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DOI: http://dx.doi.org/10.18820/2519593X/pie.v39.i3.8

e-ISSN 2519-593X

Perspectives in Education

2021 39(3): 94-108

PUBLISHED:
16 September 2021

RECEIVED:
12 December 2020

ACCEPTED:
03 March 2021

EXPLORING THE EFFECTS OF YOUTUBE ON TECHNOLOGY EDUCATION STUDENTS' COGNITIVE ACHIEVEMENT IN A MECHANICAL SYSTEM MODULE

ABSTRACT

Understanding the effects of various multimedia technologies on students' cognitive achievement is essential in this technological era. This study explored students' cognitive achievement in a technology mechanical system module using YouTube videos compared to Microsoft PowerPoint (MPP). The study employed a quasi-experimental research design, using a pre-test-post-test. The sample consisted of 53 (29 males and 24 female) students. Twenty-eight (28) students were randomly assigned to the experimental group (EG) and 24 to the control group (CG). Students' cognitive achievement was measured by administering the Geometric Optics Conceptual Understanding Test to each group of students before and after teaching. A t-test shows that there were significant differences between the EG of the pre-test (M = 60.50, SD = 7.2) and the post-test (M = 65.70, SD = 9.60) t (53) = -2.17, p = 0.03 with a gain of 5.20 and the Cohen d was 0.60. The EG students performed better in mechanical technology practice and retention tests than those in the CG. In the EG, female students performed better (M = 69.00, SD = 9.20) than the male students (M = 61.40, SD = 8.60). These results have some theoretical, instructional and institutional implications on the use of YouTube as an effective tool to enhance students' achievement in mechanical technology.

Keywords: *YouTube; Microsoft PowerPoint; multimedia; cognitive achievement; quasi-experimental.*

1. INTRODUCTION

Teaching media plays an important role in meaningful learning and skills acquisition. For many years, various forms of teaching media have been used to support learning. Traditional media such as printed materials (books, newsletter, and bulletin board), overhead radio and television are still very popular in educational settings (Bajracharya, 2016). With modern technology development, multimedia worldwide and the traditional media are gradually replaced by different interactive multimedia. Multimedia such as computers, videos, YouTube and Microsoft PowerPoint

are now considered more effective teaching and learning tools than traditional teaching media (Kieny, 2013).

YouTube is a Web 2.0 platform of distributed video sharing, widely used by students, universities and scholars (Martinho, Pinto & Kuznetsova, 2012) and has limitless opportunities to maximise learning. It also "…has the potential to anchor instruction in such rich learning contexts" (Bonk, 2008: 10). It offers a variety of user-generated and commercial media videos. The accessible content includes video clips, TV show clips, music videos, live streams, short and documentary films and other content such as video blogging, short original videos and educational videos (Srinivasacharlu, 2020). Thus, the combination of the aural input with the visual images on YouTube has encouraged many educators to adopt the technology as a teaching tool in their classrooms (Kuo & Lien, 2009; Kasch, 2019).

Microsoft PowerPoint (MPP), on the other hand, is an electronic presentation program that helps people present a speech using a collection of slides (Prentice, 2019). There are many reasons for using MPP for classroom instruction. MPP slides made up of words, pictures, flow charts and schematics during lectures may provide more vivid information and be more attractive to students (Xingeng & Jianxiang, 2012) compared to chalkboard-writing in talk-and-chalk (TAC) methods. Bartlett *et al.* (2000) reported a decrease in students' performance when the instructor switched from TAC to MPP presentation, while Duffy (2008) concluded that MPP's effectiveness depends upon the discipline, the learning objectives and learner types. Thus, an innovative and versatile teaching tool such as YouTube is needed but little is known about its effectiveness in promoting cognitive learning in technology.

1.1 Multimedia in higher education

The rationale for multimedia is that people can learn more from words, pictures, videos and animation than words alone (Mayer & Mayer, 2005). Multimedia enhances students' understanding, improves retention and advances problem-solving transfer (Mayer & Moreno, 1998). The use of multimedia in lectures has proven to be very favourable to the educational processes and provides numerous benefits for the students' cognitive abilities (Kotevski & Tasevska, 2017). When YouTube is applied correctly, students gain the breadth and depth of the subject, and it renders efficient use of class (Fleck, *et al.,* 2014).

