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Using a DVD to Illustrate Grade 12 Physical Sciences Experiments: A Teaching Aid to Support Learners

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ABSTRACT Grade 12 Physical Sciences teachers are not always adequately trained to use laboratory equipment to conduct experiments. To address this challenge, this study was based on a combination of traditional methods and technology (a DVD illustrating Physical Sciences experiments) to teach and learn four selected Grade 12 experiments. Student-teachers (n=18) were prepared and trained beforehand to execute the lessons during their practical teaching in selected rural schools, while the Physical Sciences teachers (n=18) observed. Before the student-teachers began the lessons, a pre-test was written by all Grade 12 learner participants (n=250) and the results recorded, but no feedback was given to the learners. After the lessons (taught over a period of four weeks) the same test was repeated, assessed and recorded. The results showed that 57% more learners had scored between 50% and 59% on the repeat test. Student-teachers and teachers then reflected (qualitative data) on the advantages and challenges of using a DVD teaching aid, revealing inter alia that learners could learn at their own pace; learners were more confident when interacting during discussions; unclear concepts were clarified; and lessons provided in-depth training and development not only for Physical Sciences student-teachers, but also for the teachers who had observed the lessons. This study recommends that visual illustrations of Grade 12 experiments be used in rural schools to support under-qualified Physical Sciences teachers until they are able to execute experiments on their own and with self-confidence.

INTRODUCTION

Physical Sciences education in South Africa clearly does not meet the needs of all learners as a large number of students in higher education find it difficult to successfully complete their first year of university (Jansen 2012a). According to statistics, the Physical Sciences marks of Grade 12 learners are improving (53% in 2011 and 61% in 2012) (Republic of South Africa Government Information 2013). However, these results cannot be used to compare learners' performance over a number of years, as the poor academic performance of first year students shows that it is possible that education standards may have been lowered year after year in order to pass Grade 12 learners (Jansen 2012b).

The concern in Physical Sciences education is that, because of growing learner numbers, class sizes have increased to a learner-teacher ratio of 1:45 and in some schools even higher (EduSource Data News 2011). Furthermore, teachers complain that they cannot conduct the prescribed Grade 12 experiments because of an increased work load, a lack of time and a lack of laboratories and resources (Ker-Fox et al. 2000). Muwanga-Zake (1998) and Makgatho and Mji (2006) contradict these statements, saying that many of these teachers do have equipped laboratories and resources, but are not trained to conduct the necessary experiments, depriving their learners of much-needed practical experience. This may account at least in part for the poor Physical Sciences results of Grade 12 learners (Kriek and Grayson 2009). Only 49% of Physical Sciences teachers are qualified to teach Physical Sciences and most of those are teaching in the historically advantaged schools, as few are willing to move to impoverished rural communities (Cape Higher Education Consortium (CHEC) 2009; Department of Higher Education and Training 2010).

It is imperative that under-qualified teachers in rural areas be creative and find alternative methods, non-traditional teaching methods to support their Physical Sciences teaching and enhance deep learning in their classes. The Physical Sciences DVD discussed in this article can be regarded as an aid to help teachers improve their learners' Physical Sciences education.

To improve teaching and learning among Grades 12 Physical Sciences and Mathematics learners, the Dinaledi Project (consisting of 132 secondary schools) was established in 2001. In 2005, the Dinaledi Project became a pilot project which aimed to pass 50 000 Physical Sciences

and Mathematics learners with a qualified and competent teacher in each class. In 2009, 370 Physical Sciences and Mathematics teachers were trained on content knowledge. This resulted in Dinaledi schools contributing 23% to the national Physical Sciences and Mathematics pass rate. However, it proved to have been merely a short-term intervention, as the pass rate of Dinaledi schools dropped to 18% in 2010. In order to provide quality education and improve results, the "Adopt a School project" funded by the private sector and the "Action Plan 2014" of the Department of Education were created (Republic of South Africa 2012). In addition, the curriculum was changed, so that teachers were provided with prescribed content rather than having to find their own study material on any given topic.

