Understanding the efficiency of teaching through YouTube vs PowerPoint on concept acquisition by second-year chemistry pre-service teachers[1]

Dr Ritu Bhagwandeen, Central University of Technology, South Africa

ABSTRACT

Studies indicate that YouTube and YouTube EDU are very popular tools for digital teaching and learning. However, students from disadvantaged communities have significant gaps in experiences, knowledge of the world, and access to enrichment options such as YouTube. The objective of this study was to test the effectiveness of YouTube versus PowerPoint presentation as a teaching tool to improve overall conceptual understanding of the topic, States of Matter, by 62 second-year pre-service teachers. A quasi-experimental design was used to select the groups conveniently; one group was used as an experimental group (n=31) and the other group was the control group (n=31). A pre-test for both groups was conducted on the first day at the same venue at the time when academic activities commenced at the university. The experimental group as well as the control group consisted of seven (7) males (22.58%) and 24 females (77.42%). A paired-samples t-test was conducted to evaluate the effectiveness of teaching through YouTube versus PowerPoint presentation. There was a statistically significant difference between the experimental (p=0.000) and control group (p=0.003) results. The findings of this study indicate that science lecturers can convey information to their students via digital media, devices, and techniques to improve the understanding of chemistry content. This creates sustainable teaching and learning spaces that will improve overall teaching and learning.

Keywords: digital teaching, teaching through social media and YouTube EDU, undergraduate chemistry education

INTRODUCTION

Studies have indicated that South African undergraduate students are underprepared to cope with the demands of higher education, resulting in a high level of student failure and subsequently higher drop-out rates (Du Plessis & Gerber, 2012; Kaburise, 2014; Mahabeer & Pirtheepal, 2019). Evidently, students from disadvantaged communities have significant gaps in experiences, knowledge of the world, and access to enrichment options such as YouTube (Bytheway et. al., 2010). This study researched alternative ways of teaching and learning to improve students' attention and participation, in particular relating to improving their understanding of chemistry content. Evidently (Jackman, 2019; Sakkir, Dollah & Ahmed, 2020), Millennials display a preference to using social media and platforms such as YouTube. The research

1 Date of submission 3 August 2020
Date of review outcome 16 November 2020
Date of acceptance 30 July 2022

objective of this study was to investigate the use of YouTube as an alternative teaching and learning medium, by investigating its effectiveness to improve concept understanding by second-year chemistry pre-service teachers registered for a second-year degree course at a South African university of technology.

> The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them - Sir William Henry Bragg (Dagytė, 2010, p.7).

Inspired by the quote above, the goal of this research was to examine the use of digital skills in pedagogical content knowledge (TPACK) and 21st-century effective teaching methods in chemistry. The concept of TPACK was first introduced to provide a theoretical framework for teachers who were integrating technology into pedagogical content knowledge (Koehler & Mishra 2005, 2009; Mishra & Koehler, 2006, 2011). Twenty-first-century teaching methods and skills require a different approach as opposed to how teachers have learned their subject and its contents (Niess, 2005). The fourth industrial revolution has made it virtually impossible to live without the Internet. Digital technology has dramatically influenced most areas of human life, such as shopping and playing (Kim et al., 2017). To produce learners with a high level of critical thinking ability remains one of the greatest challenges faced by South African educators. Much attention is given to the learner-centred or inquiry-based approach to learning recent policy initiatives by departments in the South African government (Department of Education, 2007; Department of Basic Education, 2011).

