European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available online at: www.oapub.org/edu

DOI: 10.46827/ejes.v11i10.5562 Volume 11 | Issue 10 | 2024

NURTURING AND PROMOTING LEARNERS' RETENTION IN ASTROPHYSICS USING VIDEO-BASED MULTIMEDIA

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Abstract:
Learners' retention of concepts in physics has been a crucial fact in students' achievement needs competencies. Therefore, innovative and friendly strategies to develop learners' retention of physics have been a matter of concern over the years. This study, therefore, strives to investigate the power of video-based multimedia (VBM) to nurture and promote learners' retention in astrophysics in selected schools in Rwanda. 294 students were purposively selected for the scientific option with physics as a major subject in Rutsiro and Rubavu districts. The astrophysics achievement test with Cronbach alpha 0.87 was used to collect data within the pre/post-test non-equivalent control group quasi-experiment research design. The output revealed that the VBM intervention group

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outperformed the usual teaching control group. The results also showed that females retained marginally more than males in VBM intervention classes, and urban students retained better than their rural counterparts. Based on the output of this study, we concluded that credit goes to VBM as a friendly and innovative teaching method. Hence, we recommend using VBM in teaching and learning physics with special attention in rural-based schools.

Keywords: astrophysics, gender, retention, rural students, urban students, video-based multimedia

1. Introduction

Physics plays an imperative role in society as it enhances research and thrives in medicine, technology, engineering, et cetera. In recent years, Rwanda's educational goal of increasing a knowledge-based and technology-led economy has pushed educators and policymakers to develop competitiveness in STEM education (REB, 2015). Mastery of basic concepts in STEM education makes learners confident in problem-solving and increases their conceptual understanding and retention (Bizimana *et al*., 2022; Tugirinshuti *et al*., 2021). Conceptual understanding and retention of concepts have been one of the anticipated attributes of STEM students (Khishfe, 2020). Through extensive research that has been conducted over the years at different grades and settings worldwide, the retention of learners in STEM education in general and physics, in particular, has been a problem (White & Massiha, 2016; Puente & Kroesen, 2020; Palermo *et al*., 2021). Studies revealed that students' poor retention of concepts led to poor performance, especially in national examinations (Adonu *et al*., 2021)

Retention in STEM education is linked to the understanding of the topic learnt (Puente & Kroesen, 2020). Retention is a process through which long-term memory saves information so that it can be identified and retrieved in the future (Anthony & Anka, 2020). Bizimana *et al*. (2022) defined retention as the ability to remember or keep information learned and retrieve it when needed. A considerable body of STEM education literature has reported that STEM students exhibit limited retention of concepts (Adonu *et al*., 2021; Anthony & Anka, 2020; REB, 2015). Several reasons have been attributed to the students' poor retention in STEM education. The most mentioned is the methodology used by the teacher (Petrus, 2018). On the one hand, previous studies reported that the teaching methodology used by STEM teachers does not make the learning of STEM easy and friendly for students (Tugirinshuti *et al*., 2021). Moreover, it has been posited that the predominant teaching practices in science do not give learners a chance to participate in their learning process and, hence, deprive them of the opportunity to participate in knowledge construction (Mukuka *et al*., 2019). On the other hand, it has been noted that in a bid to cover the syllabus, traditional teaching methods characterized by teachers' lecturing and students' memorization dominate most STEM classrooms (Oyelekan *et al*., 2017). Within this teaching method, students fail to get key information and fail to get potential opportunities to share with peers. Hence, those methods contribute to the students' lower retention level of concepts (Khalaf & Zin, 2018).

2. Literature Review

Educational literature reported that teachers tend to teach using the strategies through which they were taught (Munna & Kalam, 2021). However, the passive and traditional instructional strategies do not fit the 21st century of learners who are digital natives (Pmp, 2019; McGuire, 2018). Thus, to cope with the 21st world demands, educational researchers have advocated for the revision of instructional methodology to teach STEM subjects (Margot & Kettler, 2019; Serrano & Rodríguez, 2020; Zendler *et al*., 2018). The incorporation of multimedia in teaching and learning STEM is one of the most proposed strategies that have received widespread success. Multimedia-based instruction stems from the use of technology in education (Mayer, 2014; Tugirinshuti *et al*., 2021). Within multimedia-based instruction, learners are likely to work cooperatively, increase development in the economic and technological world, and equip learners with dynamic skills, values, and knowledge required for the development of the person (Casselman *et al*., 2021; Mayer, 2014). The choice of a suitable multimedia teaching tool to integrate into teaching and learning physics is extremely didactic and requires an evaluation process (Lindner *et al*., 2020). The benefits of multimedia on students' academic achievement and attitude toward physics depend on multiple factors, including the design methods teachers choose to use in a given topic (Ndihokubwayo *et al*., 2020).