The concern of this study is that the present education system is not able to address all learners' educational needs in a fast developing technological world, especially where Physical Sciences is concerned. Bearing in mind the socio-context and the digital age in which learners grow up requires teachers to keep abreast of the new technological developments and to select appropriate media for both in and out of class activities. Some examples may be films, videos, e-mails, the internet, virtual conferencing, social-media platforms, iPads, iPods and others, all of which can be used to support active learning, encourage learner discussions and explain and concepts learned in class (Miller 2012).

Because of the abovementioned challenges hampering Physical Sciences education, a need was identified for intervention aimed at supporting teachers in their efforts to conduct and teach Grade 12 Physical Sciences experiments in rural schools. In order to include technology in the learning environment of learners, a teaching aid to Physical Sciences teaching was selected, where a digital video disk (DVD) illustrating Grade 12 Physical Sciences experiments and traditional teaching methods were combined to teach new content.

This teaching aid was decided upon to support learners' different learning styles and engage them in active participative learning where they can discuss and apply the skills they acquire to solve real life problems deriving from the social context in which they live. Collaborative learning activities supported by technology (for example, the DVD) allow for discussions and debate among peers, where they can clarify concepts with one another and come up with possible solutions to problems (Luca 2006). These interactions among learners and created assessment activities deriving from learning activities enable teachers to determine learners' individual needs within a learner centered learning environment (Coryell and Chlup 2007). Interaction and assessment can be considered critical principles for effective learning, as learners need regular feedback on their learning activities.

Graham and Valsamidis (2006) and Singh and Reed (2001) support the selection of a DVD as a teaching aid to assist learning, indicating that a combination of both technology and traditional teaching methods can improve effective deep learning. Singh (2003) and Serva and Fuller (2004) elaborate by stating that "face-to-face" lessons (traditional methods) and technology-based instruction should be used in a meaningful pedagogical way to attract learners' interest and improve their learning and their acquisition of skills. De Amicis et al. (2011) state that technology (for example, DVD) can be used to clarify difficult concepts, but should be viewed before new content is discussed, to provide learners with an image that they can connect to new concepts taught.

Traditional instruction can be described as "face-to face" teacher instruction where the teacher imparts and discusses new knowledge according to a prescribed structured curriculum (usually from a textbook), while technology-supported methods enable teachers to teach the prescribed curriculum with the aid of technological resources such as a video recorder, DVDs, internet programmes, digital cameras and Power Point, to mention but a few.

The use of a DVD (technology) and traditional methods to illustrate and explain Grade 12 Physical Sciences experiments is supported by the learning theories of Arnold (2008), Bauer et al. (2006), Clark (2002), Gagné (1985), Keller (1987), Mayer (2000), Merrill (1994), Reed (2001) and Singh and Zemke (2002), all of whom emphasise various elements when using a teaching aid to support learning.

Gagné (1985) argues that support material (for example, DVD) is the most important element of improving the retention and transfer of learning content to real life applications. Mer-

rill's (1994) situational design theory is in agreement with Gagné and indicates that learners should be engaged in real life problems where they can apply the knowledge and skills they have acquired to solve problems. Singh and Reed (2001), in their situational instruction model, and Zemke (2002) state that the use of supportive teaching aids for learning should take place in the community. While interacting with their peers, learners can develop certain attitudes, values, skills and identities in their communities that will enable them to solve problems relevant to their needs. Arnold (2008) and Bauer et al. (2006) comment that learner motivation can increase where relevant learning activities are used. Thus, every leaning situation requires appropriate real life examples and support material to improve learning.

