning perception was 4.03 (Table 5.2). It should be noted that each agreement level carried a weight, ranging from 5 = "strongly agree" to 1 = "strongly disagree" (see subsection 4.3.2). Further analysis showed that the 4.27 facilitation mean rating was stable (see discussion under Table 5.2).

Likewise, in case study 2 (Table 5.14), a total of 67.58% of the respondents were positive about the use of ACIA in CCAIML learning environment with a perception mean of 3.94 (Table 5.15). In addition, further analysis on this mean perception showed that the respondents' rating fluctuated around 3.94. In case study 3 (Table 5.27), 82.21% of the respondents were positive in their opinion that ACIA facilitated learning. The mean perception ratio in this group was 4.22 (Table 5.28). Further analysis on this mean perception revealed that the 4.22 facilitation mean rating was stable (see discussion under Table 5.28).

6.2.3 The effect of the intervention on study participants' level of understanding of the fluid mechanics taught during intervention

Central to the above claims that CCAIML facilitated learning in fluid mechanics taught during intervention, is the level of measure in which these factors affected the study participants' conceptual understanding in the fluid mechanics module taught during intervention and consequently, the examination

achievement. Drawing from the literature cited in subsection 2.1.1, for example, Ramsden (1992) remarked that, it is expected that if the learning is facilitated, it should reflect in the level of understanding of the module and similarly in the academic achievement. In addition, Mayer and Moreno (1998) noted that lectures presented in line with the multiple representation principle offered a potentially powerful venue for improving the students' understanding.

The classroom knowledge test was administered six, four, and six weeks into the intervention in case studies 1, 2, and 3 respectively. The findings showed that in case study 1, the majority of the study participants scored between 50.67% and 84.27% (see Table 5.11). Similarly, in case studies 2 and 3, the majority of the study participants scored between 50.35% and 74.65%, and between 45.22% and 73.40% respectively (see Tables 5.24 and 5.37). The outcome of the classroom knowledge test, suggested that, the study participants understood the fluid mechanics concepts taught in the CCAIML learning approach.

These results conformed to the findings of the previous studies (Ramsden, 1992; Mayer & Moreno, 2001; Goos & Bennison, 2007; Naatanen, 2007; Alper, 2009). Since the study participants were learning fluid mechanics for the first time, it can be said that their performances may have been influenced by CCAIML learning approach they were exposed to. The results from two of the three case studies were unanimous.

6.2.4 Study participants' interest in learning fluid mechanics in CCAIML learning environment

The analysis of the results, in case studies, 1, 2 and 3 showed that the participants were generally positive about the CCAIML learning approach. They stated that the use of CCAIML learning approach aroused their interest in the study of fluid mechanics (see also subsection 6.2.1).

In case study 1 (Table 5.3), 46.51% and 44.77% of the study participants (representing “agreed” and “strongly agreed” frequencies respectively) agreed that the use of ACIA aroused their interest in the learning of fluid mechanics taught during the intervention. Thus, the majority of the study participants agreed that the use of ACIA aroused their interest in the learning of fluid mechanics. The mean calculation of the respondents’ interest perception rating gave a value of 4.22 (see Table 5.4). The questionnaire rating scale allocated a point of 4 and 5 to “agree” and “strongly agree”. Further analysis, on the mean perception showed that the mean perception rating of 4.22 was stable. These results conform to the findings of Philpot and Hall (2006) in the mechanics of material course reviewed in subsection 3.1.

However, from the researcher’s interactions with the participants during classroom observations, some the students, who mentioned that knowledge should be received from a knowledgeable lecturer, found CCAIML learning approach uncomfortable. This attitude conformed to the remark by Raymond (2008) that learners enter new learning with some preconceptions that are resistant to change. This may be why 18% of the study participants’ perception was negative.

Similarly, in case study 2 (see Table 5.16), 73.29% of the study participants agreed that ACIA aroused their interest in learning fluid mechanics. The mean of the study participants’ interest perception rating was 3.96 (Table 5.17). Table 5.16 showed that the frequency of undecided responses were quite high (116, which reflected 22.70% of the total responses). The researcher believed that this may have affected the mean perception rating calculated. This was also reflected in the data analysis of the classroom notes of a group of study participants who commented that they preferred to listen to the lecture and copy notes. They only had to memorize the notes copied in the lecture room to write either the test or examination. Perhaps, this group of study participants made up the 22.70%, who were undecided in their interest perception rating.

In case study 3 (Table 5.29), the majority (82.30%) of the study participants were positive that ACIA aroused their interest in learning fluid mechanics under review. Table 5.30, gave the mean interest perception as 4.22. The results from the field notes showed that, though the study participants were enthusiastic about the use of the ACIA and CCAIML learning method, they had problems with the English language medium in which it was compiled.

However, it was also found that interest alone was not the only factor that determined the achievement level in fluid mechanics. This was because the Pearson correlation coefficient r between the interest perception rating and achievement, was not statistically significant in any of the three case studies, where intervention was completed. In case study 1 (see Table 5.13), the Pearson correlation $r = 0.097$ with $p = 0.471$, $p > 0.05$. In case study 2 (Table 5.26), the Pearson correlation $r = 0.145$ with $p = 0.241$, $p > 0.05$. In case study 3 (Table 5.39), the Pearson correlation $r = -0.104$ with $p = 0.331$, $p > 0.05$. In addition the mean interest perception rating for case study 3 was 4.22 (Table 5.30). This is a high interest perception rating, but yet the mean examination achievement was 55.47 (Figure 5.5), the achievement level was not statistically significant (Table 5.35). As mentioned above, the analysis showed that in the three groups the study participants generally agreed that the software aroused their interest in the fluid mechanics module reviewed.

6.2.5 The relationship between the medium of classroom instruction and the language in which the instructional aid is compiled

In case study 3, the general mean interest perception rating of the study participants was calculated as 4.22 with a standard deviation of 0.48 (Table 5.30). This implied that the majority of the study participants' mean interest perception rating fell within the range of 3.74 and 4.70. However, this positive interest perception rating failed to have any effect on the study participants' achievement in the intervention examination (see Figure 5.5).

The classroom instructional medium in case study 3 was Afrikaans. The medium in which the ACIA learning aid was compiled, English, is indicted here, since all other intervention conditions were the same as in case studies 1 and 2. The study participants in case study 3 are, naturally, Afrikaans speaking people. Boero, Douek and Ferrari (2002:242) informed that only when students are fluently familiar with the use of the natural language, can they perform in a satisfactory in mathematics (it should be noted that fluid mechanics, which the module used to carry out this study, is a branch of mathematics). Perhaps, the study participants were not too familiar with the English language. It was also noted that the prescribed textbooks were written in English, hence the researcher surmised that the study participants in case study 3 should not have any problems in comprehending the animated illustrations compiled in English. However, the observation of Bohlman and Pretorius (2008:43) is important here. Bohlman and Pretorius noted that the conceptual complexity and problem solving nature of mathematics make extensive demands on reasoning, interpretive and strategic skills of learners, more so when these activities were carried out in an instructional medium that is not the learners' natural language.

The qualitative results also supported this finding. Some of the results from the observation notes, from case study 3, reflected comments made by a small group of study participants. The group commented (in English) that they preferred to memorize the lecturer's notes and pour it out in the examination. This was also noted by Reeder (2007). Maybe the case study 3 participants depended more on the lecturers' notes than the text books. The researcher did not anticipate this result; otherwise this variable would have been included among those variables investigated. More research is necessary in this direction; to determine the relationship and/or effect of the difference in the instructional medium and the language in which an instructional aid is compiled in fluid mechanics.

6.3 IMPLICATIONS

Although, the results of this study corroborated the concepts underpinning the constructionist theory, the medial-affects–learning hypothesis and the multiple representation principle, which formed the framework for this study, caution must, however, be exercised in other areas not to rest on the assumption that CCAIML learning model is a panacea for all the learning ills in engineering education.