1.2 Research problem

Teaching using the chalkboard, textbooks and in recent times MPP Zheng (2008) and Iskandar *et al.* (2018) contend that multimedia have a positive effect on learning. For example, Iskanda *et al.* (2018) investigated the effects of multimedia learning on students' achievement in terms of cognitive demand by comparing the students' learning achievement between classes that apply multimedia learning applications with those using the TAC method. The research results show that: (1) the application of multimedia learning improves student achievement for robotics courses; (2) that the learning achievement of the multimedia learning class student is better than the TAC. Similarly, multimedia is a multimodal approach that effectively teaches English Foreign Language (EFL) in Danish year-seven students because of the assistive multimedia that combines sound and images (Kasch, 2019). Students learn better, when they use their eyes and ears in MPP. DeWitt *et al*. (2013) used a descriptive approach to investigate the cognitive effects of multimedia. Other studies have collected basic information directly from YouTube, such as the length of videos, while others have developed coding schemes to rate YouTube content (Paek, Kim & Hove, 2010). This study's quasi-experimental

research design based on pre-test and post-test explored the cognitive effects of YouTube videos on technology students' cognitive achievement in the mechanical system module. Consequently, students do not perform well possibly because they lack interest to enhance their cognitive capacity. Furthermore, none of these studies used YouTube videos to improve students' cognitive achievements and this is a knowledge gap in research. Therefore, to address this knowledge gap, the researchers posed questions similar to any research process (Plowright, 2011) as follows: 1) What is the difference in students' cognitive achievements between students taught using Microsoft PowerPoint presentations compared to students taught using YouTube videos? 2) What are the cognitive achievement of males compared to females taught using YouTube videos?

2. THEORETICAL FRAMEWORK

This study's main design guidelines are grounded in the cognitive theory of multimedia learning (CTML) (Mayer, 2005). CTML is relevant to this study because it is built on other established theories, such as adaptive control of thought-rational (ACT-R): A cognitive architecture for modelling cognition (Ritter, Tehranchi & Oury, 2019), dual coding theory (Paivio, 1990; Clark & Paivio, 1991) and cognitive load theory (Sweller, van Merriënboer & Paas, 2019). According to Ritter, Tehranchi and Oury (2019), ACT-R is a theory of the mechanisms that constitute cognitive architecture. The theory postulates that a fixed set of mechanisms can be used to perform an activity to predict and explain the steps of cognitive human behaviour. The theory belongs to a unified cognition paradigm theory (Newell, 1990; Byrne, 2012). It also surmises the brain activation for human behaviour to know how to do an activity (procedural knowledge) and knowledge of facts about the world around them (declarative knowledge). These two forms of knowledge work together for an individual to perform an activity. Thus, ACT-R is a hybrid cognitive architecture that comprises programmable information-processing mechanisms that can predict and explain human behaviour. One of the most important concepts in ACT-R is the distinction between declarative and procedural knowledge. The formation of two types of knowledge working together to create human cognition and memory as well as behaviour (Anderson & Schunn, 2000; Anderson & Gluck, 2001). For example, using Pavio's theory of dual coding (1992), images and words are processed in separate channels of working memory before becoming integrated into a single, coherent, organised conceptual framework. Thus, the duo visual and audio components provide a unique mental model formation (Kasch, 2019). In this study, researchers envisaged students to explain their cognitions as they used videos to learn technology. However, the cognitive load theory (Sweller, van Merriënboer & Paas, 2019) may limit the amount of information one can process at one time. Therefore, the cognitive theory of multimedia learning (Mayer, 2005) and the theory of cognitive load (Sweller *et al.,* 2019) add credence to researchers to examine how YouTube multimedia instruction could be designed to improve cognitive performance.

3. LITERATURE REVIEW

In higher education, YouTube videos play a vital role in courses that use flipped classrooms, online e-learning, Massive Open Online Courses (MOOCs) and mobile learning (Chapes, 2017). YouTube videos' use can be traced from the first video clips created by the three former PayPal employees, Hurley, Chen and Karim (2005), to sharing video materials among its workers (YouTube, 2012). Today, the YouTube platform enables users to share video clips through uploading, viewing and sharing. There is no doubt that YouTube videos connect,

inform and inspire individuals and transform and how teachers deliver instruction to learners. Consequently, online videos that are of academic and professional nature reinforce classroom discussions and engage students (Kasch, 2019).