According to Clark (2002), the significance of technological support material such as visual graphics can improve learners' learning if the teacher adds relevant educational – and not merely decorative – graphics to the learning content. Clark (2002) agrees with Mayer's (2000) results, which indicate that learners' averages can improve if words are integrated at the bottom of the visuals displayed on the screen of, for example, DVDs. In addition, Keller's (1987) teaching principle that graphics should be explained with audio to improve learning can be considered as central to an effective leaning approach. This is because learners still need to engage with the teacher "face to face" while viewing visual activities such as (in this study) watching the DVD. On the other hand, Merrill (1994) warns that teachers should refrain from using an overload of visuals and audio when explaining new content to learners. For example, overload could occur if learners have to watch an experiment and read the text at the same time, whereas the instructional voice of the teacher or the audio of the DVD can help them understand what they are observing.

In this paper, the support of a DVD as a teaching aid, to enhance teaching and learning of Physical Sciences experiments, is evaluated. The emphasis is on how student-teachers, Physical Sciences teachers and Grade 12 Physical Sciences learners experienced the use of this teaching aid and whether it improved the learners' academic performance.

METHODOLOGY

The research was based on quantitative and qualitative data and guided by theoretical findings in the literature study. Qualitative data was gathered from Physical Sciences student-teachers (n=18) from a selected South African university and Physical Sciences teachers (n=18) from 18 schools to determine their perspectives on the use of a teaching aid, the DVD in Physical Sciences teaching and learning. The schools were mostly historically disadvantaged schools situated in the Gauteng (n=4), Limpopo (n=3), Mpumalanga (n=4) and KwaZulu-Natal (n=7) provinces of South Africa. The schools in each province were selected according to the participating student-teachers' choices of where they wanted to conduct their practical teaching.

A quantitative data approach was used where the pre- and final-test results of Grade 12 learners (n=250) were compared. This was done to establish whether traditional methods used in combination with a teaching aid (in this study a DVD) by student-teachers to teach and learn Grade 12 Physical Sciences experiments could improve learners' academic results.

The research methodology was based on the following research question:

What are the advantages and challenges when Physical Sciences learners view a DVD that illustrates and explains Grade 12 experiments and the student-teacher/teacher facilitates the learning process?

In the research, it was decided to use affordable technology such as a video recorder, television set and DVD to illustrate Grade 12 Physical Sciences experiments, since not all schools are equipped with computers/internet access.

The reason for using a DVD, was to determine whether combining technology with traditional teaching and learning methods could improve learners' Physical Sciences marks. To ensure the validity of this study, the participating student-teachers were trained and prepared in several lectures on how to use a combination of technology as teaching aid and the traditional methods in lessons during their practical teaching.

The Following Procedures Were Followed to Train and Prepare Student-Teachers

Because of time restrictions, student-teachers identified four experiments that they experi-

enced as difficult in Grade 12 Physical Sciences. The student-teachers selected the following four experiments for this study: Build a simple direct current electric motor; the working of a galvanic or electrochemical cell; electrolysis of copper (II) chloride; and the reactions of alkanes and alkanes with bromine. Student-teachers were then instructed on how to use a video recorder – for example how to connect the recorder to the television and how to pause, record and play the DVD. The researcher conducted an example of a lesson using one of the four experiments and illustrating how a DVD can be used to support teaching and learning.

Student-teachers were allocated to groups of five each, and four lessons based on the selected Physical Sciences experiments and a work sheet for each lesson were compiled among them. After the completion of lessons and worksheets student-teachers discussed and changed the worksheets until one worksheet was constructed by all for each experiment. Back in their groups, student-teachers were issued with previous Grade 12 Physical Sciences examination papers in which there were questions relating to the four experiments and instructed to compile a test by selecting questions from the different groups in the papers. They brainstormed and compiled one test that enabled Grade 12 learners to think critically and link the question(s) to the acquired content. Each student-teacher then had to arrange for a television and a recorder at the school, and to copy the test and worksheets beforehand as not all schools can afford copying facilities.

Executing the Lessons

All student-teachers used the same materials: DVD illustrations, planned lessons, copies of worksheets and a test to determine if a teaching aid could improve Grade 12 learners' learning performance.

