

The Effects of Traditional, Outcomes Based Education (OBE) and Blended Teaching Approaches in Alleviating Conceptual Difficulties and Alternative Conceptions in Grade Twelve Mechanics

S. P. Mchunu¹ and S. N. Imenda²

¹*Umalusi, Pretoria, South Africa*
E-mail: Stephan.mchunu@gmail.com

²*University of Zululand, South Africa*
E-mail: ImendaS@unizulu.ac.za

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ABSTRACT According to literature and classroom experience many learners experience serious difficulties with some mechanics concepts. This paper reports the results of a study comparing the effectiveness of three instructional approaches in alleviating learning difficulties of grade 12 learners in mechanics. The research sample consisted of 140 grade 12 physical science learners drawn from four high schools in the Empangeni education district, South Africa. A quasi-experimental, non-equivalent comparison group research design was used. ANOVA and average normalized gain scores were used to analyse the data. The results showed that all the three interventions significantly alleviated conceptual difficulties and alternative conceptions of the learners in mechanics. However, the blended intervention was the most effective, followed by OBE and then the traditional approach. The comparison group showed no conceptual growth between the pre- and post-tests.

INTRODUCTION

Since the introduction of the National Curriculum Statement (NCS), physical science educators have experienced many challenges with regard to its implementation. The NCS introduced many changes, such as new content knowledge areas and core concepts, learning outcomes (LOs), assessment standards (ASs), and the inclusion of practical investigations as well as research projects as compulsory components of the assessment programme in the Further Education and Training (FET) education band (grades 10 to 12). The new curriculum was introduced in the FET band (grades 10 – 12) in 2006. Since then, the Department of Basic Education (DBE 2011, 2013, 2014) has streamlined the implementation of the curriculum through the introduction of the Curriculum and Assessment Policy Statement (CAPS) – which is “a single, comprehensive, and concise policy document, which replaces the Subject and Learning Area Statements, Learning Programme Guidelines and Subject Assessment Guidelines for all the subjects listed in the National Curriculum Statement Grades R – 12” (DBE 2013: 2).

To be able to assist learners through the new curriculum, educators need to have an adequate

understanding of all the attendant changes, as well as applied competences to successfully implement the curriculum. The FET physical science curriculum seeks to attain specified learning outcomes (LOs) and assessment standards (Ass). LO1, for example, focuses on instilling practical investigation skills in learners. Thus, in order to give the learner the requisite experience with regard to this LO, educators need skills to plan and assess practical investigations and research projects – as well as skill in developing the attendant assessment rubrics. As Schreuder (1999: 83) observes, “the effective implementation of curriculum presupposes clear understanding and preparation of teacher”. He further states that the effective implementation of a curriculum also “includes conceptual understanding, the availability of materials and ongoing support. It also presupposes good subject knowledge”.

Since the advent of this new curriculum, there have been cries about difficulties in realising the full and effective implementation of the curriculum. This has been captured by Jita and Mokhele (2008: 254) in their observation that “many schools in South Africa and elsewhere struggle to offer high quality instruction, especially in the Sciences and Mathematics”.

In this study, the researchers chose mechanics as one of the most challenging sections of the FET physical science curriculum. In general, the main purpose of mechanics is to teach learners the fundamental laws and principles of physics and to give them experience in reasoning out how these laws and principles apply to the world about them (Bueche 1986).

Challenges pertaining to the conceptual development of learners' understanding of concepts and principles related to mechanics have been a subject of research in many countries around the world. In their study investigating differences in learning outcomes and other instructional variables between online and blended delivery methods, Lim et al. (2007) reported no significant differences between the two delivery format groups. Hopf et al. (2011: 1) reported that due to the complexity of the topic itself, students' misconceptions and also the generally poor quality of instruction "students' understanding of mechanics – even after instruction – is fragmentary." Laws et al. (2014: 490) were "enthusiastic about the potential of Video Vignettes as a viable alternative to on-line lectures and other on-line teaching modalities." Using a digital pen-and-paper technology called Live scribe smarten, as a data collecting device, Mackay and Fawcett (2014: 524) recorded and analysed "student explanations of simple physical phenomena in the form of "pen casts from electricity and magnetism, mechanics, thermodynamics as well as from basic physics ideas in anatomy and physiology" and found that this approach contributed "substantially to the identification and amelioration of the common errors detected in the explanations generated by the students." Okoronka and Taale (2014: 579) used "cues, prompts, probes, gestures and questioning strategy to remediate some learning difficulties of students in some physics concepts" and reported "an improvement in students' understanding on basic concepts in optics, heat and mechanics."