YouTube allows teachers and students to explore and download visual and audio content relevant to their courses. In rural areas where some students may not access YouTube, they can rely on what their teachers present to them in class. These videos can facilitate thinking and problem solving (Haugsbakken & Langseth, 2014); assist students with mastery of learning (Galbraith, 2004) as well as inspire and engage students (Willmot, Bramhall & Radley, 2012).

To demonstrate that YouTube videos support multimedia learning, Fralinger and Owens (2009) investigated students' achievements. The research focused on applying YouTube, major strengths of the YouTube project in the learning process, instructors' effectiveness and improving learning.

3.1 Pedagogically designed videos

Martin (2016) investigated the potential of pedagogically designed video demonstrations to support students' engagement and learning outcomes in a Land Surveying module at a College of Engineering and Built Environment. The outcomes of multimedia resources show that students showed increased retention of key topics (Mayer, 2019). Thus, this study's findings suggest that YouTube videos and related quality multimedia learning materials will continue to play a significant role in serving the needs of 21st century students.

3.2 Limitations of YouTube-based instruction

Based on research by Liimatta (2015) on the use of online YouTube videos in the classroom, one of the limitations is that YouTube does not always allow students to communicate with their instructors. Additionally, YouTube videos do not promote communication among students yet.

While social media, in general, offers space for innovative teaching in classrooms, they pose several ethical dilemmas for teachers (Henderson, Auld & Johnson, 2014). In addition, there may be issues about the use of YouTube videos regarding what constitutes private and public data. Rosenberg (2010) posits that people may perceive multimedia data differently. For example, a video developed and posted on YouTube for friends would not be suitable for classroom instruction. On the other hand, unmonitored youth access to YouTube raises genuine concerns in light of adolescents' lack of knowledge about the risk attenuation needed to discern and manage online dangers (Delmonico & Griffin, 2008). Therefore, instructors are strongly encouraged to determine whether the video's content is credible, particularly technology education information. Lastly, computer protection against Spyware and viruses is important to consider, as recent reports have indicated that computer hackers may be using online video sources to upload Spyware and viruses (Trier, 2007).

4. METHODOLOGY

The study employed a quasi-experimental design to explore the effects of YouTube videos on students' cognitive performance (Campbell & Stanley, 2015). The quasi-experimental design aims to establish a cause-and-effect relationship between independent methods used (YouTube, MMP and PPT) and dependent variable (students' achievements). One reason

for choosing a quasi-experimental design is that researchers often **do not have control over the treatment** but instead study pre-existing groups that received different treatments after the fact (Thomas, 2020).

4.1 Validity

The study employed a researcher constructed Cognitive Assessment Test (CAT) for pre-test and post-test. Both tests consisted of 30 multi-choice questions covering the three cognitive domains (understanding, comprehension and application). Two academic staff in the Department of Mathematics, Science and Technology Education validated the CAT content. The recommended changes were effected before the pre-test and post-test were administered.

4.2 Internal consistency

The researchers employed the following four steps (Slack & Draugalis (2001): 1) To guard against selection bias, samples were randomly assigned to EG and CG. 2) Researcher bias was avoided by the researchers not showing preferences of any aspect during data collection. 3) For instrument reliability, a pilot study was conducted with six students (3 males and 3 females) who were not part of the study but from a similar environmental background like the study groups and a strong Cronbach Alpha was 0.84, suggesting that it was reliable since it was above 0.70 (Taber, 2018), and 4) For testing effects, questions of post-test materials were rearranged to avoid cognition.

4.3 Participants

Fifty-three students consisting of 29 (54.7%) males and 24 (45.3%) females with a mean age M = 22, SD = 4 participated in the study. Based on the research design, twenty-eight (28) students were assigned to the Experimental Group (EG) and twenty-four (24) to the Control Group (CG) based on non-random criteria (Table 1).

Table 1: Distribution of sample for the study

Group	Gender		Mean Age (years)
	Male	Female	22 ± 4
PowerPoint Lecture Slides	15	13	
YouTube video	14	11	
Total	29	24	

4.4 Data collection

The CG was taught using Microsoft PowerPoint slides. Altogether, the researchers designed four sets of MPP slides based on Hydraulic system content. The MPP lecture slides were presented during the lecture period that covered 45 minutes. The MPP lecture slides consisted of words, pictures and animation as an alternative treatment for the CG.