It has been observed that the attention span of chemistry students has declined appreciably in the past decade, and these pre-service student-teachers are addicted to electronic devices (Pearson, Tobola & Fowler, 2010). The problem is how this short attention span problem can be solved because to do well in most of the science subjects one needs five D's, namely, dedication, determination, discipline, diversity, and direction (Nair, 2016). It appears as if the younger generation of digital natives, whether in terms of biological age or terms of the heart, are addicted to the Internet in such a way that life comes to standstill without the Internet. Goldberg's (1995) first description of Internet addiction was based on measures similar to those used to study substance abuse. The area of Internet addiction is advancing rapidly even without its official recognition as a separate and distinct behavioural addiction and with continuing disagreement over diagnostic criteria (Cash, et al., 2012). YouTube is the world's most popular online video-streaming site which has gained an audience of billions of users, including educators and scholars. YouTube EDU offers institutions the ability to choose only the videos they require, and which are free from controversial comments. Recently YouTube has launched the YouTube Go app, which is designed for places with poor connectivity or expensive cellular data prices (Timeslive, 2018). Moreover, research has indicated that YouTube can be used as an alternative teaching tool for chemistry education (Bohloko et al., 2019; Černá & Borkovcová, 2020; Gallardo-Williams et al., 2020; Limpanuparb et al., 2020; Pekdağ, 2020).

LITERATURE REVIEW

The theoretical framework chosen for this study is not only based on the educational theories of constructivism and social learning (Vygotsky, 1992), but also includes concepts of digital storytelling (Robin, 2008), personal learning environment (PLE) (Dabbagh & Kitsantas, 2011) and flipped classroom (Bishop & Verleger, 2013) as part of the TPACK framework. According to Vygotsky, cognitive growth occurs first on a social level followed by the individual emphasis on a zone of proximal development (Vygotsky, 1978). Thus, a social constructivist classroom environment is democratic, and learners are actively involved. Constructivists believe that the current knowledge of learners forms the basis of constructing new knowledge and learning cannot be passive (Hoover, 1974) while Piaget believes that understanding is to discover, or the reconstruction of understanding leads to rediscovery (Piaget, 1973). Based on these theories, the researcher believes in constructing a classroom, which is custom-built to fit the individual and creates a suitable environment in the class of students of today's digital world. A powerful teaching and

learning tool that has emerged over the past few years is digital storytelling. This medium offers numerous opportunities for teachers not only to engage and assess learners but also to enhance and accelerate their comprehension (Burmark, 2004). Digital storytelling not only connects technology and the curriculum, but it is also becoming a part of a powerful 21st-century teaching method (Deron, Kerper & Landis, 2011). A personal learning environment (PLE) is also a potentially promising pedagogical approach for integrating both formal and informal learning using social media and supporting student self-regulated learning in higher education contexts (Dabbagh & Kitsantas, 2011). The flipped classroom is a new pedagogical method which employs both video lectures and practice problems as homework, and active, group-based problem-solving activities in the classroom (Bishop & Matthew, 2013). In addition, pedagogical content knowledge (PCK) is the way a teacher transforms the understanding of content knowledge of a certain subject through illustration, representation and by using various examples (Shulman, 1986), while the technological pedagogical content knowledge (TPACK) refers to the knowledge required by teachers for integrating technology into their teaching in any content area (Schmidt et al., 2009). Research in educational technology has often been criticised for a lack of theoretical grounding (Mishra and Koehler, 2006). The debate to produce high-quality science teachers is ongoing (Kind, 2009) and the Royal Society of Chemistry, United Kingdom argues as follows:

> The best teachers are those who have specialist subject knowledge and a real passion and enthusiasm for the subject they teach…The Royal Society of Chemistry believes that young people deserve to be taught the sciences by subject specialists (RSC,2004, quoted in Kind, 2009: 2).