Apart from teaching strategies, the issue of school location, urban or rural, especially when talking about the incorporation of technology in education, is another variable that could affect learners' outcomes and retention in physics due to the influence that geographical location exerts on STEM education (Saw & Agger, 2021). The difference between urban students and rural students concerning conceptual understanding and retention in STEM has been a problem for many years (Morris *et al*., 2021). Researchers in different countries reported that urban students perform better than rural (Avery, 2013; Chen, 2012; Harris & Hodges, 2018) either with no difference (Alokan & Arijesuyo, 2013) or rural students' dominant urban students. Consequently, studies on geographical location in physics education continued to yield inconsistent results and it has been attributed to unequal exposure of urban and rural students to instructions relevant to physics education and the integration of multimedia in teaching and learning.

Gender is another variable that cannot be left behind when talking about science education and integrating technology, such as VBM, in teaching and learning (Stoet & Geary, 2018). The issue of gender equity and equality has remained a persistent challenge worldwide in STEM education in general (Makarova *et al*., 2019) and physics education in particular (Dusen & Nissen, 2020). Therefore, the issue of masculinity and femininity concerning STEM education has received a lot of attention for many years (Acker &

Oatley, 1993; Jia *et al*., 2020; Kahle *et al*., 2010). Moreover, studies on the influence of gender on students' performance in STEM education have been indecisive over the years and continued to produce inconsistent results (Seyranian, *et al*., 2018). Researchers reported that girls' education is handicapped by access to resources, teaching and school climate, cultural norms and expectations, and poor infrastructure (Wolf *et al*., 2016)

2.1 Rational of the Study

Educational literature has shown the potential and effectiveness of using VBM in STEM education (Ndihokubwayo *et al*., 2020; Nyirahabimana *et al*., 2022; Tugirinshuti *et al*., 2021). It has been revealed that VBM improved students' motivation, problem-solving ability, and critical thinking and ultimately improved students' academic performance. This study noted the gap in the previous studies that have focused on the learners' achievement but very hardly regarded the learners' retention. Moreover, the literature revealed that multimedia-based instructional strategies can be influenced by gender and school location. Therefore, this study seeks to test the usefulness of VBM on learners' retention of astrophysics. Hence, based on the literature review and research problem highlighted above, this study seeks to test the research hypotheses (RH) at a 0.05 level of significance.

RH$_1$: There is no statistically significant difference in retention mean scores in astrophysics of learners taught astrophysics using VBM and those taught astrophysics using the teachers' usual teaching strategies

RH$_2$: There is no statistically significant difference in retention mean score of astrophysics between urban students and rural students taught using VBM.

RH$_3$: There is no statistically significant difference in retention mean score of astrophysics between boys and girls taught using VBM.

3. Methodology

3.1 Research Design & Paradigm

A quasi-experimental design with pre-test, post-test, and retention test (also called post-post-test) for the control and experimental group was employed in this research. In line with the positivist world of view (Park *et al*., 2019), this study uses the quantitative method, which assisted us in evaluating the learners' retention after five weeks of post-test.

3.2 Sampling and Research Participants

Eight public secondary schools from the Rutsiro district (rural settled area) and Rubavu district (urban settled area) in the western province of Rwanda were purposively selected for this study. Those schools were selected based on two conditions: i) they have smart classrooms (also called computer laboratories), and ii) they have STEM combinations at the advanced level, where physics is a major subject. These combinations include

Mathematics-Physics-Geography (MPG), Physics-Chemistry-Biology (PCB), and Physics-Chemistry-Mathematics (PCM). In each selected school, all senior five (grade 11) classes with physics as a primary subject from each school and all learners from each selected classroom were included in the sample. The choice of senior five students was made to strike a balance because it is a medium class at the advanced level. Senior four students are now at the advanced level and have not covered much, while senior six, being a terminal class, are busy preparing for the national examination. Moreover, the senior five students are in a good readiness position to respond to any activity in astrophysics as they have acquired knowledge and competencies from previous grades of their study, and they have shaped their attitude towards astrophysics. In view of the sampling criteria set above, eight public schools (four from each district) made a total of 294 (168 boys and 126 girls) senior five students sampled for this study. Among eight selected schools, four (two in each district) were randomly assigned to the experimental group, and the other four (two in each district) were assigned to the comparison group. Students in the experimental group were taught using the VBM strategy, while those in the comparison group were taught using teachers' usual teaching strategies (UTS). The topic area covered in all groups was astrophysics, and the unit covered was stellar distance and radiation.