The EG was taught Hydraulic mechanical system using online YouTube video clips that are posted on the internet via Next Vista. English is used in all the video clips. Four YouTube video clips were selected because they were considered relevant to the study topic. The constructs explained in the video clips are components of the hydraulic system, fluid mechanics and how the hydraulic pump works. To avoid internal validity threats, the YouTube video clips were restricted by the designer's license terms and conditions for access and

use, which were only granted to the researchers. To avoid boredom, the video clips were used during the lecture for not more than 20 minutes. The researchers used informal rather than formal discussion during a video presentation. This method has yielded a large effect on students' learning, partly because of the students' sense of social partnership with the narrator (Mayer, 2008).

4.5 Procedure

The hydraulic, mechanical system is offered as a module to Year 3 pre-service Technology students. This module followed an earlier module on the pneumatic system and control. The Hydraulic system and control covers hydraulic fluids, Pascal theory, Hydraulic components and system design and function. For the study, the lecture timetable was adjusted to cover two periods per week. This allowed the CG and EG to be taught the same topic through using different multimedia. Before the treatment commenced, a pre-test was administered to both CG and EG to assess their prior knowledge of hydraulic systems and controls and their test scores recorded. The treatments were administered in a Technology classroom by a researcher for 45 minutes per period. During treatments, both groups were taught the same hydraulic system and control content by the same lecturer to minimise personality effects. The exception was that while the CG received lectures supported by MPP lecture slides, the EG received lectures supported by YouTube videos. At the end of the intervention period, the researchers administered a post-test to both groups. The scripts were marked and the post-test scores were recorded for comparison with the pre-test scores.

4.6 Data analysis

Data were analysed using descriptive (Sharma, Kanchan & Krishan, 2018; Igual & Seguí, 2017) means, standard deviation and inferential statistics (Gibbs, Shafer & Miles, 2017; Amrhein, Trafimow & Greenland, 2019): T-test, and Cohen *d*. All pre-test and post-test data were analysed using SPSS Version 22. Kolmogorov-Smirnov Test (Field, 2009) from SPSS was used on mean scores to identify if the data were uniformly distributed so that a parametric statistics T-test could be applied. Indeed, data were uniformly distributed and so the researchers used the T-test. Also, a T-test was run on the pre-test and post-test results to identify any differences between the EG taught using YouTube and CG taught using MPP at confidence level ($p < 0.05$), and Cohen *d* was calculated using Cohen formula $d\ (M_2 - M_1) / SD$ (Cohen, 1998) to find the magnitude of gain.

4.7 Ethical considerations

This study was part of a larger collaborative work, the IRG – South Africa/Uganda Cooperation Bilateral Programme with Makerere University, which is approved by the National Research Council (NRF) (Grant Number197811). Before the commencement of the study, consent was obtained from the participants and they were informed about ethical principles such as privacy, anonymity and confidentiality (Bryman & Bell, 2007).

5. RESULTS

Data analysis results related to the effects of MPP presentations and YouTube videos on students' cognitive performance are presented in this section based on the two research questions. To answer the first research question, a t-test was conducted to establish if

there was any significant difference between the CG pre-test and post-test scores (MPP). A summary of the t-test results is presented in Table 2 below.

Table 2: T-test of CG pre-test and post-test results for students taught using MPP

Results:	Pre-test	Post-test
Count	28.00	28.00
Mean	56.07	54.94
Standard Deviation	12.48	17.44
Mean Difference	1.14	
Std Error Difference	4.06	
Df	54.00	
T	0.28	
P-Value (2-sided)	0.78*	
UC (2-sided, 95%)	9.26	
LC (2-sided, 95%)	-6.98	

**Denotes statistical significance*

Table 2 show that in the CG there was no significant difference in the mean scores for pre-test (M = 56.0, SD = 12.4) and post-test (M = 54.9, SD = 17.4) conditions; t (56) = 0.28, p = 0.77 and Cohen *d* is 0.07. The reasons for no significant difference between pre-test and post-test can be explained as follows: First, the p-value (0.77) was higher than the significance level (0.05). Second, the test statistic (T- Stat, 0.28) does not fall in the critical region of 5-28, third because the zero falls within the confidence interval (9.26, -6.98) and provides a reason for no significant difference between pre-test and post-test.

Similarly, a T-test was used for EG to determine if there were significant differences between pre-test and post-test scores. The results are presented in Table 3.