To solve problems in mechanics, learners need to have a clear understanding of the basic principles of mechanics. However, there are conceptual blocks and alternative conceptions associated with mechanics which tend to prevent learners from having a good understanding of concepts. This study, therefore, sought to investigate whether specific instructional approaches could help alleviate or over-

come such conceptual difficulties and alternative conceptions.

Statement of the Problem

Jimoyiannis and Komis (2001: 1) state that "a major research domain in physics education is on the effects of various types of teaching interventions aimed to help students' alternative conceptions transformation." This study focused on the alleviation of conceptual difficulties and alternative conception in mechanics, by way of three treatment conditions developed and implemented for this purpose, namely the traditional, OBE and blended approaches.

In literature, the 'traditional method' to teaching and learning is dominated by passive student lectures (that is, the telling method), recipe laboratory activities and algorithmic problem solving (Hake 2002; Hunt 2002); it is mainly associated with memorisation by learners – the teacher as the disseminator of information. Thus, typically, traditional learning approaches are taken to be based on the notion of 'transmission of information' – mistaken as being the same thing as 'transmission of knowledge'. However, the reality is that 'knowledge' cannot be transmitted from one person to another, for the simple reason that every individual 'makes' their own knowledge from their learning and environmental experiences. Indeed, only information can be transmitted; knowledge, understanding, skills and attitudes all have to be developed by each individual for themselves – and that is why they cannot be transmitted.

Another aspect of the traditional approach (sometimes referred to as 'reception learning') is that in this form of instruction, the emphasis is on what the 'lecturer' does during the lesson, and, therefore, the success of the lesson is determined in relation to the performance of the 'lecturer', rather than the gains made by the learner.

With regard to the effectiveness of the traditional approach, the literature purports that it has only a limited prospect of inducing changes in the learners' understanding (Halloun and Hestenes 1985; Hake 1997). In the same vein, Pride et al. (1998: 150) posit that "teaching by telling is an ineffective mode of instruction for most students."

Both the OBE and Blended instructional philosophies fall under the category of 'interactive'

approaches, based on principles of constructivist teaching and learning. In this regard, learners' questions, comments, responses in tests and during class are ploughed back into the instructional process. Instruction involves open interactions among the educator and students, as well as learner-learner interactions. Thus, the main difference between the OBE and blended instructional approaches is more with regard to the wider application of educational media in the blended approach, as opposed to OBE. As Rovai and Jordan (2004: 1) aver, blended learning is "a hybrid of classroom and online learning that includes some of the conveniences of online courses without the complete loss of face-to-face contact".

According to Valiathan (2002) the term blended learning is used to describe a solution that combines several different delivery modes, such as collaboration software, Web-based courses, and knowledge management practices. Singh and Reed (2001: 2) assert that "the original use of the phrase 'Blended Learning' was often associated with simply linking traditional classroom training to eLearning activities". According to Valiathan (2002) the term 'blended learning' is also used to describe learning that mixes various event-based activities, including face-to-face classrooms, live e-learning, and self-paced learning. Picciano (2006) opines that blended learning is not one thing. It comes in many shapes, flavours, and colours:

In one course, blended learning may be used to enhance the traditional lecture with electronic instructor notes, additional readings, and images of charts, graphs, or other hand-outs. In another course, online learning may be combined with face-to-face instruction so that rather than meeting in a classroom three hours a week, a course meets two hours per week with the third hour consisting of an online threaded discussion (Picciano 2006: 2).

Furthermore, Picciano (2006: 2) states that "in the broadest sense, blended learning can be defined or conceptualized as a wide variety of technology/media integrated with conventional, face-to-face classroom activities".

Typically, blended learning environments involve a combination of face-to-face instruction with web-based / online instruction. Expanding on online learning Wright (2014: 13) posits that online learning:

... involves the use of computer networks and course management software to share educational content among students, teachers, administrators, and support staff. Other forms of distance education include interactive TV and teleconferencing. Online learning, via the advent of internet tools such as search engines, social networks, uploading technology (for example YouTube, Wikipedia), and course management networks, has revolutionized and popularized distance education.