The following actions were followed: Before the lessons, all participants in all 18 schools wrote the same pre-test to establish their level of knowledge on the concepts to be taught. These tests were marked by student-teachers but learners received no feedback at that stage.

During each lesson the student-teacher taught the specific content of the experiment and showed the DVD while explaining certain concepts. The DVD was paused, replayed and stopped several times to enable learners to develop critical thinking skills such as analysing and synthesising information, predicting the outcome of the experiments and formulating conclusions. The Physical Sciences teachers observed all the lessons.

After each lesson, all Grade 12 learners had to complete a worksheet prepared beforehand by participating student-teachers. The worksheets were assessed and discussed with their peers and corrections made. This pattern was followed in all four lessons.

After each of the four lessons, learners wrote the same test as the pre-test again, to determine if the lessons supported with a DVD had helped them make academic progress. The tests were marked by student-teachers, handed back to learners and discussed intensively. The results were recorded by the student-teachers and the Physical Sciences teachers. The results of the pre-test and final test were compared to make findings on learners' academic performance.

Learners' pre- and final test results were compared at the end of each practical teaching session. Student-teachers combined their learners' pre- and final test averages in categories of 0-39%, 40-49%, 50-59%, 60-69%, 70-79% and 80-100% to establish whether learners' marks did improve when technological and traditional teaching methods were combined.

After the DVD supported lessons a open-ended question was used to collect qualitative data from student-teachers and Physical Sciences teachers. Participants had to reflect on the advantages and challenges of using a DVD to illustrate Grade 12 Physical Sciences experiments.

RESULTS AND DISCUSSION

Analysis of the reflections of all participants and comparisons of Grade 12 Physical Sciences learners' pre- and final test results are presented and discussed below.

Quantitative Data

When the student-teachers returned from teaching practice they calculated the learners' pre- and final test results and grouped them according to the percentages achieved in both pre- and final test. The average results obtained for the pre-test (n=250) are reflected in Figure 1.

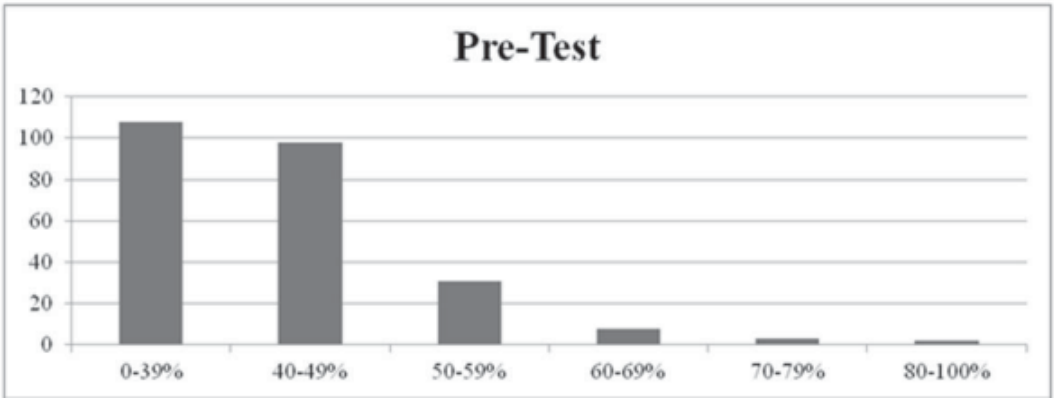

Fig. 1. Pre-test results of Grade 12 physical sciences learners

The pre-test as summarised in Figure 1 illustrates the following scores: Of the participating learners, 108 scored below 39%, 98 averaged 40-49%, 31 averaged 50-59%, 8 averaged 60-69%, 3 averaged 70-79 % and 2 averaged more than 79%. It was shocking to observe that 44% of the learners scored below 39%.