Traditional teaching methods alone can no longer eliminate all the problems experienced in science education (Osborne & Collins, 2001); as such, the use of video teaching can provide a potential solution (Sanger & Greenbowe, 1997; Burke et al., 1998; Ebenezer, 2001; Kelly & Jones, 2007). Havlik (2014) identified the applications to promote science and digital literacy, including Facebook, Twitter, YouTube, Feedly, Vine, Easel.ly, Google Docs, Pinterest, and WordPress. Literature alludes (Ramachandran et al., 2019; Fitzgerald, 2019; Jolley et al., 2016) that familiar platforms (e.g., YouTube videos) offer teachers the opportunity to further develop skills and self-efficacy as explained in the TPACK framework and could encourage them to use more new technologies. Teachers are more inclined to integrate new technologies when it forms part of their community of learning, and where there is verbal and technical support (Blonder, 2013). However, many teachers may still not have the requisite understanding in the application and inclusion of these technologies in their teaching praxis (Judge, Puckett & Cabuk, 2004). The Office for Standards in Education (Ofsted) sums up the issue as follows:

> Teacher familiarity, confidence, and skill in choosing software and integrating technology into the curriculum are dependent on teacher training and time for self-directed exploration and learning. Due to the relative newness of computer technology, many teachers have not received adequate training to select appropriate technologies and lack support to use them (Ofsted, 2008: 17).

Most educators and policymakers have one common goal in practice, namely motivation, which is the critical ingredient for learning. Thus, 21st-century teachers have to learn effective ways to engage students with the help of multimedia techniques. A study conducted by Castro-Romero (2015) indicated that student-student interactions, student-educator interactions, development of skills, and level of satisfaction can potentially be improved by the use of social media. Many researchers (Al-Aufi & Fulton, 2014; Hamid et al., 2015) have discussed the broad benefits of social media in higher education. Research has indicated that social media have benefited conversation and community as well as improving student life satisfaction, trust and participation (Anshari et al., 2015; Romero, 2015; Valenzuela, Park & Kee, 2009), student motivation and effective learning (Mazer, Murphy & Simonds, 2007), enhancing student learning and teaching engagement (Paul, Baker & Cochran, 2012) as well as students' personal emotional support

and self-confidence (Sobaih & Moustafa, 2016). Research has been ongoing whether to use or not to use social media in higher education in developing countries (Sobaih et al., 2016). YouTube has been used extensively as a teaching and learning tool at various levels of instruction, not only in chemistry but in various other subjects (Szeto, Cheng & Hong, 2016; Blonder et al., 2013; Moghavvemi et al., 2018). YouTube is relatively too new to be considered as an educational tool to facilitate teaching and learning by researchers; however, educationists and researchers have suggested that videos have the potential to enhance any classroom lessons (Mullen & Wedwick, 2008; Buzetto-More, 2014). Recent studies in chemical education suggest that student-generated videos have been used by the educationist to maintain the visual nature of chemistry (Gallardo-Williams et al., 2020).

RESEARCH DESIGN

The objective of the study was to test the effectiveness of YouTube versus PowerPoint presentation as a teaching tool to improve overall conceptual understanding of the topic, State of Matter, by second-year pre-service teachers to examine the use of digital skills in technology, pedagogy, and content knowledge (TPACK) and 21st-century effective teaching methods in chemistry. A quasi-experimental design was used to select the groups conveniently; one group was used as an experimental group (n=31) and the other group was the treatment group (n=31). Data collected for this study were analysed by using SPSS 25.