Likewise, Drysdale et al. (2013: 90) also surmise that blended teaching is "the thoughtful integration of online and face-to-face-instruction." Mapping out the extent of student involvement possible in a blended learning environment, Ismail reported that from his/her study, active learning strategies "enabled the students to share their individual learning experiences with each other through Blackboard communication tools and discussion board, and helped them to conduct an online search for extra websites to expand their experiences in the field and its current applications for learning and training purposes" (Ismail 2013: 130).

Overall, it may be said that the blended learning approach is based on the assumption that all teaching strategies and methods are vitally important – particularly given that in a class of many learners one also finds different learner characteristics, needs and learning styles which not a single instructional approach can satisfactorily address and satisfy. As operationalized in this study, the OBE approach was dominated by demonstrations, question-and-answer sessions, as well as group discussions – while the educator functioned as a facilitator.

Research Question

This study set out to answer the following research question: Which intervention(s) among the traditional, OBE-based and the blended approaches will best alleviate the conceptual difficulties and alternative conceptions related to mechanics among grade 12 physical science students?

Statistical Hypothesis

The answer to the above research question was determined through the statistical testing of the following null hypothesis:

H_0 : There is no statistically significant difference amongst traditional, OBE-based and blended instructional interventions in alleviating the conceptual difficulties and alternative conceptions held by grade 12 learners in mechanics.

METHODOLOGY

This study used the quasi-experimental, non-equivalent comparison group research design involving 140 grade 12 physical science learners drawn from four high schools in the Lower Umfolozi Circuit of the Empangeni Education District. Learners in each school constituted one experimental group, making four groups each comprising 35 learners; one of the four groups was used as a comparison group.

The participating schools were selected from a total of fifteen (15) high schools with computer facilities, using purposive sampling. The selected schools were geographically convenient to reach by the first author who carried out the field research. Purposive sampling was preferred because the researchers needed to ensure that the intended interventions could be implemented in the participating schools. In particular, to meaningfully implement OBE and the blended approaches, certain conditions and resources needed to be in place. Thus, no claim is made in this study that the selected schools were representative of the wider, high school population in the province.

All the four groups were pre-tested to detect any possible initial differences among the four (4) groups. The teaching and learning approaches constituted 'treatment conditions', which were then administered to the participating groups. All the four groups were post-tested following the administration of the treatment conditions. A researcher-designed test: the Test in Basic Mechanics (TBM) was used to collect the data, and it was used as both pre- and post-test. Data were analysed using the statistical package for social sciences (SPSS) computer package. Analysis of variance (ANOVA) and average normalized gain scores were used to compare the effectiveness of the three treatment conditions, amongst themselves and against the comparison group. The differences in the post-test scores among the four groups indicated the effectiveness of the respective interventions. The degree of change in the dependent variable

for the different groups was then compared to establish the relative effectiveness of the three interventions.

Treatment Conditions / Instructional Interventions

For the traditional group the concepts were treated according to the traditional way of teaching – dominated by lecturing (frontal, teacher-centred exposition) and sole use of the prescribed textbook as the main reference material. Thus, for this intervention, the teacher remained in complete control of class proceedings while the students were mostly passive recipients of teacher talk.

For the OBE group, the concepts were mainly learner-centred, involving teacher-learner and learner-learner interactions, as well as the use of extra reference resources – both within and outside the classroom. The researcher used intervention strategies which adhered to the notion of constructivism – focusing on the ideas which were allowed to develop in the learners' own mind through a series of activities (Gray 1997). Thus, learners' questions, comments and responses in tests and during class were used in developing the direction and essence of the learning process. Lessons were characterised by open and deliberate interactions between the educator and the learners, as well as learner-learner interactions. The students participated fully in the lessons through the following activities: handing in assignments; giving feedback by use of transparencies on the overhead projector; controlled class discussions; negotiating meaning in small discussion groups; hands-on activities; individual problem solving tasks; articulating relevant personal experiences; and wrestling with real world problems rather than memorising answers. The teacher played the role of a facilitator. Understanding was assessed by means of different continuous assessment assignments. Peer and self-assessment modalities were also used.