Figure 2 illustrates that learners received much higher scores in the final test than in the pre-test. Of the 246 participants (four learners were absent during the final test), the majority scored between 50 and 59% (n=94), whereas in the pre-test the scores had peaked at the 0-39% level (n=108). It was pleasing to note that the final test showed an overall improvement in all categories, of which the 50-59% level was the highest (n=98), followed by the 60-69% (n=43) category, where results had improved by 36%. Fewer learners obtained less than 40% (n=32) compared to the pre-test, where 108 learners had scored less than 40%. In the category of 50-59% there was an overall increase of 57.4 %. It was noteworthy that 38 learners' marks had improved from the 50-59% category to 60% and higher.

The quantitative data showed a positive improvement from the pre-test to the final test. This may have been because the DVD had clarified certain concepts, or that the pre-test had prepared them in terms of what they should focus on during experiment lessons. However, according to the quantitative data not all learners benefitted from the DVD supported lessons, as student-teachers pointed out that seven of their learners had not shown improvement between the pre-test and the final test.

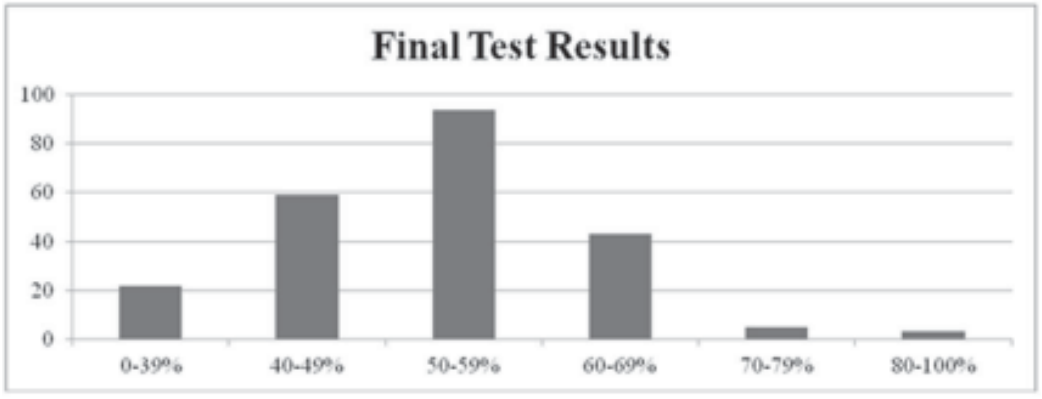

Fig. 2. Final test results of Grade 12 physical sciences learners

Qualitative Data

At the end of the teaching and learning of lessons using the DVD as a teaching aid, and after the final test had been written, assessed and recorded, student-teachers (instructors) and Physical Sciences teachers (observers) reflected on their experiences and completed the same reflective open-ended question on a questionnaire:

What are the advantages and challenges when Physical Sciences learners view a DVD that illustrates and explains Grade 12 experiments and the student-teacher/teacher facilitates the learning process?

The most frequently occurring responses of participants (student-teachers and Physical Sciences teachers) were grouped together in the themes set out below. Positive and negative reflections were kept separate.

Positive Reflections on the DVD Supported Lessons

A Technology Resource to Help Clarify Physical Sciences Concepts

According to 83% of the participants the DVD had been a major source of assistance to them, as they were able to pause and replay the video to explain and point out difficult concepts in the experiment at any time during the lesson and to explain complex concepts.

It was noted that the video illustrated experiments in a well-organised, step by step way, from beginning to end, in a short period of time, which makes it easy for learners to understand the experiment.

A Support Method for Learners Facing Learning Barriers

Several participants (n= 12) stated that learners facing learning barriers could be helped by pausing the video, explaining unclear concepts and allowing learners to replay the DVD after school in their own time.

A few teachers (n=6) saw the opportunity of using the DVD to enable learners to work at their own pace. Learners could watch the experiment over and over again until all concepts were clear to them.