Originally the sample of second-year pre-service teachers consisted of more than 75 respondents. However, only, those who participated in the pre-test as well as in the post-test were included in the data for statistical analysis. A total of 62 pre-service teachers in the second-year undergraduate programme were selected to participate in this research. Stratified random sampling was done according to gender and age to determine whether there are any statistically significant differences in the given strata. It was a mere coincidence that an equal number of participants was found for treatment as well as for the control group. Ethical clearance to conduct this research was obtained before commencing this study. In addition, informed consent was obtained from the participants notifying them about privacy, confidentiality, and anonymity, and that they were free to terminate their participation at any stage. Further, it was ensured that both treatment and control groups had an equal number of participants based on gender. Treatment group participants also indicated that they had access to the Internet at home. Thus, the pre-test and post-test questions were based on gaseous state, kinetic molecular theory postulates, and its application to explain various fundamental properties associated with states of matter. A multiple-choice questionnaire was administered by the researcher for both groups when academic activities for the module commenced at the institution. A questionnaire was developed by the researchers based on the prescribed textbooks for the degree course and the questionnaire was also checked by another colleague lecturing the same module of chemistry. The control group was taught by the researcher using PowerPoint presentations at the institution and YouTube videos were carefully selected by the researcher for the treatment group; these videos were played in the institution where the researcher was present. This process was carried out to ensure that videos were shown in a controlled environment, that the cost of data was curbed by using institution facilities and that the video could be replayed upon request. The chemistry laboratory was used as a venue for the groups to show selected YouTube videos and to teach groups using PowerPoint. The selection of YouTube videos was aligned with the contents of the second-year pre-service teachers' undergraduate programme of the institution. It is important to mention that the treatment group was taught by means of YouTube videos only. However, once the post-test had been concluded, both group participants were exposed to similar teaching tools in that the presentations and the YouTube videos were also shared with pre-service teachers of the second-year undergraduate programme. This was done at the request of the respondents at the end of the post-test. The memorandum of the questionnaire was also discussed in length to provide feedback to all respondents.

The following research hypotheses were tested:

H_0= There is no statistically significant difference in the mean scores for time 1 (pre-test) and time 2 (post-test) results of the treatment group and experimental group.

H_1= There is a statistically significant difference in the mean scores for time 1 (pre-test) and time 2 (post-test) results of the treatment group and experimental group.

H_0= There is no statistically significant difference between male and female students in time 1 (pre- test) and time 2 (post- test) results of the treatment group and experimental group.

H_1= There is a statistically significant difference between male and female students in time 1 (pre-test) and time 2 (post-test) results of the treatment group and experimental group.

H_0= There is no statistically significant difference between students aged 18-20 and students aged 21-28 in time 1 (pre -test) and time 2 (post-test) results of the treatment group and experimental group.

H_1= There is a statistically significant difference between students aged 18-20 and students aged 21-28 in time 1 (pre-test) and time 2 (post-test) results of the treatment group and experimental group.

While administering the questionnaires, it was found that respondents comprise two different age groups, and respondents aged 21 and above are considered as adults. The researcher sought to determine the effect of maturity level on this study.

DATA ANALYSIS AND FINDINGS

A pre-test (Time 1) was conducted on the first day on which academic activities commenced at the university and the post-test (Time 2) was conducted three weeks after the intervention. The control and treatment samples each consisted of seven (7) males (22.58%) and 24 females (77.42%). A paired-samples t-test was conducted to evaluate the effectiveness of teaching through YouTube. Data collected were analyzed by SPSS version 25. The problem associated with small sample size was eliminated by calculating effect size in addition to the p-value (Pallant, 2016). Scores of pre-tests ranged from 12 to 42 and all respondents were included in the study. However, similar studies conducted by other researchers suggest that in future studies respondents with perfect pre-test scores can be excluded (Ramachandran et al., 2019).

There was a statistically significant difference between the pre-test and post-test scores of the control group as well as those of the treatment group.

Table 1:
Comparison of scores Time 1 and Time 2

		M	*SD*	*t*	*df*	*p*	*d*
Control group				-6.86	**30**	**0.00**	**0.61**
	Pre-test	36.61	6.62				
	Post-test	44.94	9.25				
Treatment group				-10.13	**30**	**0.003**	**0.77**
	Pre-test	33.61	7.06				
	Post-test	47.32	8.17				

The calculated effect size for the treatment group is 0.77, indicating that there was a large effect, with a substantial difference in the scores obtained before and after the intervention. Independent sample t-tests were used to compare the mean scores of pre-service teacher respondents based on their gender and age. Leaven's test of equality of variance was more than 0.05 in both these cases; thus, the results confirmed that the assumption of homogeneity of variance was not violated. The pre-service teachers performed significantly better on the treatment post-test (M=47.32, SD=8.17) than on the pre-test (M=33.61, SD=7.06) t (30) =−10.13, p<0.001 in comparison with the control group post-test (M=44.94, SD=9.25), t (30) =-6.36, p=0.000.