The blended approach makes the assumption that all teaching strategies and methods are vitally important, given that in a class of many learners one also finds different learner characteristics, needs and learning styles. Thus, in this study, a continuum of teaching strategies was used – as in the OBE approach – and were further re-enforced through the use of computer

mediated teaching / learning. The comparison group studied chemistry topics during the intervention period to ensure that there was no interference with mechanics that was being taught to the three treatment groups.

RESULTS

The results are presented and discussed below under various sub-headings.

Biographical Profile of Respondents

The research sample consisted of more girls than boys. In total there were 140 learners who participated in the study, comprising 56 males (40%) and 84 females (60%).

Comparison of Pre-test Means

Table 1 shows the means of all the four groups, that is, traditional (48.43%), OBE (48.74%), blended (49.31%) and comparison (49.71%) groups at the beginning of the study.

Table 1: Pre-test means of the traditional, OBE, blended and comparison groups

Group	N	Means (%)
Traditional pre-test	35	48.43
OBE pre-test	35	48.74
Blended pre-test	35	49.31
Comparison pre-test	35	49.71
The average of means	35	49.05

The pre-test scores for the four groups were statistically compared for equivalence. The result is presented in Table 2. The result shown

in Table 2 indicates a non-significant difference in the pre-test scores of learners belonging to the four groups. The critical F_c is greater than the observed F_o – hence, $p > 0.05$. This result shows that the groups were statistically equivalent at the onset of the study, with regard to their pre-test scores. The result provides the basis to assume that any differences subsequently observed in the learners' scores, after the instructional interventions, could reasonably be attributed to the respective instructional interventions.

The Effectiveness of the Three Interventions

Table 3 presents the means scores of the different treatment groups on the post-test, showing the mean differences among the groups. According to Table 3, the post-test mean for the blended group was the highest (94.28%), followed by the OBE-based group (72.37%), and lastly, 62.43% for the traditional group. The differences in means were 9.94%; 21.91% and 31.85% between the traditional and OBE, the OBE and blended and between the traditional and the blended groups, respectively.

In line with the *a priori* hypothesis stated above, Table 4 presents the ANOVA summary of the data reflected in Table 3. The comparison group was not included in Table 4 as there was no significant difference between the pre- and post-test scores of this group. Table 4 indicates a significant difference in the post-test scores of the three groups ($F_c < F_o$; $\alpha = 0.05$). This means that there was a significant difference among the three groups with regard to their effectiveness in alleviating the conceptual difficulties and alternative conceptions of the students in mechanics. Therefore, the existence of a significant difference in the post-test scores among

Table 2: Statistical comparison of the pre-test means of the three groups on the BMT

Source	SS	Df	MS	F_o	F_c	Result
Between	34.43	3	11.48	0.17	2.68	p>0.05 not significant
Within	9399.94	136	69.12			
Total	9434.37	139				

Table 3: Post-test means of the three experimental groups

Group	n	Means (%)	$\bar{A}$ Trad vs. OBE (%)	BE vs $\bar{A}$ O Blend (%)	$\bar{A}$ Trad vs Blend (%)
Traditional Post-test	35	62.43	9.94		31.85
OBE Post-test	35	72.37		21.91	
Blended Post-test	35	94.28			

Table 4: ANOVA for the three intervention groups on the post-test

Source	SS	Df	MS	F_o	F_c	Result
Between	531.37	2	265.69	5.84	3.09	P < 0.05
Within	4643.14	102	45.52			
Total	5174.51	104				

the three groups led to the rejection of the *a priori* null hypothesis of this study. It was therefore necessary to conduct *a posteriori* comparisons among the three groups in order to establish where the significant difference(s) lay. Thus, the following *a posteriori* statistical hypotheses were formulated, and subsequently tested:

$H_{o1.1}$: There is no significant difference between the traditional and OBE-based instructional interventions in alleviating learning difficulties and alternative conceptions in mechanics.

$H_{o1.2}$: There is no significant difference between the traditional and the blended instructional interventions in alleviating learning difficulties and alternative conceptions in mechanics.

$H_{o1.3}$: There is no significant difference between the blended and OBE-based instructional interventions in alleviating learning difficulties and alternative conceptions in mechanics.