To guarantee the efficacy of CCAIML as a learning model, commitment from all role players involved; the fluid mechanics learners, lecturers of fluid mechanics, school administrators and fluid mechanics curriculum planners, are very essential. Effective learning is inspired by good teaching strategies. Good teaching strategies encourage the students to learn particularly in a social context (Vygotsky, 1978; McDevit & Ormond, 2004). The students are given the opportunity to discuss and search for new ideas with the aid of conceptual animations, evaluate their own ideas and apply the new knowledge in finding solutions to practical real-life problems (Papert, 1991). Against this backdrop the research in this study imply the following:

1. Fluid mechanics lecturers should provide to the students, ample opportunity to formulate their own ideas as provided for in CCAIML learning model, rather than students absorbing the lecturer's own ideas. It is important for the fluid mechanics lecturers to note that all knowledge emanates as a hypothetical construction (Piaget, 1980; Papert, 1991; Vygotsky, 1978; Shé and Looney, 2007). The knowledge that the study participants constructed by themselves is more meaningful than that which was transmitted to them by someone else (Killen, 2007). The lecturer should only play the role of a learning facilitator in the lecture room. The instructional method should support student-centred

instruction, instead of lecturer-centred instruction (Eyyam, Menevis, & Dogrur, 2010).

2. Fluid mechanics teaching should aim at exposing students to activities that involve exploring multiple sources in the search for new ideas. This makes the animations of theoretical concepts, like ACIA in CCAIML learning model, imperative in learning fluid mechanics. It aids students' imaginative skills, and facilitates the process of knowledge construction. As noted by Moreno (2006) and Taiwo (2009), multiple representations of concepts facilitate learning. In addition, evidence from this study has shown that learning activities, which engaged fluid mechanics students in a critical search for new ideas, enhanced critical thinking. Assimilation should therefore, not be seen as a passive registration of new ideas, but rather as a filtering of new ideas through an action structure, so that the structures are themselves enriched (Bell-Gredler, 1986).
3. In providing conceptual animated learning aid, it is important to develop the learning aid in a language medium, which will be the same as the classroom instructional medium, where it will be used. When the instructional aid is constructed in a language the students are not familiar with, learning might be impaired (Boero, Douek & Ferrari, 2002; Bohlman & Pretorius, 2008). This was evidenced in case study 3.
4. It is also imperative that the fluid mechanics curriculum needs to be adjusted (Desha & Hargroves, 2010; Glassey, 2010) such that it gives sufficient time to accommodate the instructional strategies proposed by CCAIML. Obviously, the current traditional instructional strategies need less time to complete the fluid mechanics scheme of work in a semester, compared to CCAIML learning environment, where each student constructs his or her own knowledge, which has to be criticized or accepted by other students in the class. As noted by Piaget (1977),

knowledge construction is a complex cognitive process. It involves four distinctive cognitive events: formulation of ideas, inquiry, review of meaning, and transfer of knowledge. Time plays a crucial role in this process. In addition, the current method is lecturer-centred. CCAIML is a student-centred approach (Kahn & Walsh, 2006). The pace of the lecture is decided by the students, while the lecturer moderates. In addition, the curriculum should emphasize practical knowledge construction as well as theoretical concepts application.

5. Concerning the assessment procedures in view of the proposed learning outcome of CCAIML, fluid mechanics should avoid the standardized assessments. Instead, the assessment should focus more on how students can demonstrate adequate knowledge in practical application of concepts as advised by Papert (1993). In addition, assessment should be made part of the learning process, so that students play a larger role in judging their own progress.
6. The fluid mechanics lecturers should pursue a short teaching qualification course; to better equip themselves in performing their duties as educators. According to Achor, Imoko, and Uloko (2009), lecturer's non utilization of an appropriate teaching method results in students' low achievement. It was observed that all the fluid mechanics lecturers used in this study did not have any teaching qualification; they only had the content knowledge, but lacked the professional skill to guide the students appropriately to acquire the necessary knowledge. Generally, the engineering lecturers in South Africa do not have teaching qualifications. It is pertinent that anybody who is involved in the art of teaching, at any educational level, should have a teaching qualification. Perhaps, if the fluid mechanics lecturers involved in this study were to have had a

teaching qualification, they would have approached the use of CCAIML in a better way.

The management of Rhodes University, South Africa, also observed this professional deficiency in some of the South African university lectures and set up 'The Centre for Higher Education Research, Teaching and Learning' [CHERTL]. Part of the objective of this centre is to develop university lectures as professional educators.

7. Conducting a research that involves evaluating students' achievement in the universities, may pose some challenges. In South Africa, each university is autonomous both in practice and curriculum design. Therefore, clustering universities into control and treatment groups may compromise the study, because of these inherent contextual differences. Furthermore, the university authority may not allow the control and treatment groups' research design, since it may constitute double standards, because all the students write the same end-of-the-semester examination. In the light of the various challenges enumerated above, static group design looks most appropriate for this type of study (Washington, Parnianpour, and Fraser, 1999).

6.4 LIMITATIONS

This study was carried out despite some intrinsic limitations. As a result of these unavoidable limitations, the findings and, consequently, the conclusions drawn may have been affected in one way or the other. These limitations are enumerated and explained below:

1. It was noted that all the fluid mechanics lecturers used in this study did not have any teaching qualification; they only had the content knowledge. If they had a teaching qualification, they might have approached the use

of CCAIML in a better way. Perhaps, the results of the study would have been different.

2. A bigger sample space of at least five universities, out of the eight South African universities that were eligible to participate in this study, is preferred. But only four universities indicated their interest to participate in the study. Conversely, one of the four universities that originally agreed to be part of the study, dropped out when it could not keep up with the schedule dates for data collections, leaving the study with only three case studies. Nevertheless, the quality of the study was not compromised, given the type of its design (see section 4.1), combined with the fact that sufficient necessary data could still be gathered from the three remaining universities.

6.5 CONCLUSION

As stated in subsection 1.3, the researcher's intentions to carry out this study were to promote active learning of fluid mechanics, improve the quality of graduating mechanical engineering students and to encourage more learners into engineering fields in South African universities. The findings that emerged from the study suggested that learning fluid mechanics in CCAIML learning environment has potential to meet all the above intentions of the researcher. Actually, the use of CCAIML to learn fluid mechanics might bring about the much needed solutions to skill shortages in the field of engineering in South Africa. The researcher in this study, therefore, proposes that CCAIML be used in the learning of fluid mechanics in engineering classes in South African universities.

6.6 RECOMMENDATIONS FOR FURTHER STUDIES

Considering CCAIML as a new leaning model in engineering education, the fact that the primary intentions of this study were met (subsection 6.5), paves the way for this study to span other research ideas. Thus, the researcher in this study suggests the following for further research:

- Investigate the effect of the researcher's learning model on students' academic achievement in higher fluid mechanics modules in mechanical engineering;
- Investigate the effect of the researcher's learning model on students' academic achievements in other similar modules in other engineering courses different from mechanical engineering;
- Evaluate the effect of restructuring the curriculum of the fluid mechanics reviewed on students' performance; and
- Evaluate the effect of restructuring the assessment of the fluid mechanics used to carry out this study, on students' performance in line with the CCAIML learning approach.

REFERENCES

- Abel, M. (2006). Individualizing learning using intelligent technology and universally designed Curriculum. *The Journal of Technology, learning, and Assessment* 5(3).
- Achor, E. E., Imoko, B. I., and Uloko E. S. (2009). Effect of ethnomathematics teaching approach on senior secondary students' achievement and retention in locus. *Educational Research and Review*, 4(8): 385 – 390.
- Ainsworth, S., & Van Labeke, N. (2002). *Using a Multi-Representational Design Framework to Develop and Evaluate a Dynamic Simulation Environment*. Paper presented at the International Workshop on Dynamic Visualizations and Learning, Tübingen, Germany.
- Airasian P. (2005). Classroom Assessment. Concepts and Applications; New York McGraw/Hill, New York.
- Alper, A. and Gulbahar, Y. (2009). Trends and issues in educational technologies: A review of recent research in TOJET. *The Turkish Online Journal of Technology*, 8(2).
- Alias, M. (2005). Assessment of learning outcomes: validity and reliability of classroom tests. *World Transactions on Engineering and Technology Education*.
- American College Personal Association. (1996). *The student learning imperative*. Washington, D.C: authors.
- Akst, G. (1996). Effectiveness of mediated learning: Borough of Manhattan Community College (CUNY), Tom Hale of California Polytechnic State University.
- Anyanwu, R.N. (2008). The implementation and evaluation of a constitutivist intervention in secondary school science teaching in Seychelles. Available: <http://hdl.handle.net/10500/2407>, accessed 7th November, 2009.

Apple, M. (2008). SA targets 2500 engineers a year. Available at <http://www.skillsportal.co.za/asgisa/jipsa/737502.htm>. Accessed 5th September 2009.