Revision of Experiments

Here the positive responses were overwhelming, as most participants (n=22) felt that the DVD had been a significant help in revising the experiments and preparing learners for tests or examination in a short period of time. Naturally, these responses can be linked to the fact that curricula, teaching, revision and the conducting of experiments alike are all exam-driven and time-driven.

Learners' Reasoning Abilities

Many participants (n=15) pointed out that it was because the learners' interest in Physical Sciences and their cognitive reasoning skills had improved that contributed to the improvement of their Physical Sciences result. In contrast, two student-teachers stated that there had been no significant differences in some of their learners' reasoning skills in respect of Physical Sciences.

Learners' Interest and Motivation

A high number of participants (n=21) reflected that the video had drawn their learners' interest, attracted their attention and enabled them to concentrate for longer than when only traditional methods were used. In contrast, a few (n=4) felt that some of their learners had struggled to concentrate when viewing a DVD and needed more interaction with the student-teacher.

Applying Concepts to Real Life

A few (n=4) noted that the Physical Sciences DVD provided an opportunity to teach learners how theories viewed on DVD could be applied to their daily lives. In the technology-driven world we live in, filled with controversial world issues as it is, learners need to engage in socially relevant behaviour such as collaborative discussions with peers, exchanging ideas and together identifying the best solution to any given problem.

Promoted Training and Experience

Many of the participants (n=25) noted that watching the DVD illustrating Physical Sciences experiments actually trained them on how to conduct the experiments correctly. A number (n=10) also stated that they themselves had

actually understood the value of applying the experiments to their daily lives for the first time. The Physical Sciences DVD could therefore be seen as a valuable training session for teachers, helping them understand the content knowledge and abstract concepts, thus gaining confidence in the conducting of experiments.

Improved Understanding of Language

Some of the participants (n=16) indicated that many learners struggled to learn Physical Sciences when the medium of instruction was English (their second or third language). Visual presentations with English explanations of the experiment could help learners understand abstract concepts better. Using the Physical Sciences DVD as a medium to visualise new concepts could help address language barriers, lessening the effect of poor language proficiency on Physical Sciences results. In addition, some learners (n=3) requested that the DVD be translated into their home language.

Workload of Physical Sciences teachers

Many of the participants (n=23) said that the DVD could remove extra pressure from them as they did not need to buy and set up expensive experiment materials or conduct real experiments. The author appreciated the honest opinions of some teachers (n=7) who stated that their experiments were often unsuccessful, which meant that they were not able to show their learners the final results of the experiment. This naturally caused the teachers in question to feel incompetent in their learners' eyes and therefore rather to avoid conducting the necessary experiments.

Developing Learners' Critical Thinking Skills

A few (n=3) identified the opportunity to develop learners' critical thinking skills by pausing the DVD at regular intervals so that learners could write down what they had observed, predict what the outcome of the experiment would be and formulate their conclusions. More importantly, learners could, after viewing the full DVD, correct any wrong predictions or conclusions.

Encouraging Discussion

According to most student-teachers and teachers (n=21) mutual assistance and discussions among learners could help them understand concepts from different viewpoints.

Large Classes

Participants pointed out that one of the advantages of watching a DVD in a large class was that learners could share in the same emotions – laughing, crying, fearing, hoping or anticipating the same things. The collective experience resulting from watching visual material together as a class can have an immense influence on teaching and learning in the Physical Sciences class.

Negative Experiences When Using the DVD as a Teaching Aid in Lessons

Several participants pointed out possible challenges related to using a DVD to demonstrate Physical Sciences experiments:

- Not all schools have electricity, making it impossible for such schools to utilise modern technology.
- Learners cannot always ask questions while watching the DVD in order to clarify unclear concepts. The video can therefore not be viewed without continuous interruptions from the teacher.
- Teachers may encounter discipline problems during lessons where technology is not used, as learners might come to expect interesting visual media to attract their attention.
- Some participants indicated that schools did not always have video recorders and television screens, so that they had to go and watch the DVD at a neighboring school. This took a lot of careful planning, since schools that have such resources usually have only one video recorder and one television screen to share among many teachers.
- The Physical Sciences DVDs are expensive and the school budget does not allow for the purchasing of such visual material. Interestingly, a few of the student-teachers saw the opportunity to apply their entrepreneurial skills by video-recording all the Grade 12 experiments and selling them to interested Physical Sciences teachers and learners.
- A few teachers (n=3) noted that they taught large classes, making it impossible to use the DVD in class as the screen size was too small to allow clear visibility for all learners

or to promote interactive participation in class.