Thus, the research hypothesis was accepted, and the null hypothesis was rejected. The initial findings for the research sample are in alignment with the chemical education studies where YouTube videos were used to prepare students for analytical chemistry prelab sessions and general chemistry undergraduate sessions (Jolley et al., 2016; Ramachandran et al., 2019).

Table 2 gives a summary of the results which show that there was no significant difference based on gender and the efficiency of teaching through YouTube on concept acquisition by these pre-service teachers, while the effect size calculated was found to be very small.

Table 2:
Comparison of male and female pre-service teachers and efficiency of teaching through YOUTUBE on concept acquisition (n =31: male 7 and female 24)

	Test	N	M	SD	df	t	p	d
Control group					**29**	**0.46**	**0.65**	**0.007**
	Pre	Male	36.34	8.06				
		Female	35.20	5.90				
	Post	Male	43.00	9.21				
		Female	47.00	9.33				
Treatment Group					**29**	**1.27**	**0.213**	**0.05**
	Pre	Male	36.57	6.70				
		Female	32.75	7.70				
	Post	Male	52.00	8.02				
		Female	47.96	7.87				

The calculated effect size **for the treatment group** is 0.05, indicating that there was a small effect before and after the intervention. Independent sample t-tests were used to compare the mean scores of pre-service teacher respondents based on their gender. The pre-service female teachers performed significantly better on the treatment post-test (M=47.96, SD=7.87), than the pre-test male teachers (M=36.57, SD=6.70) t (29) =1.27p>0.05 in comparison with the control group female post-test (M=47.00, SD=9.33), t (29) =1.27, Thus, the null hypothesis was accepted, and the research hypothesis was rejected.

Pre-service teacher respondents were further categorised based on their age and were divided into two age groups, namely 18-20 and 21-28, to measure whether the level of maturity plays any role while teaching using social YouTube. The results of the independent sample t-test conducted are shown below in Table 3.

Table 3:
Comparison of 18–20-year-old and 21–28-year-old pre-service teachers and efficiency of teaching through YouTube on concept acquisition (n =31: 18-20 years old N = 15 and 21-28 years old, N = 16)

	Test	Age group	Mean	SD	df	t	p	d
Control group					**29**	**-0.28**	**0.78**	**0.003**
	Pre-	18-20	35.27	6.70				
		21-28	35.94	6.75				
	Post-	18-20	43.00	9.21				
		21-28	46.00	9.33				
Experimental group					**29**	**-0.11**	**0.275**	**0.000**
	Pre-	18-20	32.25	6.70				
		21-28	35.06	6.75				
	Post-	18-20	47.75	9.60				
		21-28	46.86	6.62				

The calculated effect size **for the treatment group** is 0.00, indicating that there was no effect before or after the intervention. Independent sample t-tests were used to compare the mean scores of pre-service teacher respondents based on their age groups. There was no significant difference in the scores of the two age groups.

The post-test result of the comparison of treatment age group 18-20 (*M*=47.75, *SD*=9.60) and the post-test of the control group age group 18-20 (*M*=43.00, *SD*=9.21), *t* (29) =-0.28, *p*=0.03 indicated that the treatment group performed better; however, the effect size was very small.

The post-test result of the comparison treatment age group 21-28 (*M*=46.86 *SD*=6.62) *t* (29) =-0.11, *p*=0.00, and the control group age (*M*=46.00, *SD*=9.33), *t* (29) =-0.28, *p*=0.003, indicated that the effect size was very small.

The p-value is greater than 0.05; thus, there was no statistically significant difference between the two age-groups of respondents and the type of intervention at the pre-test and post-tests. Therefore, the research hypothesis was rejected (Cohen, 1988). The calculated effect size was found to be very small.