Atkinson R.C and Shiffrin R.M. (1968). Human memory: a proposed system and its control processes. In the Psychology of Learning and Motivation: *Advances in Research Theory*. Vol. 11. (eds K.W. Spence and J.T. Spence). pp. 89 – 195. Academic Press, San Diego.

Australian allarat Diocese, (1989). School level evaluation project/a project funded jointly by the commonwealth schools commission and the Diocese of Ballarat. Catholic schools Victoria, Ballarat region (ANB/PRECIS SIN 0602310).

Baddelery, A. (1992), *Working memory Science*, 255: 556 – 559.

Balazinski, M. And Przybylo, A. (2005). Teaching Manufacturing processes using computer animation. *Journal of manufacturing system*, 24(3); ABI/INFORM Global pg 237.

Bailey, K.D. (1987). *Methods of Social Research*. New York: Free Press.

Bandura, A. (1977). *Social Learning theory*. Englewood cliffs, NJ: Prentice – Hall.

Barnes, C., Camburn, E., Holmstrong, K., and Han S.W. (2009). Scaling-up high quality literacy instruction in high poverty schools: Resources and routines for learning. *Paper presented at the 2009 annual meeting of the American Educational Research Association in Sa Diego, California, April 16th, 2009.*

Bell–Gredler, M.E. (1986). *Learning and instruction: Theory into Practice*. Macmillan Pnblishing Company, 866 Third Avenue, New York 10022.

Bennett, G.J., Kelley, K., Collins, R., Boland, F., McGoldrick, C., Pavia, S., and O’Kelly, K. (2010). Implimentation of project based learning in a large

engineering program. *Proceedings of 3^d International symposium for Engineering Education, 2010, University College Cork, Ireland.*

Berger, P.H., and Luckmann, T. (1966). *The social construction of reality: A treatise in the sociology of knowledge*. Garden City, NY: Doubleday.

Best, J.W. and Kahn, J.V. (2002). *Research in Education*, 7th ed. New Delhi: Asoke, K. Ghosh, Prentice – Hall.

Black, T.R. (1999). *Doing Quantitative Research in the social science: An integrated approach to research design, measurement and statistics*. London: Sage.

Blake, A.J.D. and Hill, D. M. (1980). The understanding in science test as a measure of Piagetion level of intellectual development. *Research in Science Education*, 10: 83-91.

Boero, P., Donek, N., and Ferrari, P.L. (2002). Developing mastery of natural language: Approaches to theoretical aspects of mathematics. In : L. English (Ed.), *Handbook of international research in mathematics education* (pp. 241-268). New York: Lawrence Erlbaum.

Bohlmann, C. and Pretorius, E. (2008). Relationships between mathematics and literacy: Exploring some underlying factors. *Pythagoras*, 67: 42-55

Bonder, G.M. (1986). Constructivism: A theory of knowledge. *Journal of Chemistry Education*, 63: 873-878.

Bonder, G.M and McMillen, T.L.B. (1986). Cognitive restructuring as an early state in problem solving. *Journal of Research in Science Teaching*. 23: 727-737

Borko, H. and Putnam, R. (1998). *The role of context in teacher learning and teacher education*. In *Contextual Teaching and Learning: Preparing Teachers to*

Enhance student Success in and Beyond School, pp. 35-74. Columbus, OH: ERIC Clearinghouse on Adult, Career, and Vocational Education; and Washington, DC: ERIC Clearing house for Teaching and Teacher Education, 1998. (ED 427 263)
hHp : // www.contextual.org.

Bowe, M., Jansen, D., Feland, J. and Self, B. (2001). When Multimedia Doesn't Work: An Assessement of visualization modules for learning enhancement in Mechanics. *Proceedings of the ASEE Annual Conference, Albuquerque, NM, June 2001*.

Brandon, R. and Jennifer, C. (2003). Factors influencing learner's choice of Mechanical Engineering as a career. *African Journal of Research in SMT Education*, 7: 73-83

Brandt, R. (1993). On teaching for understanding: A conversation with Howard Gardner. *Educational leadership*, 50.

Briggs, A.R.J. and Sommefeldt, D. (2003). *Managing effective learning and teaching*. London: Paul Chapman Publishing.

Bruner, J.S. (1960). *The process of education*. Cambridge: MA: Harvard University Press.

Bringuier, J.C. (1980). *Conversations with Piaget*. Chicago: University of Chicago Press

Brooks J.G and Brooks, M.G. (1993). In search of understanding: The case for Constructivist Classrooms. *Alexandria, CA: Association for Supervision and Curriculum Development*.

Brose, A. And Kautz, C. (2010). Research on student understanding as a guide for the development of instructional materials in introductory engineering courses. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland*.

Bruner, J.S. (1964). *Some theorems on instruction illustrated with reference to mathematics*. In E.R. Hilgery (ED), *Theories of learning and instruction*. The sixty-third yearbook of the National Society for the study of Education, Part 1 (pp.306-335). Chicago: University of Chicago Press.

Bruinsma, M. and Jansen, E.P.W.A. (2007). Educational Productivity in Higher education: An examination of part of the Walberg Educational Productivity Model. *School Effectiveness and School Improvement*, 18(1): 45-65.

Calson, L. and Sullivan, J.F. (1999). Hands-on Engineering: Learning by doing in the international teaching and learning program. *Journal of Engineering Education*, 15(1): 20-31.

Cameron L. (2002), *Teaching language to young learners*. Cambridge: Cambridge University Press.

Confrey, J. (1990). What Constructivism implies for Teaching. *Journal for Research in Mathematics. Monograph 4*:107-122.

Campos, D.M.S., and Queiroz, A.C. (2010). Project teaching in biomedical engineering. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland*.

Chandler, P., and Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and instruction*, 8: 293 – 332.

Chi, M.T.H., Feltovich, P.J., and Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science* 5: 121-152.

Chiarić, G. and N.L. (1996). Psychological Constructivisms: A metatheoretical differentiation. *Journal of Constructivist Psychology*, 9: 163-184.

Clark, J. M., and Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, 3: 149 – 210

Cleghorn, W.L. and Dhariwal, H. (2010). Pedagogical impact of the multimedia enhanced electronic teaching system (MEETS) on the delivery of engineering courses *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland.*

Cole, J. and Spence, S. (2010). First year Fluids Engineering student engagement when the class size is large. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland.*

Criteria for institutional audit, (2004). Council on Higher Education and Higher Education Quality Committee.

Cronbach L.J. (1951). Cronbach, coefficient alpha and internal consistency of tests. *Psychometrika*, 16: 297-334.

Cronbach L.J. (1990). Cronbach, Essentials of psychological testing. (5th ed.) Harper and Row, New York.

Crowther, D.T. (1997). The constructivist Zone. [Online]. Available: <http://unr.edu/homepage/jcannon/ejse/ejser2nzed.html>.

Cuban, L., (1986). *Teachers and Machines: The classroom use of Technology since 1920*. New York: Teachers College Press.

Daniels, H. (2001). Vygotsky and Pedagogy. NY: Routledge / Falmer.

Dearn, K.D., Tsolakis, A., Megaritis, A. and Walton, D. (2010). Adapting to engineering education and teaching challenges. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland.*

De Graaff, E and kolmos, A. (eds.) (2007). *Management of change. Implementation of problem-based and project-based learning in engineering*. Rotterdam: Sense.

Desha, C. and Hargroves, K.C. (2010). *Engineering education and sustainable development 'A guide for rapid curriculum renewal'*. Earthscan Press.

Dewey, J. (1916). *Democracy and Education: An introduction to the philosophy of Education*. New York: Macmillan.

Dewey, J. (1929) *Experience and Nature*, New York: Dover. (Dover edition first published in 1958). Explores the relationship of the external world, the mind and knowledge.

Dimitrov D.M and Rumrill, P.D. Jr. (2003). Pretest – posttest designs and measurement of change. *Work* 20: 159-165. 105 Press.

Dorin, H., Demmin, P.E. and Gabel, D. (1990). *Chemistry: The study of matter*, 3rd ed. Englewood Cliffs, NJ: Prentice Hall, Inc.

Duffy, G. and Bowe, B. (2010). A framework to develop lifelong learning and transferable skills in an engineering programme. *Proceedings of 3rd International Symposium for Engineering Education, 2010, University College Cork, Ireland*.