- Being deprived of opportunities to actually do experiments themselves, Physical Sciences teachers and learners alike do not develop the process skills a scientist needs. Republic of South Africa (2011) requires the active involvement of Physical Sciences learners in hands-on experiences, where they can formulate hypotheses, make inferences and draw conclusions.

Nonetheless, despite these challenges, the majority of participants were of the opinion that combining technology with traditional teaching held learners' interest, clarified unclear concepts and promoted participation in class.

CONCLUSION

The objective of the study was to establish if a learning method using traditional instructional methods and technology (DVD) can improve Physical Sciences learners' knowledge on selected Physical Sciences experiments. A pretest before the four experiments and final test afterwards showed that the majority of learners' marks improved and that the combination of technology with traditional teaching evoked interest and active participation in class. In conclusion, some of the findings indicated that the preparation, teaching and observing of the four lessons provided both in-depth training and development opportunities for Physical Sciences student-teachers and Physical Sciences teachers alike. Visually illustrated experiments can therefore be regarded as valuable training for under-qualified Physical Sciences teachers.

A combination of traditional teachings methods and a DVD as a teaching aid could be used to assist under-qualified Physical Sciences teachers in teaching and learning Grade 12 Physical Sciences experiments and to explain new concepts.

Preparing lessons, teaching the content and observing Physical Sciences experiments on a DVD developed and trained not only student-teachers but also the Physical Sciences teachers who observed the lessons. The lessons can be regarded as valuable training sessions for teachers to enable them to understand the knowledge content and abstract concepts, and to conduct Physical Sciences experiments with more self-confidence.

Poor language proficiency could contribute to low Physical Sciences results. English explanations along with the visual presentation of the experiment can therefore clarify abstract and unclear concepts for learners for whom English is their 2nd or 3rd language.

Despite the fact that large classes were pointed out as a constraint to achieving better Physical Sciences results, many participants pointed out that watching a DVD together in a large class gives learners the opportunity to share the same experience in respect of emotional reactions such as laughter, sadness, amazement, and most of all knowing – as they discuss difficulties with one another – that they are not the only ones who find certain concepts challenging. Previous research indicates that by combining technology with collaborative learning activities allows learners to debate and discuss their views among themselves, clarify concepts with one another and come up with possible solutions to problems that they might apply to their lives.

It is argued that DVD illustrations do not provide opportunities for learners to conduct the experiments themselves. However, the study proved that creative teachers can develop learners' critical thinking and process skills by pausing the DVD at intervals so as to allow learners to analyse, synthesise and evaluate the material, predict the outcomes of the experiment and finally formulate their conclusions and compare their predictions to what actually happened.

However, either technology or traditional methods on its own will not achieve the same outcome as a combination of these methods.

RECOMMENDATIONS

Using a DVD instead of actually conducting the experiments concerned can save the teacher time; is a good resource to use for revision purposes and to prepare learners for tests and examinations within a short period of time; provides an opportunity to teach learners how theories viewed on DVD can be applied to their daily lives; attracts learners' interest and allows them to learn at their own pace. Learners with learning barriers can also work at their own pace when the teacher pauses the DVD frequently in order to explain unclear concepts and allows learners to replay the DVD during school breaks or after school as needed. This has the advan-

tage that learners are not bound to a specific period to master new content knowledge.

The combination of a traditional method (with the teacher as instructor) and technology (the DVD) to support new content can improve learners' deep learning.

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