Table 3: T-test pre-test and post-test for EG taught using YouTube

Results:	Pre-test	Post-test
Count	24.00	24.00
Mean	60.48	65.72
Standard Deviation	7.28	9.62
Mean Difference	-5.24	
Std Error Difference	2.41	
Df	48.00	
T	-2.17	
P-Value (2-sided)	**0.03***	
UC (2-sided, 95%)	-0.39	

Results:	Pre-test	Post-test
LC (2-sided, 95%)	-10.09	

**Denotes statistical significance*

Table 3 shows that in the EG there were significant differences in the mean scores for pre-test (M = 60.5, SD = 7.2) and post-test (M = 65.7, SD=9.6) with T(24) = -2.17, p = 0.03, and Cohen d is 0.6. Three reasons can be given for the mean score differences between pre-test and post-test scores of EG using YouTube EG. First, the p-value (0.03) was lower than the significance level (0.05). Second, because the test statistic (T = -2.17) does not fall in the critical region. Third, the zero value falls within the confidence interval (-0.39, -10.09). These results suggest that YouTube videos affected students' cognitive achievements. Furthermore, the Cohen d of 0.6 confirms that the gains achieved using YouTube videos are significant.

The pre-test and post-test mean scores for CG taught using MPP and for EG taught using YouTube were compared (Table 4).

Table 4: The pre-test and post-test mean scores for CG and EG

Treatment	Pre-test	Post-test	Mean Gain Score
Microsoft PowerPoint for CG	56.00	54.90	-1.10
YouTube video for EG	60.50	65.70	5.20
Mean score difference	4.50	10.80	4.10

Table 4 shows that there is a mean gain in both CG taught using PowerPoint presentations (-1.10 points) and the EG taught using YouTube video (5.2 points). The mean score difference between pre-test and post-test for CG and EG was significant. These results suggest that the use of YouTube videos in EG improved students' cognitive performance and not in the CG taught using MPP.

A t-test was conducted to establish if there was a significant difference between male and female students' post-test mean scores using YouTube videos to answer the second research question. The t-test was calculated between the post-test of the CG taught using MPP and the EG taught using YouTube. The result of post-test of CG (Mean = 62.70, SD = 5.90) and the post-test EG (Mean = 65, SD = 9.60); t-2.17, (51); p = 0.03) and a Cohen *d* of 1.74 were statistically significantly different. These results suggest that EG outperformed the CG in their cognitive achievements.

A t-test was done to establish if there were any differences between males and females in EG (Table 5).

Table 5: T-test of EG post-test mean scores difference for male and female taught using MPP

Results	Male	Female
Count	11.00	14.00
Mean	61.46	69.07
Standard Deviation	8.61	9.29

Results	Male	Female
Mean Difference	-7.62	
Std Error Difference	3.63	
Df	23.00	
T	-2.10	
P-Value (2-sided)	**0.04***	
UC (2-sided, 95%)	-0.12	
LC (2-sided, 95%)	15.12	

**Denotes statistical significance*

Table 5 shows that female students performed better (M = 69.00, SD = 9.20) than the male students (M = 61.40, SD = 8.60) and there were significant differences between male and female students (24) = -2.10, p = 0.04, Cohen *d* is 0.85. The mean gain scores between the pre-test and post-test for males and females in the EG is shown in Table 6.

Table 6: Mean gain scores of male and female students in the YouTube group

Group	Post-test	Mean Gain Score
Male	61.50	7.50
Female	69.00	

These results in Table 5 show that female students have higher mean scores than male students. Equally, the data analysis posted 7.50 mean gain score indicates a significant difference between the two gender groups and also Cohen *d* of 0.85 suggests that the gain was significant.

6. DISCUSSION

The study explored students' cognitive achievement in a Technology Mechanical system module in the EG taught using YouTube videos compared to CG taught using Microsoft PowerPoint (MPP) presentations. The results show that the EG students' cognitive achievements taught using YouTube videos were higher than the achievements for CG students taught using MPP presentations. Students taught using PPT did not increase their cognitive achievements. These findings are consistent with that of Beets and Lobingier (2001), Susskind (2005), Szabo and Hastings (2000) and Gier and Kreiner (2009), who did not find any beneficial effects of MPP. In contrast, Amosa, Gambari and Balogun (2015); and Nouri and Shahid (2005) found a significant difference in the learning achievements in favour of the group taught technical drawing concept using MPP presentations. These results suggest that students taught using videos used their duo senses: visual and audio to learn, which is consistent with the dual coding theory (Pavio, 1990; Kasch, 2019).