Duffy, T.M. and Jonassen, D.J., eds. (1992) *Constructivism and the Technology of Instruction: a Conversation*. Hillsdale, NJ: Lawrence Erlbaum Associates

Eyyam, R. Meneviş and Doğruer N. (2010). Perceptions of prospective teachers towards technology use in class. *Procedia Social and Behavioral Sciences*, 3: 88 - 93

Earnest P. (1999). *The one and the many*. In L.Steffe and J. Gale (Eds.): *Constructivism in Education* pp. 459-486. New Jersey: Lawrence Erlbaum.

Felder, R.M., (1988). Learning and teaching styles in engineering education. *Engineering Education*, 78(7): 671-681.

Felder, R.M. (1995). A longitudinal study of engineering student performance and retention. IV. Instructional methods and student responses to them. *Journal of Engineering Education*, 84(4): 361-367.

Felder, R.M. and Brent, R. (2005). Understanding student differences. *Journal of Engineering Education*, 94(1): 57-72.

Fishbein, M. (1967). Attitude and the prediction of behaviour. In M, Fishbein (Ed.), *Readings in attitude theory and measurement* (pp.477-492). New York: Wiley.

Forsyth, D.R. (2003). *The Professoer's guide to teaching: Psychological principles and practices*. Wachinton, DC: *American Psychological Association*.

Fox, R. (2001). *Constructivism examined*. Oxford Review of Education, 27(1).

French, B.F., Immerkus, J.C., and Oakes, W.C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education* 94(4): 419-425.

Gadsden Educations: Available: [http://www.gadsenstate.edu/ie/faculty/classroom % 20 observation % 20 checklist](http://www.gadsenstate.edu/ie/faculty/classroom%20observation%20checklist.pdf). Pdf.

Gagne, R.M., Wager, W.W., Golas, K.C., and Keller, J.M. (2005). *Principles of instructional design* (5th ed.). Stratford Publishing Services, Inc.

Gallagher, J.J. (2000). Teaching for understanding and application of science knowledge. *School Science and Mathematics*, 100:310-318.

Gay, L.R. and Airasian, P. (2003). Educational research: Competencies for analysis and applications. Pearson Education, Inc., Upper Saddle River, New Jersey 07458.

Gerseon, H.B.P., Sorby, S. A., Wysocki, A. and Baartmans, B.J. (2001). The development and assessment of multimedia software for improving 3-D spatial visualization skills. *John Wiley and Sons. Inc.*

Glasse, J. (2010). Sustainable words or do we really teach the engineering effectively. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland.*

Goos, M. and Bennison, A. (2007). Technology-enriched teaching of secondary mathematics: factors influencing innovative practice mathematics. *Essential Research, Essential Practice*, 1: 315 – 324.

Gottfried, A. (1990). Academic intrinsic motivation in young elementary school children. *Journal of Educational Psychology*, 82: 525 – 538

Greene, W.C. (1953). Platonism and its Critics. HSCP 61.

Hall R.H., Philpot, T.A., and Hubling, N. (2006). Comprehensive assessment of a software development project for engineering instruction. *The Journal of Technology, Learning, and Assessment.*

Hartley, J. (1998). *Learning and Studying. A research perspective.* London: Routledge.

Hart, K.E., & Kritsonis, W.A. (2006). Critical Analysis of an Original Writing on Social Learning Theory: Imitation of Film-Mediated Aggressive Models. *Doctoral FORUM-Journal for Publishing and Mentoring Doctoral Student Research*, 3(1)

Hart, E.K. and Kritsonis, W.A. (2006). A critical analysis of John B. Watson's original writing: Behaviourism as a behaviourist views it. *National Form of Applied Educational Research Journal* and 20(3).

Hilgard, E.R. (1980). The Trilogy of the mind: cognition, affection, and conation. *Journal of the History of Behavioural Sciences*, 16: 107-117.

Hubing, N., Ogleby, D.B., Philpot, T.A., Yellamraju, V., Hall, R.H. and Flori. R.E. (2002). Interactive learning tools: Animating statics. *Proceeding of the 2002 American Society for Engineering Annual Conference and Exposition*.

Hoyt, C. (1941). Test reliability estimated by analysis of variance (ANOVA). *Psychometrika*, 6: 153-160.

Jawitz, J. and Case, J. (1998). Exploring the reasons South African students give for studying Engineering. *International Journal of Engineering Education*, 22: 281 – 292.

Joyce, b B. And Weil, M. (1986). *Models of teaching (Third Edition)*. New Jersey: Prentice – Hall Inc.

Joyce, T. and Dunne, N. (2010). A comparison of interactive teaching methods used in bioengineering / biomaterials modules at two Russell Group Universities. *Proceedings of 3^d International symposium for Engineering Education, 2010, University College Cork, Ireland*.

Kadiyala, M., and Cryues, B. (2000). A review of literature on effectiveness of use of information technology in education. *Journal of Engineering Education*, p.177 – 189.

Kahn, P and Walsh, L. (2006). *Developing your teaching: ideas, insight and action*. Abingdon: Routeledge.

Kaiser, H.F. (1991). Coefficient alpha for principal component and the Kaiser-GuHman rule. *Psychological Reports*, 68:853-858

Kalyuga, S., Ayres, P., Chandler, P., and Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist*, 38: 23 – 31

Karpov Y.V., and Haywood, H.C. (1998). Two ways to elaborate Vygotsky's concept of Mediation. *American Psychologist*, 53(1): 27-36

Köhler, W. (1929). *Gestalt psychology*. New York: Liveright.

Kelly, G.A. (1955). *The Psychology of Personal Construct*. New York: Norton.

Kelly, G.A. (1991a). *The Psychology of Personal Construct: vol. 1. A theory of personality*. London: Routledge. (Original work published, 1955)

Kelly, G.A. (1991b). *The Psychology of Personal Construct: vol. 2. Clinical diagnosis and psychology*. London: Routledge. (Original work published, 1955).

Killen, R. (2007). *Effective teaching strategies: lessons from research and practice*. Cengage learning Australia

Kuhn, T.S. (1970). *The Structure of Scientific Revolutions*, (2nd ed.), Chicago: University of Chicago Press.

Kyza, E.A., Erduran, S., and Tiberghien, A. (2009). Technology enhanced learning in science. In Balacheff, N., Ludvigsen, S., de Jong, T., Lazonder, A., and Barners, S. (2009). *Technology enhanced learning: principles and products*.

Landfield, A.W. (1980). The person as perspectivist, literalist, and chaotic frgmentalist. In A.W Landfield and L.M. Leituer (Eds.), *Personal Constuct Psychology: Psychotherapy and personality*, pp. 3-17. New York: Wiley.

Lemon, N. (1973). Attitude and their measurement. New York: Wiley.

Leung, M.Y., Lu, X.C.D., and Lu, M. (2008). Impact of teaching approaches on learning approaches of construction engineering students: a comparative study between Hong Kong and Mainland China. *Journal of Engineering Education*, 97 (2); *ProQuest Education Journals*, p. 135.

Li, Q., McCoAch, D.B., Swaminathan, H. and Tang, J. (2008). Development of an instrument to measure perspective of engineering education among college students. *Journal of Engineering Education*, 97(1).

Lorsbach, A. and Tobin, A. (1992). Constructivism as a referent for Science Teaching, *NARST Newsletter*, 30: 5-7.

Maier, P.H. (1984). *Räumliches Vorstellungsvermögen*, Lang, Frankfurt.

Malone J.A. (1996). Preservice secondary mathematics teachers' beliefs: two case studies of emerging and evolving perceptions. In: L. Puig and A. Gutierrez (eds). *Proceedings of the twentieth conference of the psychology of mathematics education, vol. 3. Valencia, Spain*.

Mapolelo C.D., (2003). Case studies of changes of beliefs of two in-service primary school teachers. *South African Journal of Education*, 23(1): 71-77.

Massy, W.F. and Zemsky, R. (1995). Using information technology to enhance academic productivity. *Washington, D.C: Educom, Occasional paper*.

Marek, B. and Aleksander, P. (2005). Teaching manufacturing processes using computer animation. *Journal of Manufacturing Engineering Systems*, 24 (3): 237.

Mayer, R.E. (1996). Learning strategies for making sense out of expository text: the SOI model for guiding three cognitive processes in knowledge construction. *Educational Psychology Review*, 8: 357 – 371.

Mayer, R.E. (1997). Multimedia learning: Are we asking the right questions? *Educational psychologist*, 32: 1- 19.

Mayer, R.E. (2001). *Multimedia Learning*. New York: Cambridge University Press.