Table 5 shows the results of the comparison between traditional and OBE. The result in Table 5 shows that there was a significant difference between the post-test scores of the traditional group vis-à-vis the OBE group ($F_c < F_o$; $p < 0.05$). Examination of the post-test mean

scores, in Table 3, shows that the statistical difference is in favour of the OBE-based intervention. Thus, the answer to $H_{o1.1}$ is that an OBE-based instructional intervention is more effective in alleviating learning difficulties and alternative conceptions in mechanics than a traditional intervention. The null hypothesis is therefore rejected.

Table 6 shows ANOVA results on the comparison of the effectiveness of the traditional versus blended interventions. The results in Table 6 show that a significant difference ($F_c < F_o$) existed between the two interventions ($p < 0.05$). Examination of the mean scores of the two interventions, presented in Table 3, shows that the statistical difference is in favour of the blended intervention. Thus, the answer to $H_{o1.2}$ is that a blended instructional intervention is more effective in alleviating learning difficulties and alternative conceptions in mechanics than a traditional intervention. The null hypothesis is therefore rejected.

Table 7 presents ANOVA post-test score comparisons between the blended and OBE-based instructional interventions. Table 7 also

Table 5: ANOVA results on the comparison between traditional and OBE groups

Source	SS	Df	MS	F_o	F_c	Result
Between	1732.54	1	1732.54	53.15	3.98	P < 0.05
Within	2216.75	68	32.60			
Total	3949.29	69				

Table 6: ANOVA results on the comparison between traditional and blended interventions

Source	SS	Df	MS	F_o	F_c	Result
Between	17763.54	1	17763.54	216.18	3.98	P < 0.05
Within	5587.71	68	82.17			
Total	23351.25	69				

Table 7: ANOVA results on the comparison between the OBE and blended interventions

Source	SS	Df	MS	F_o	F_c	Result
Between	8400.84	1	8400.84	96.57	3.98	P < 0.05
Within	5915.31	68	86.98			
Total	14316.16	69				

presents statistically significant results between the two interventions, ($F_c < F_0$; $p < 0.05$). On the basis of the post-test means in Table 3, the difference is in favour of the blended intervention. Therefore, the answer to the third and final *a posteriori* statistical hypothesis (H_0 1.3) is that the blended instructional intervention is more effective in alleviating learning difficulties and alternative conceptions in mechanics than an OBE-based intervention. Again, the null hypothesis is rejected in favour of the alternative.

The Average Normalised Gain Score (ANGS) Concept

The average normalised gain score concept was also used in this study to ascertain whether or not the effectiveness of the three treatment conditions, namely: traditional, OBE-based and blended, fell within the *interactive-engagement zone*. Table 8 shows the three interventions with their pre- and post-test mean scores, as well as average normalised gain score (ANGS) percentages, calculated using the formula $(g) = \% (G) / \% (G)_{\max} = [\% (S_f) - \% (S_i)] / [100 - (S_i)]$ – where S_f and S_i are the final (post) and initial (pre) group averages, respectively. Hence, (G) represents the actual average gain expressed as $[\% (S_f) - \% (S_i)]$; and $\% (G)_{\max}$ represents the maximum possible average gain expressed as $[100 - \% (S_i)]$. The total marks of the BMT test was 129 marks. Table 8 presents the results of the comparisons based on the ANGS concept.

Table 8 shows that the average normalised gains (g) for the traditional, OBE, blended and comparison group interventions were 0.20; 0.30; 0.60 and 0.00, respectively. According to Hake (1997, 2002) (g) is a much better indicator of the extent to which a treatment is effective. If the

treatment yields $(g) > 0.30$, then the treatment could be considered as in the “interactive-engagement zone” (Hake 1998; Meltzer 2002). More specifically, “high gain” is defined as the one with $(g) \geq 0.70$; “medium gain” with $0.70 > (g) \geq 0.30$; and “low gain” with $(g) < 0.30$ (Hake 1998). The comparison and traditional interventions were not in the ‘interactive-engagement zone’. This means that, as a measure of effectiveness, the interactive-engagement methods were poorly or not used at all with respect of these two groups. On the other hand, the OBE intervention was in the ‘interactive-engagement zone’, with a medium gain, $[(g) = 0.30]$. Thus, it may be said that the interactive-engagement methods (for example, group discussions) were fairly well used. The blended intervention was also in the medium gain $[(g) = 0.60]$ which was the highest gain among the three interventions. Hence, the analysis according to the ANGS concept confirms the ANOVA results reported above.