The post-test results of the EG and CG were statistically and significantly different from each other (T-test: t = -2.17, p = 0.03) and a Cohen *d* of 1.74. These results show that the cognitive achievement of EG students taught using YouTube videos was better than that of CG students taught using PPT. The high value of Cohen *d* of 1.74 suggests that the increase in the EG was not by chance, but it was due to the use of the intervention, the YouTube

videos. Furthermore, the pre-test and post-test results of EG were significantly different (Table 3). This observation also agrees with the cognitive theory of multimedia learning (CTML) (Mayer, 2002) and the positive role of dual coding theory where students use audio and visual to improve their cognitive achievements through various forms of representations (Pavio, 1992; Kasch, 2019).Thus, the words and images generated from videos provided permanent images in the students' minds for a long term, which explains in part, why students in the EG who used videos increased their cognitive achievements. Furthermore, Mayer (2003) argues that meaningful learning from words and videos happens when a student engages in five cognitive processes. These five cognitive processes include: 1) selecting relevant words for processing verbal working memory; 2) processing visual working memory, 3) organising selected words into a verbal model and 4) selecting images and 5) integrating the verbal and pictorial representations with prior knowledge. The results suggest that EG students could have used such processes to attain better cognitive achievements compared to the CG students.

The pre-test and post-test mean gain scores show that while MPP decreased by 1.10-point score, YouTube video increased by 5.20 points score (Table 4). The decreased scores of -1.10 in CG results are not surprising because MPP obscures varied professional and pedagogically sound presentations (Jones, 2003). Furthermore, Xingeng and Jianxiang (2012) contend that MPP often uses too many slides and may lead the instructor to stick to the order of slides. Consequently, that approach may limit the extemporaneous performance of the instructor for the learners' cognitive achievements. The increased scores of 5.20 in EG suggest that students taught using YouTube had higher cognitive achievements in the post-test than the pre-test. Our findings are consistent with that of Guy and Marquis (2016) who found that the YouTube instructional method improved students' final grades.

The EG students' results show that females scored 7.5 points higher than males, suggesting that YouTube video affected female students more than male students. These results are in contrast to Hoogerheide *et al.* (2018) who found that males' achievements were higher than females on troubleshooting electrical circuits. The gender differences could be due to positive attitudes and the time spent using the videos (Pickowicz, 2008). In addition, a few studies show that there are gender cognitive differences among students from other fields of study (Petri *et al.,* 2017; Sagala *et al.,* 2019). Although other factors were not explored, it seems that females easily develop positive attitudes with videos compared to males. The results of this study show that the integration of YouTube in teaching increased students' cognitive achievements and the YouTube videos improved female cognitive achievement more than the males. These results have implications for lecturers in STEM education. More studies are needed to ascertain the students' achievements when both visual and audio sense are engaged in technology using different topics and also explore other salient factors regarding gender differences exhibited in the is study and other earlier studies.

7. LIMITATIONS AND FUTURE RESEARCH

This research has some limitations that can also serve as areas for future research. Firstly, the study used a small sample that limits the generalisation of the results. Future studies on the topic could be carried out using a larger sample size. Secondly, the lack of the qualitative aspects also limits its interpretation in terms of attitudes that the two groups had on the methods used. Thirdly, the study used internet-based YouTube videos. Future studies should consider using internet-designed YouTube videos and for various topics in technology. Also,

insufficient consideration was given to the CG on the access and prior background knowledge of the YouTube video used by the EG. Consideration of these factors in future studies could greatly improve the reliability of the data collected. While this research and others have shown that YouTube videos can support learning, further research is still needed to compare the effects of YouTube videos with other multimedia learning materials.

8. CONCLUSION

Notwithstanding the limitations, the study results show that the integration of YouTube videos can improve students' cognitive achievements. These results are consistent with the cognitive theory of multimedia learning (CTML) (Mayer, 2002) and the dual coding theory (Pavio, 1992). According to Mayer (2003), the use of multimedia (YouTube videos) in teaching encourages the learner to build an intelligible mental representation from the presented materials. Thus, multimedia enables a learner to make sense of the material, which leads to the construction of new knowledge. As studies show, YouTube is a valuable learning medium for millennials who are already immersed in the technology (Dumitrescu, 2014). Thus, combined with transformational pedagogy (Kruse & Veblen, 2012), the use of YouTube for online teaching and learning in higher education institutions could prove limitless in the face of the Covid-19 pandemic.

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