Mayer, R.E. and Moreno, R. (1998). A cognitive theory of multimedia learning: Implication for design principles. Available: <http://www.unm.edu/Moreno/PDFS/chi.pdf>.

Mayer, R.E, and Moreno, R.(2001). Aids to Computer-based multimedia learning. *learning and Instruction* 12: 107-119; www.Elsevier.com/locate/learninstruc.

Mayer, R.E. and Moreno, R. (2002a). Animation as an aid to multimedia learning. *Educational Psychology Review*, 14: 87-99.

Mayer, R.E. and Moreno, R. (2002b). Aids to computer-based multimedia learning. *Learning and Instruction*, 12: 107-119

Mayer, R.E. and Moreno R. (2003). Nine ways to reduce cognitive load in multimedia learning. *In Web-Based Learning: What DO We know? Where DO We Go?* (eds R. Bruning, C.A. Horn and L.M. Pytlitzilling), pp. 23 – 44. Information Age Publishing. Greenwich, CT.

McDevitt, T.M. and Ormond, J.E. (2004). *Child development*: Upper Saddle River, N.J: Pearson, 2004.

McGuinness, C, (1990). *Talking about thinking: The role of metacognition in teaching thinking*. In K. Gilhooly, M. Deane and G. Erdos (Eds.), *Lines of thinking* (vol. 2, pp. 310 - 312). San Diego, CA: Academic Press.

Merriam, S. and Caffarella (1991). *Learning in Adulthood: A comprehensive guide*. San Francisco: Jossey-Bass.

Moreno, R. (2004). Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback on discovery-based multimedia. *Instructional Science*, 32: 99 – 113.

Moreno R. (2005). *Instructional technology: promise and pitfalls. In technology – based education: Bringing researchers and practitioners together* (eds L. Pytlikzillig, M. Bodvarsson and R. Bruning), pp. 1 – 19. Information Age Publishing, Greenwich, CT.

Moreno R. (2006a). Does the modality principle hold for different media? A test of the method – affects – learning hypothesis. *Journal of Computer Assisted Learning*, 22: 149 – 158.

Moreno R. (2006b). Learning with high tech and multimedia environments. *Current Directions in Psychological Science*, 15:63-67.

Moreno, R. and Duán, R. (2004). Do multiple representations need explanation? The role of verbal guidance and individual differences in multimedial, mathematics learning. *Journal of Educational Psychology*, 96: 492 – 503.

Moreno, R. and Mayer, R.E. (2007). Interactive multimodal learning environments. *Educational Psychology Review*, 19, 309-326

Moreno R., Mayer R.E., Spires H. and Lester J. (2001). The case for social agency in computer – based teaching: do students learn more deeply when they interact with animated pedagogical agents? *Cognition and Instruction*, 19: 177 – 213.

Morris, C.C. (1990). Retrieval processes underlying confidence in comprehension judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16: 223 – 232.

Multimedia Fluid Mechanics. Cambridge University Press, 2004 eds. ISBN 604761.

Naatanen, M. (2005). The mathematics education into the 21st century project. *Enriching mathematics teaching with computers*, 169 – 171.

National Science Foundation (NSF), (2004). An emerging and critical problem of the science and engineering labour force: a comparison to science and engineering indicators 2004. Available at <http://www.nsf.gov/statistics/nsb0407>

Neimeyer, R.A., and Raskin, J.D. (2001). *Varieties of constructivism in psychotherapy*. In K.S. Dobson (Ed.), *Handbook of cognitive – behaviour therapies* (2nd ed., pp.393-430). New York: Guilford.

Ngo, C.C., and Lai, F.C. (2001). Teaching thermodynamics with the aid of Web-Based Modules. *Proceedings of ASEE Annual Conference, Albuquerque, NM, June 2001*.

Nyaumwe, L. (2006). Investigating Zimbabwean mathematics teachers' dispositions on the 'O' Level calculator syllabus 4028. *South African Journal of Education*, 26(i): 39-47.

O'Dwyer, A. (2010). Analysis of engineering students learning styles on level 7, level 8, and level9 programmes. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland*.

Ogbonnaya U.I. (2010). Improving the teaching and learning of parabolic functions by the use of information and communication technology (ICT). *African Journal of Research in MST Education*, 14(1): 49 – 60.

Ornstein, A.C. (1990). *Strategies for effective teaching*. HarperCollinshers, Inc. New York.

Paivio, A. (1986). *Mental representations: A dual coding approach*. Oxford, England: Oxford University Press.

Paldy, L.G. (1997). Graphics in the lecture hall. *Journal of College of Science teaching*, 27(1) :4-5.

Papert, S. (1980). *Mindstorm. Children, Computers, and Powerful ideas*. New York: Basic books.

Papert, S. (1991). Situating constructionism. *Constructionism*, eds. Idit Harel and Seymour Papert.

Papert, S. (1993). *The children's Machine: rethinking school in the age of the computer*. BasicBooks, A Division of HarperCollins Publishers, Inc.

Papert, S. (1996). Computers in the Classroom: Agent of change. *The Washinton Post Education Review*.

Petruska, J. (2010). Introduction of the problem based learning to mechanical engineering curricula. *Proceedings of 3rd International symposium for Engineering Education, 2010, University College Cork, Ireland*.

Phillips, S. (1976). The Contributions of psychology to education. *Oxford Review of Education*, 2(2).

Philpot, T.A. and Hall, R.H. (2004). Animated instructional software for mechanics of materials: implementation and assessment. *Wiley Periodicals Inc*.

Philpot T.A. and Hall, R.H. (2006). Animated instructional software for mechanics of materials. Implementation and assessment. Wiley Periodicals Inc.

Piaget, J.(1967). The child's conception of the world. (J. and A. Tomlinson, Trans.). London: Routledge and Kegan Paul. BF721.P5 1967X.

Piaget, J. (1969). *The Mechanism of Perception*. London: Routledge and Kegan Paul.

Piaget, J. (1970). *Genetic Epistemology*, (E. Duckworth, translation). New York: Columbia University Press.

Piaget, J. (1975). Comments on mathematical education. *Contemporary Education*, 47(1): 5-10.

Piaget, J. (1977). Problem in equilibration. In M. Appel and S. Goldberg (Eds.), *Topics in cognitive development*: vol. 1. Equilibration: Theory, research, and application (pp. 3-13). New York: Plenum Press.

Piaget, J. (1980). *Adaptation and intelligence: organic selection and phenocopy* (S. Eames, Trans.). Chicago: University of Chicago Press.

Piaget, J. and Inhelder, B. (1969). *The psychology of the child* (H. Weaver, Trans.). New York: Basic Books.

Plass, J.L., Chun, D.M., Mayer, R.E. and Leutner, D. (1980). Supporting visual and verbal learning preferences in a second language multimedia learning environment. *Journal of Educational Psychology*, 90(25-36).

Pytlíkzillig, M.L., Bodvarsson, M., and Brunning, R. (2005). *Technology – baased education: bringing researchers and practitioners together*. Information Age Publishing, Inc.

Race, P., (2006). *The lecturers\Toolkit*. 3rd ed. London: Routledge.

Ramsden, P. (1992). *Learning to Teach in Higher Education*, London: Routledge.

Reamon, D.T., and Sheppard, S.D (1999). Educational interactive multimedia software: can it effectively teach engineering concepts? *Proceedings of DETC, 1999 ASME Design Engineering Technical Conferences, Las vegas, NV*.

Reeder, E. (2007). Measuring what counts: Memorization versus understanding. Available: <http://www.edu-topia.org/measuring-what-counts-memorization-versus-understanding>, accessed 7th November, 2009.

Resnick, L.B., and Hal, M.W. (1998). Learning Organizations for Sustainable Education Reform. *Daedalus*, 12(7): 89-118

Rhymer, D., Jensen, D., and Bowe, M. (2001). An assessment of visualization modules for learning enhancement in mechanics. *Proceedings of the ASEE Annual conference, Albuquerque, NM.*

Rogers, A. (2003) *What is the Difference? A new critique of adult learning and teaching*, Leicester: NIACE.

Rose, D.H. and Mayer, A. (2002). Teaching every student in the digital age: Universal design for learning. Alexandria, VA: Association for supervision and Curriculum Development.

Ruthven, K. (1998). The use of mental, written and calculator strategies of numerical computation by upper primary pupils within a 'calculator-aware' number curriculum. *British Educational Research Journal*, 24(i); ProQuest Education Journals.