DISCUSSION

The unfortunate thing about the instructional process is that “teaching does not automatically lead to learning” (Vermun and Verloop 1999: 258). Over the years, educational literature has advocated a shift away from teacher-centred to learner-centred instructional approaches – concomitantly associated with learning psychologies that favour active learning instructional strategies over the ones where learners sit passively during lessons. The contention behind this shift has been that there are certain educational benefits that would result from active learning modalities. According to Van Dijk and Jochems (2002: 275):

Table 8: Comparisons of all the groups based on the ANGS Concept (n=140)

Descriptions	Interventions/treatments and comparison group			
	Traditional	OBE	Blended	Comparison
Total marks	129	129	129	129
Pre-test means	48.43	48.74	49.31	49.71
Post-test means	62.42	72.37	94.28	50.74
$\% (S_i)$	37.54	37.78	38.23	38.53
$\% (S_f)$	48.39	56.10	73.09	39.33
$\% (S_f) - \% (S_i)$	10.85	18.32	34.86	0.8
$100 - \% (S_i)$	62.46	62.22	61.77	61.47
$(g) = [\% (S_f) - \% (S_i)] / [100 - \% (S_i)]$				
	0.17- 0.20	0.29-0.30	0.56-0.60	0.01-0.00
ANGS (g)	0.20	0.30	0.60	0.00

... active participation of students in the learning process is often put forward in educational literature as a means of developing higher order cognitive skills and of changing attitudes ... This assumption is based on the constructivist view of learning, which states that students are actively involved in the construction of mental representations, instead of merely being empty vessels waiting to be filled with knowledge.

Echoing the same sentiments earlier, Vermun and Verloop (1999: 258) observed that learning “is not a passive, knowledge-consuming and externally directed process, but an active, constructive and self-directed process in which learners build up internal knowledge representations that are personal interpretations of their learning experiences.” They further pointed out that the mental representations which learners create from their learning experiences change constantly on the basis of the meanings that they attach to their experiences.

Another term used for ‘active learning’ is ‘interactive engagement’. According to Hake (1998: 2) interactive engagement takes place when students are involved in “heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors.” Thus, from the teaching point of view, it is important how one understands the learning process, as Vermun and Verloop (1999: 258) point out:

When learning is conceived more as self-regulated knowledge construction than as taking in already existing external knowledge, the role of teaching changes too, from transmission of knowledge to supporting and guiding self-regulated knowledge construction ... The processes of students’ knowledge construction become the object of teachers’ efforts.

In this regard, it is perceived and believed that active learning approaches would be effective in motivating learners and would lead to a high degree of satisfaction with the learning experience and, therefore, yield better grades (Ismael 2013). Overall, the main thrust behind this investigation way to conduct a comparison of instructional approaches along the Active-Passive learning continuum – where blended was perceived to entail ‘most active’, followed by the OBE and finally the traditional approach. More specifically, the traditional approach was perceived to be mainly ‘passive’, in-so-far as learner engagement is concerned.

The findings of this study have revealed that the traditional approach produced significantly lowest scores on the post-test, as compared to the OBE and the blended interventions. In the same vein, McDermott et al. (1993) also concluded from their study that traditional instruction did not enhance students’ understanding of dynamics. Similarly, Hake (1998: 2) also “found that students taking interactive engagement (IE) courses had dramatically better conceptual understanding, compared to students taking traditional courses.” Thus, these results show that the traditional approach was relatively ineffective in promoting students’ conceptual understanding and alleviation of their learning difficulties.