RECOMMENDATION

The findings of this study support the notion that social media such as YouTube can easily be used to enhance the efficiency of teaching chemistry and concept acquisition. Millennials, being digital natives, are comfortable using the Internet and social media. Classifying them based on age and gender revealed no significant difference in this study. Test-tube and YouTube can work together to improve teaching and learning (Pekdağ, 2020; Limpanuparb et al., 2020). However, studies suggest that replacing laboratory work for videos is not feasible, especially not in rural areas where access to the Internet is difficult and unreliable. (Soares et al., 2020). There was a difference between the results of the pre- and post-tests on a selected topic, and further studies must be conducted for bigger groups, including the various levels of undergraduate pre-service science teachers.

The growing use of social media by digital natives begs further research and, subsequently, further considerations by policymakers. In the search for suitable teaching methods for the 21st century, and to meet the challenge of reducing cognitive load, the use of YouTube videos may shift the teaching approach from teacher-centred to learner-centred so that formerly passive learners can participate actively. However, teachers need further technical training on how to select an appropriate video or medium so that e-flooding on social media is avoided (Borup, Graham & Velasquez, 2010). Future research will be conducted involving chemistry lecturers and pre-service teachers on various science subjects such as physics and biology. The constructs of TPACK should be developed during a group discussion in the meetings involving science teachers and various tools can be designed to test and monitor the effectiveness of social media teaching. The use of YouTube videos and any other social media requires better infrastructure, stable Internet connectivity, and a wide network coverage remain major challenges in rural Africa (Tungela & Iyamu, 2019). It is recommended that science lecturers should consider delivering a significant proportion of information to their students through digital media, devices, and techniques (Maziriri, Gapa & Chuchu,2020). The researcher was aware of the inadequate access to the Internet at respondents' homes, depending on their location, income, and access to electricity. However, this was avoided in the current studies because institution Wi-Fi and facilities were used to show the carefully selected YouTube videos to the experimental group because the net generation likes YouTube (Moghavvemi et al., 2017). The study findings suggest that YouTube can be used as an alternative tool for teaching and learning as it was positively received by these net generation students.

LIMITATIONS OF THE STUDY

The questionnaire used during the first leg of research did not include a vast variety of numerical and analytical thinking level questions because the aim of the researcher was not only to determine the effectiveness of YouTube videos as a possible alternative teaching tool but also to understand the readiness of these pre-service teachers for the second-year degree-course contents of chemistry. Furthermore, there was limited time to administer the experimental and the control group based on the timetable and space availability. Respondents were not given a choice to select the videos on their own, but videos were selected which were aligned to the contents of prescribed textbook and the syllabus. All videos were shown to the experimental group under a controlled environment. Under no circumstances is the researcher trying to replace contact sessions and the necessity of laboratory sessions in chemistry.

The study was limited to the participants of second-year natural sciences pre-service teachers at a South African university of technology. The researcher plans to include the qualitative aspect and a bigger sample for future studies, including the questions based on calculations, analytical thinking, and descriptive section on various levels of undergraduate chemistry course contents.

CONCLUSIONS

Although the study was conducted for a limited time and included videos on only one section of the undergraduate chemistry contents for pre-service teachers, the use of YouTube as an alternative tool for concept understanding was positively received. The findings that were limited to this sample suggest that information conveyed by science lecturers to their students can by means of digital media, devices, and techniques. The results support the postulated hypotheses and limitations of the study and suggest that future studies are required in the African setting to evaluate the effectiveness of TPACK and the use of YouTube as an alternative platform to facilitate teaching and learning which will create sustainable teaching and learning spaces that will improve overall teaching and learning.

ACKNOWLEDGEMENTS

The researcher would like to thank Dr. A. Rambuda, Senior Lecturer in the department of educational and professional studies at Welkom Campus, Central University of Technology, for his continuous support and

guidance. The researcher would also like to thank the editor and all the anonymous reviewers for their invaluable comments, suggestions, and feedback. This study would have been impossible without the participation of the respondents; thus, a special vote of thanks is extended to all respondents.

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