Säljö, R. (1979). Learning in the learner's perspective. I. Some common-sense conceptions. *Reports from the Institute of Education, University of Gothenburg*, 76.

Schwartz, B. and Latz, H. (1982). Behaviourism, science, and human nature. New York: Norton.

Shé, C.N., and Looney, L. (2007). Facilitating active learning in the classroom. *Proceedings of the International Symposium for Engineering Education, Dublin City University, Ireland.*

Skinner, B.F. (1938). *The behavior of organisms*. New York: Appleton-century-Crofts.

Skinner, B.F. (1950). Are theories of learning necessary? *Psychological Review*, 57: 193-216

Skinner, B.F. (1966). Contingencies of reinforcement for designing a culture. *Behavioural Science*, 11: 159-166.

Skinner, B.F. (1973). The free and happy student. *Phi Delta Kappan*, 55: 13-16.

Smith, I.M. (1964). *Spatial ability – Its educational and Social Significance*. London: University of London.

Sorby, S.A. (2007). Developing 3-D spatial skills for engineering students. *Australasian Association of Engineering Education*, 13(1)

South African Higher Education Quality Committee (HEQC): June 2004 Criteria for Institutional Audits.

Standing L.G. (2006). Why Johnny still can't add: Predictors of university students' performance on an elementary arithmetic test. *Social Behavior and Personality* 34(2): 151-160.

Steif, P.S and Naples, M.L. (2003). Design and Evaluation of problem solving courseware modules for mechanics of materials. *Journal of Engineering Education*.

Taiwo, S. (2009). Teachers' perception of the role of medial in classroom teaching in secondary schools. *The Turkish Online Journal of Education Technology*, 8(1).

Taraban R., Hayes, M.W., Anderson, E.E., and Sharma, M.P. (2004). Developing On-Line homework for introductory thermodynamics. *Journal of Engineering Education*, 94(3): 339-342. (2004).

Taraban R., Hayes, M.W., Anderson, E.E., and Sharma, M.P. (2004). Giving students time for the academic resources that work. *Journal of Engineering Education*, 93(3): 205-210.

Taraban, R., Anderson, E.E., Definis, A., Brown A.G., Weigold, A. and Sharma, M.P. (2007). First steps in understanding engineering students growth of

conceptual and procedural knowledge in an interactive learning context. *Journal of Engineering Education*, 96(1); ProQuest Educational Journals.

Thompson, R.A. and Zamboanga, B.L. (2004). Academic aptitude and prior knowledge as predictors of student achievement in introduction to psychology. *Journal of Educational Psychology*, 96: 778-784.

Thorndike, E.L. and Woodworth, R.S. (1901). The influence of improvement in one mental function upon the efficiency of other functions. 1, 11, and 112. *Psychological Review*, 8: 247-261, 384-395, 553-564. Reprinted in E.L. Thorndike, *Psychology and the science of Education*, pp. 48-55.

Thorndike, E.L. (1911). *Animal intelligence*. New York: Macmillan.

Thorndike, E.L. (1913). *Educational Psychology*: vol. 1. The original nature of man. New York: Teachers' College Press.

Thorndike, E.L. (1924). Mental discipline in high school studies. *Journal of Educational Psychology*, 15:1-22, 83-98.

Von Glasersfield, E. (1995). *Radical Constructivism: A way of knowing and learning*. London: Falmer Press.

Vygotsky, L.S. (1978). *Mind and Society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Waite-Stupiansky, S. (1997) *Building understanding together: A constructivist approach to early childhood education*. Albany, NY: Delmar.

Washington, N., Parnianpour M., and Fraser, J. M. (1999). Evaluation and assessment of a biomechanics computer-aided instruction. *Computers and Education*, 32: 207-220.

Watson, J.B. (1913). Psychology as the behaviourist views it. *Psychological Bulletin*, 20: 158-177.

Watson, J.B. (1926). *Psychology from the standpoint of a behaviourist*, pp. 1 (Philadelphia, Lippincott).

Waugh N.C and Norman D.A (1965). Primary memory. *Psychological Review*, 72: 89 – 104.

Webster (2003). *Webster's New Collegiate Dictionary 11th Edition*. Springfield, MA : Merriam – Webster.

Wertsch, J.V. (1991). *Voices of the mind: A Sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

Williams, R.H., and Zimmerinan, D.W., (1968). An extension of the Rulon Formal for Test Reliability: The case of correlated true and error components of scores. *The Journal of Experimental Education*, 36(3).

Wiske, M.S., Franz, K.R., and Breit, L. (2005). *Teaching for understanding with technology*. San Franciseco: Jossey-Bass, (Chapter 1)

Wittrock, M.C. (1989). Generative processes of comprehension. *Educational Psychologist*, 24: 345 – 376.

Xiaoyan, W. (2003). Integration of modern and traditional teaching strategies in plant physiology. *The china Papers*, July, 53-57.

Yolton, J. (1970). *John locke and the compass of human understanding*. Cambridge: Cambridge University Press, 1970.

Yushau, B., Mji, A. and Wessels, D.C.J. (2003). Creativity and computer in the teaching and learning of mathematics. *Technical Report Series, TR 311*.

Zisow, M. (2000). Teaching style and technology. *TechTrends*, 44(4): 36 – 38.

APPENDICES

Appendix 1: Letter to the Universities to Participate in the Study



June 12, 2007

.....
University of

Department of Mechanical Engineering

Dear.....

I write this letter on behalf of my PhD student, Mr Faleye Sunday. Mr Faleye is doing a PhD program in Mathematics Education. Part of his research is to develop software to be used in learning fluid mechanics, for students who are fluid mechanics first time learners, in mechanical engineering classes.

For this project to be successful, we need the participation and cooperation of fluid mechanics lecturers and their respective students. We, therefore, solicit your participation in this project.

Thank you in advance for taking time to help us in this matter. We are confident that you will be very satisfied with the outcome of this project.

Please, send your enquiries to me at maritr@unisa.ac.za.

Sincerely,

A handwritten signature in blue ink, appearing to read "R Maritz", is written over a light blue circular stamp.

Dr R Maritz

Department of Mathematical Sciences

UNISA



University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix 2: Permission to Extract and Use some Video Clips from Multimedia Fluid Mechanics

Faleye, Sunday

From: Linda Nicol [lnicol@cambridge.org]
Sent: 21 July 2009 09:43 AM
To: Faleye, Sunday
Subject: Re: Multimedia Fluid Mechanics CD

July 21, 2009

Dear Faleye Sunday

Multimedia Fluid Mechanics CD ISBN 604761

Thank you for your email in which you request permission to include selected extracts from the above CD for your PhD research at the University of South Africa, Institute of Science and Technology Education.

On the understanding the extracts are being used for research purposes only and will not be distributed outside your university.

We are pleased to grant non-exclusive permission free of charge for this specific one time use on the understanding you have checked that the extracts are not acknowledged to any other sources.

Please ensure full acknowledgement to our publication appears with any extracts taken from it.

Should you wish to make the software available outside your university this will be subject to further permission and may be subject to a licence fee.

Yours sincerely

Linda Nicol
Permissions Manager, Legal Services
Cambridge University Press
The Edinburgh Building, Shaftesbury Road
Cambridge CB2 8RU, United Kingdom
www.cambridge.org

-----"Faleye, Sunday" <Faleys@unisa.ac.za> wrote: -----
To: "rights@cambridge.org" <rights@cambridge.org>
From: "Faleye, Sunday" <Faleys@unisa.ac.za>
Date: 13/07/2009 03:00PM
Subject: Multimedia Fluid Mechanics CD

This message (and attachments) is subject to restrictions and a disclaimer. Please refer to <http://www.unisa.ac.za/disclaimer> for full details.

Sir/Ma,

I am a PhD student at University of South Africa, Institute of Science and Technology Education. My research topic is to do with the use of animated package in the teaching of fluid mechanics. I did my masters degree in fluid mechanics (applied mathematics). I saw how dry and abstract the teaching of fluid mechanics is in South Africa. Therefore, the aim of my PhD research work is to find out what effect could animation (e.g. video clips,) of basic fluid mechanics concepts have on the students conceptual understanding of the course. This comes at a time when South Africa is experiencing high level of skill shortage. I put into consideration the importance of fluid mechanics in engineering and mathematics.