In agreement with the findings of this study, Ates (2009: 222) contends that “the future requires blended learning since with the infusion of various technologies and other interactive modes of communication into our lives, we are surrounded by a blending world which will be more blended in the future.” Blended teaching appears to be most effective mainly because it caters for different learner characteristics, particularly considering that in diverse classrooms, different learners learn best through different approaches. Indeed, in this study, the blended instructional approach made use of a variety of teaching / learning platforms – including computer-mediated teaching and learning, short lectures, group work, and others, as part of its blended intervention. With specific reference to computer-assisted learning, Jimiyiannis and Komis (2001: 2) make the observation that “computer simulations are applications of special interest in physics teaching because they can support powerful modelling environments involving physics concepts and processes.” In the study by Jimiyiannis and Komis, learners were of about the same age as those who constituted the research sample for this study. Their findings revealed that “students working with simulations exhibited significantly higher scores in the research tasks” (Jimoyiannis and Komis 2001: 2). They further concluded that “computer simulations may be used as an alternative instructional tool, in order to help students confront their cognitive constraints and develop functional understanding of physics” (p. 12). These observations influenced the use of computer-mediated learning activities in this study.

The interest in blended learning environments has not been limited only to science ed-

ucation. Maulan and Ibrahim (2012) examined students' perception, engagement and performance in a blended learning environment concerning a pilot project for English for Academic Purposes, and reported that there was no significant difference between students who were involved in blended learning and those who were not. Lim et al. (2007: 27) investigated differences in learning outcomes and other instructional variables between online and blended delivery methods, and reported that "no significant differences existed in learning outcomes; however, significant differences existed in several instructional and learner factors between the two delivery format groups." Al-Qahtani and Higgins (2013: 220) investigated the effect of e-learning, blended learning and classroom learning on students' achievement, and found that "there was a statistically significant difference between the three methods in terms of students' achievement favouring the blended learning method." However, they found no significant difference between the e-learning and traditional learning groups in terms of students' achievement. Pereira et al. (2007) reported blended learning to have been more effective than traditional teaching for teaching human anatomy. The overall picture that emerges is that teachers and lecturers teaching topics such as mechanics need to "adopt a variety of teaching strategies, which make these subjects interesting and comprehensible so that learning can be effective and enjoyable" (Karin 2011: 6).

Overall, the results of this study concur with those reported in the literature, and go further to emphasise the growing demand for using blended teaching and learning environments. In particular, the findings have supported the view that active learning approaches hold greater benefit for learners than approaches that do not require immediate learner engagement. However, in making this observation, the researchers are well aware that to achieve success with active learning approaches, learner motivation plays a critical role (Wen and Lin 2014: 86).

CONCLUSION

The results of this study showed that all the three interventions significantly alleviated conceptual difficulties and alternative conceptions of the learners in mechanics. It may then be said that all methods of teaching should be used to

accommodate different learner characteristics since learners learn in different ways. However, there was relative effectiveness of the three interventions in favour of the blended approach, followed by OBE. It may be argued that the effectiveness of the blended approach lay in its capacity to cater for and accommodate the diversity of learning styles and needs of the learners. Therefore, one main recommendation coming from these findings is that teachers use a variety of instructional approaches in order to meet the optimum learning conditions for each learner. This notion explains why the blended approach emerged as the most effective instructional approach.

RECOMMENDATIONS

On the basis of the findings of this study, blended learning has emerged as a very effective approach to enhancing learner achievement. It is evident from the results reported in this paper, and the literature presented therein, that using a variety of educational media in combination with face-to-face instruction, increases prospects for learning for the majority of learners. As such, the researchers wish to recommend that teachers and school authorities consider giving students more and more opportunities to learn under blended learning environments. However, acknowledging the wide gaps disparities one observes in school resourcing, particularly in developing countries, it is recommended that a loose definition of 'blended environments' be used, whereby face-to-face instruction is integrated with other forms of educational media – including web-based ones, where possible, in combinations that can be supported within a given school environment. This calls for both governmental and institutional policy formulation and/or adoption to support this move. Once the enabling policies have been adopted, teachers will need to be capacitated in order that they are enabled to create and use different forms of blended learning environments, as required.

The researchers acknowledge that further research is still needed on a number of key issues concerning blended learning environments, including (a) development of a theory that will adequately explain the fundamental tenets under which blended learning could be optimised; such a theoretical framework would assist teach-

ers make appropriate decisions about how to effectively blend and/or which blends to choose, (b) learner characteristics (for example, preferences, motivation, learning styles, limitations) with respect to specific blended learning design features, (c) practitioner (teacher) competencies and other characteristics with regard to teaching and learning under blended learning environments, (d) the supervisory role that is needed – and with respect to what kinds of blends, and (e) the resources needed, school-support mechanisms, resourcing modalities and models needed to support blended learning environments.

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