To this end, your Multimedia Fluid Mechanics (Multilingual version, 2000, 2004) is one of the resource that I found useful for this purpose. I hope to use the photo clips in the software. This work is not for any financial gain but for my PhD degree and to promote the use of multimedia in the teaching of fluid mechanics, to make knowledge transfer easier.

I therefore ask for your permission to use some aspects of the Multimedia Fluid Mechanics (Multilingual version, 2000, 2004) CD. I will duly reference your work accordingly.
Thanks very much.

Appendix 3: Baseline Study Questionnaire

University of South Africa
Institute for Science and Technology Education
Method of Teaching Fluid Mechanics Questionnaire Survey

Fluid Mechanics Instructor

This survey is part of my PhD study that seeks to establish whether or not the use animated computer instructional software can facilitate the learning of fluid mechanics. I therefore appeal for my study by completing this questionnaire. Please write your responses in the space provided.

1. What is the average number of students that you teach annually?

.....

2. What is the average number of students that registered for fluid mechanics annually?

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3. i. Please tick the teaching approach from the two provided below that is more applicable to your fluid mechanics classes.

Traditional Approach: In which case you teach from your lecture notes and textbooks. In addition, you use Microsoft power point to display your lecture notes.

OR

Student-Centre Approach (Constructivist): In which case the students take the lead as they discuss and explain fluid mechanics concepts to each other in a group within the class, while the lecture moderate and correct the students' discussion.

- ii. Please provide a brief description of your typical fluid mechanics lecture.

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4. i. Does any of your lectures involve the use of animated computer instructional software?

Yes No

- ii. If Yes, please describe the instructional software that is used in your lectures

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5. In your view, which topic in fluid mechanics do students normally find difficult.

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6. In your view, which topic in fluid mechanics do students normally find easy.

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7. How would you describe the students' perspective of fluid mechanics as a module in mechanical engineering course?

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Thank you very much for your time and the information you provided. It will now enable me to move to the stage of my study.

University of South Africa
Institute for Science and Technology Education
Method of Teaching Fluid Mechanics Questionnaire Survey

Fluid Mechanics Students

This survey is part of my PhD study that seeks to establish whether or not the use of animated computer instructional software can facilitate the learning of fluid mechanics. I therefore appeal for my study by completing this questionnaire. Please write your responses in the space provided.

1. Age: Male ☐ Female ☐

2. Which topic do you find most challenging in fluid mechanics?

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3. Which topic do you find least challenging in fluid mechanics?

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4. Please describe how your fluid mechanics lectures are normally conducted.

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5. i. Has any computer software programme been used in any of your fluid mechanics lectures? Yes No
- ii. If yes, please provide a description of such software programme

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6. Do you have any tutorial sessions for fluid mechanics? Yes No

7. Please describe how a typical tutorial session, referred to in 6, is normally conducted.

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Thank you very much for your time and information provided.

Appendix 4: Main Study Questionnaire

UNIVERSITY OF SOUTH AFRICA
INSTITUTE FOR SCIENCE AND TECHNOLOGY EDUCATION
SUMMATIVE EVALUATION OF ANIMATED INSTRUCTIONAL AID
IN THE TEACHING AND LEARNING OF FLUID MECHANICS

This survey is part of my PhD study which seeks to measure the impact of introducing an animated instructional aid into the teaching and learning of fluid mechanics in mechanical engineering classes. I, therefore, solicit few moments of your time to help me acquire important data by completing this questionnaire. Please, tick which of the scale (SA, A, UD, DA, and SD) that correspond to your responses. Your responses shall be treated with absolute confidentiality.

Gender: Male: Female:

Institution

Degree

SA Strongly Agree 5	A Agree 4	UD Undecided 3	DA Disagree 2	SD Strongly Disagree 1
---------------------------	-----------------	----------------------	---------------------	---------------------------------

S/No.	Item	SA 5	A 4	UD 3	DA 2	SD 1
1.	I found the software easy to navigate.					
2.	I have easy access to the software.					
3.	The software is not difficult to understand.					
4.	It provides better visualisation than explanation on paper.					
5.	It presents a clearer presentation of fluid mechanics basic concepts in 3-D					
6.	The animation of basic fluid mechanics concepts contained in the software added another interesting dimension to my learning of fluid mechanics.					
7.	It helps me to visualize the fluid mechanics basic concepts in its 3-D from.					
8.	It helps to reinforce an understanding of fluid mechanics topics.					
9.	The animated movies make me to be more interested in fluid mechanics					
10.	I understand fluid mechanics concepts in illustrative movies better than reading from textbooks or lecture notes.					
11.	The software is a good learning aid.					
12.	The animated movies were fascinating.					
13.	I think the time spent using the software was a worthwhile use of my study time.					
14.	I enjoy using the software.					
15.	The software is educating.					

16. Give your overall evaluation of the software as a learning tool

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Thank you.

Appendix 5: Observation Checklist Instrument

LECTURE ROOM OBSERVATION CHECKLIST

Case Study

Time

Topic Treated

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Date :.....

Below are the activities observed and the rating scale.

OBSERVABLE CHARACTERISTICS:	YES	NO	NI*	NA**
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(1) Lecture room resources

1. Lecture room is provided with data projector,

white board screen, chalk board, computer.	----	----	-----	----
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2. The lecture room is very spacious and students

are comfortably sittted.	----	----	-----	----
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3. Materials presented is appropriate to the

course level.	----	----	-----	----
---------------	------	------	-------	------

4. Materials presented is related to the course

	objectives.	-----	-----	-----	-----
5.	Integrate recent developments in the field of Mechanical Engineering in the class discussion.	-----	-----	-----	-----
(2)	PRESENTATION:	YES	NO	NI*	NA**
1.	Begins class at the schedule time.	-----	-----	-----	-----
2.	Initial activities include:	-----	-----	-----	-----
(a)	Students sit in groups	-----	-----	-----	-----
(b)	Review of previous work by using question approach.	-----	-----	-----	-----
(c)	Statement of objective for the immediate class period.	-----	-----	-----	-----
(d)	Introduction of the day's material to be presented.	-----	-----	-----	-----
(e)	Displayed the animated illustration of the necessary concept on the screen.	-----	-----	-----	-----
(3)	Students engage in group discussion as the construct new knowledge.	-----	-----	-----	-----
(4)	Lecturer go – round each groups discussion.	-----	-----	-----	-----

- (5) Each group present how they understand
the concepts under pinning the day's work. -----
- (6) Real – life problems are discussed and
solved in each group. -----
- (7) Study participants present the solutions as they
discussed and understood it from each group. -----
- (8) Lecturer summarized major concepts. -----

Field Notes

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Appendix 6: Instrument Validation Form for Baseline Study

INSTRUMENT VALIDATION FORM

This survey is part of my PhD study that seeks to establish whether or not the use of animated computer instructional software can facilitate the learning of fluid mechanics. The instrument is meant to collect data on the current approach of teaching fluid mechanics and the challenges the students are facing as a result of the current teaching approach. I, therefore, solicit a few moments of your time to help me to judge the instruments' items.

Please judge each item on: Sureness and Relevance.

Where the 3 Sureness levels are:

1 = not very sure; 2 = pretty sure; 3 = very sure

and the 3 Relevance levels are:

1 = low/not relevant; 2 = somewhat relevant; 3 = highly relevant.

Instructor's Instrument

Items No.	Sureness	Relevance	Do not write in this column
1			
2			
3			
4			
5			
6			
7			

Students' Instrument

Items No.	Sureness	Relevance	Do not write in this column
1			
2			
3			
4			
5			
6			
7			

Appendix 7: ACIA validation form

ANIMATED COMPUTER INSTRUCTIONAL AIDE (ACIA) INSTRUMENT VALIDATION FORM

My PhD project seeks to investigate the effect of introducing animated computer instructional aide (ACIA) in the teaching and learning of fluid mechanics. The CD accompanying this form contains ACIA package. The AICA is to be used as a teaching/learning aide in mechanics engineering classes. The targeted students are the fluid mechanics learners. The fluid mechanics lecturers that are participating in this project are expected to use the ACIA as a teaching aid, while their students will be given one on CD each so that they can use it during their private studying time.

As part of the validation procedures, you are selected as one of the judges to rate ACIA as an intervention instrument in this project. The ratings shall be on:

- (1) How far the treated ACIA covered the fundamental concepts of fluid mechanics.
- (2) The relevance of each topic (considered as an item) treated in the ACIA to fluid mechanics to first time learners, and whether the ACIA contained appropriate definitions and illustrations.

In view of the above, the judging shall be in two parts; part A and B.

Part A

After you have gone through the ACIA CD, please judge to which extent do you think the topics treated in the ACIA covered the fluid mechanics fundamental concepts which are expected to be learnt by first time learners in fluid mechanics as a module.

You shall judge based on the following rating scale:

1 = not well covered

2 = somewhat well covered

3 = very well covered

Rating

Comments

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Part B

In this part, you are to judge the relevance of each topic (considered as an item) to first time learners of fluid mechanics, as well as the appropriateness of definitions and illustrations given in each topic.

Where the three relevance levels are:

1 = not/low relevance

2 = somewhat relevant

3 = highly relevant

and the three appropriateness levels are:

1 = not appropriate

2 = somewhat appropriate

3 = highly appropriate

In carrying out the tasks stated above, please kindly complete the table provided below.

Topic (Item)	Relevance	Appropriateness
1		
2		
3		
4		
5		
6		
7		

Comments

.....

.....

Appendix 8: Main Study Questionnaire Validation Form

INSTRUMENT VALIDATION FORM

Animation instructional teaching aid which aims at introducing another dimension to the traditional method of teaching fluid mechanics in some South African universities was developed. The study participants have been using the instructional aid for about four weeks now. The instrument is meant to measure the usability of the software and its impact on learning in mechanical engineering classes. I, therefore, solicit few moments of your time to help me to judge the instruments' items.

Please judge each items on: Sureness and Relevance.

Where the 3 Sureness levels are:

1 = not very sure; 2 = pretty sure; 3 = very sure

and the 3 Relevance levels are:

1 = low/not relevant; 2 = somewhat relevant; 3 = highly relevant.

Items No.	Sureness	Relevance	Do not write in this column
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Appendix 9: Observation Checklist Instrument Validation form

INSTRUMENT VALIDATION FORM

Animation instructional teaching aid which aims at introducing another dimension to the traditional method of teaching fluid mechanics in some South African universities was developed. The study participants will start to use the instructional aid, during which time the researcher is expected to conduct series of classroom observation. The data collected through the observation checklist instrument, will be used to measure the learning facilitative component of the study and also to corroborate the quantitative results. I, therefore, solicit few moments of your time to help me to judge the instruments' items.

Please judge each items on: Sureness and Relevance.

Where the 3 Sureness levels are:

1 = not very sure; 2 = pretty sure; 3 = very sure

and the 3 Relevance levels are:

1 = low/not relevant; 2 = somewhat relevant; 3 = highly relevant.

Observable Character	Items No.	Sureness	Relevance	Do not write in this column
Lecture Room Resource	Sub Character			
	1			
	2			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			

Appendix 10: Table of factor analysis eigenvalue

A

Component	Total Variance Explained			Extraction Sums of Squared	
	Initial Eigenvalues			Loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	6.149	40.994	40.994	6.149	40.994
2	2.368	15.788	56.782	2.368	15.788
3	1.293	8.618	65.400	1.293	8.618
4	.964	6.428	71.828		
5	.816	5.438	77.267		
6	.625	4.165	81.432		
7	.525	3.500	84.931		
8	.474	3.161	88.092		
9	.445	2.965	91.057		
10	.375	2.502	93.559		
11	.265	1.765	95.324		
12	.247	1.647	96.971		
13	.226	1.509	98.480		
14	.115	.765	99.245		
15	.113	.755	100.000		

Extraction Method: Principal Component Analysis.

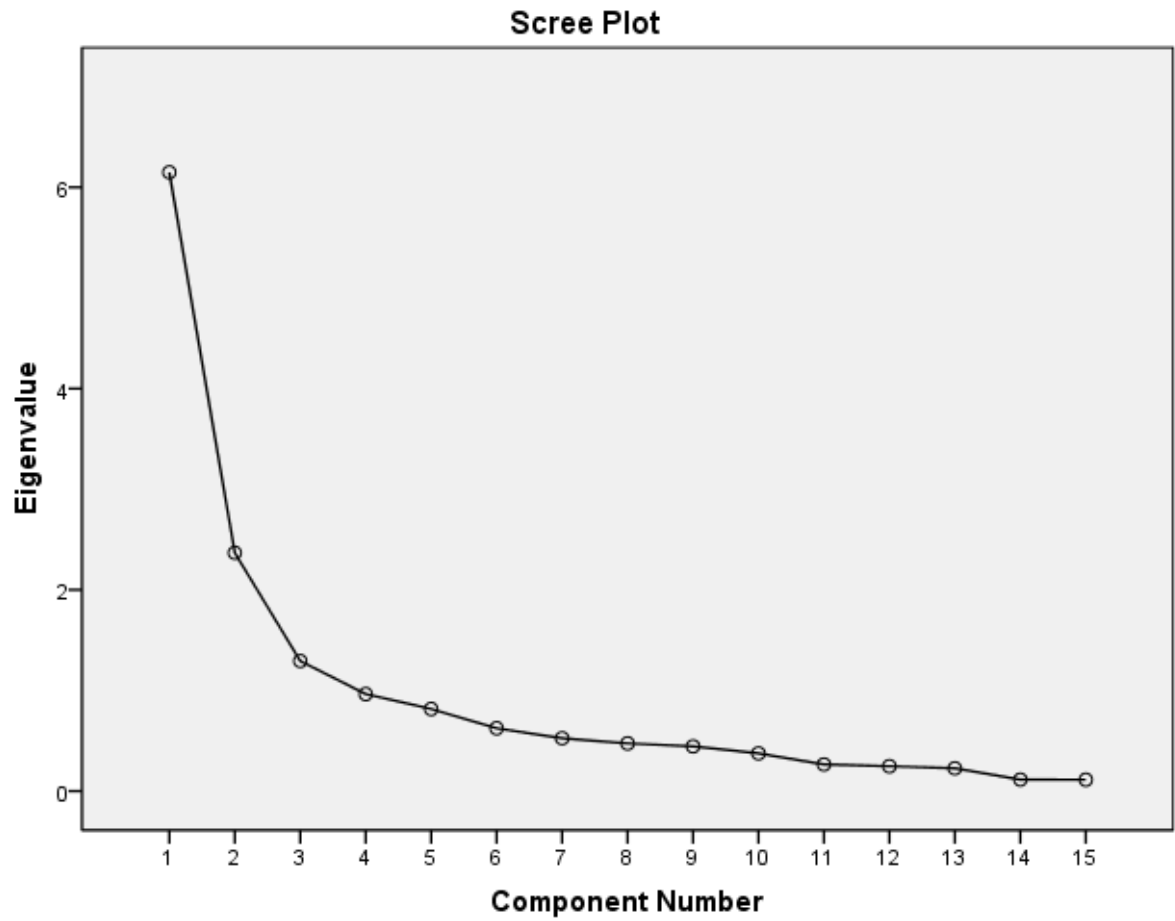
B

Total Variance Explained

Component	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings		
	Cumulative %	Total	% of Variance	Cumulative %
1	40.994	4.177	27.843	27.843
2	56.782	2.829	18.861	46.704
3	65.400	2.804	18.696	65.400
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Extraction Method: Principal Component Analysis.

Appendix 11: Eigenvalue Scree Plot



Appendix 12: ACIA CONTENTS

- 1.0 Fluid Concepts
 - 1.1 Definitions
 - 1.2 Fluid Properties
 - 1.2.1 Thermodynamics Properties
 - 1.2.2 Secondary Properties
- 2.0 Flow Types
 - 2.1 One Dimensional Flow
 - 2.2 Two Dimensional Flow
 - 2.3 Three Dimensional Flow
 - 2.4 Laminar Flow
 - 2.5 Turbulent Flow
 - 2.6 Transitional Flow
- 3.0 Flow Fields
- 4.0 Motion of Particles
 - 4.1 Motion of point particles
 - 4.2 Fluid as a continuum
 - 4.3 Flow of particles vs. continuous fluid
- 5.0 Flow Patterns
 - 5.1 Pathlines
 - 5.2 Streaklines
 - 5.3 Timelines
 - 5.4 Streamlines
- 6.0 Pressure Variation in a Fluid
- 7.0 Reynolds Number (Re)
 - 7.1 Definition
 - 7.2 Inertia and Viscosity
 - 7.3 Effect of Reynolds number (Re) on simple flow
 - 7.4 Dynamics similarities
 - 7.5 How to achieve low Reynolds number (Re)
- 8.0 Boundary Layers