3.3 Instruments and Validation

For this study, the Astrophysics retention test (ART) was used. The ART was made of a re-arranged astrophysics achievement test (AAT) that was developed based on the unit of stellar distance and radiation from the topic area of astrophysics as specified by Rwanda's national curriculum, advanced level physics syllabus (REB, 2015). The initial AAT was made of 45 questions. Those 45 questions were subjected to experts in astrophysics (One university lecturer, one PhD student in astronomy, and three master's students in physics education) and secondary school teachers with 5 and above years of experience in teaching physics in secondary schools. Their contributions led to the amendment of the AAT and 37 questions out of 45 were retained.

The AAT was subjected to a pilot study for validation and reliability analysis. 53 (34 boys and 19 girls) students from the school who were not part of the main study but had comparable characteristics as the sample schools participated in the pilot study. Exploratory factor analysis (EFA) using SPSS version 21 was used for reliability analysis and construct validity. EFA was done using the principal component analysis extraction method which was performed to determine the number of questions that could be extracted from the 37 questions of the initial AAT. 7 questions were extracted, and the remaining 30 had a factor loading greater than 0.40. The 30 questions were analyzed for internal consistency and given a Cronbach's Alpha of .87, which was considered acceptable since it was greater than the recommended of .70 (Taber, 2018). All 30 questions were independent since there are no pair's inter-item correlations of more than .80.

3.4 Procedure

The ART was administered to all groups five weeks after the post-test. Prior to the treatment, both the experimental and control groups were subjected to a pre-test to examine the level of learners and to identify the initial differences among groups. After the pre-test, both the experimental and comparison groups were taught the same topic in the topic area of astrophysics. The unit taught was stellar distance and radiation from senior five syllabi with the same length of time for both experimental and comparison groups. One week before the start of the intervention, teachers from selected schools were trained based on the objectives of the study, the topic area, and unit to be taught, the procedural strategies, as well as the general conduct of the study. Moreover, teachers in the experimental group were accurately and independently trained on the effective use of VBM at this stage of research. During the four weeks of the intervention period, the teachers were supervised by researchers to ensure smooth intervention and learning. The experimental group was taught using VBM, while the comparison group was taught using teachers' usual teaching strategy. In the comparison group, teachers taught using chalk and board and textbooks with some drawings to explain some phenomena, while in the experimental group, teachers taught using selected videos, and some practical demonstrations were manipulated by both teachers and learners using moving pictures on the screen or personal computers. After four weeks of teaching, a post-test was administered in both groups. To answer the questions in both the pre-test and post-test, students worked individually under the supervision of a class subject teacher, and the time limit was 80 minutes, which equals two school periods. To test the learners' retention in astrophysics, a retention test was scheduled and administered to the participants five weeks after the post-test, as recommended by researchers (Tuckman, 1975). The retention test was made by the rearranged questions of AAT. Students worked individually on retention tests under the supervision of the research assistant and subject teachers. The time limit was 80 minutes. All learners who participated in the pre-test and post-test were also present in the retention test.

3.5 Data Analysis

Analysis of collected data was done using the Statistical Package for Social Science (SPSS) version 21. Descriptive analysis, such as standard deviation, mean, and percentage, was used to analyze data from tests. In all statistical tests, the research hypothesis was accepted or rejected at the significant level of 0.05

4. Results

Table 1: Comparison of Learners' Post-test and Retention Test Results

Intervention	N	Test	Average of correct answers	%	SD	Min	Max
VBM	144	Post-test	16.01	53.35	11.96	11	26
		Retention test	15.93	54.09	8.91	12	26
UTS	150	Post-test	9.14	30.46	8.21	6	19
		Retention test	6.12	20.06	8.83	3	12

Table 1 displays the learners' results on the post-test and retention test. The result revealed that the learners' retention in the experimental group was much higher than the learners' retention in the comparison group. Therefore, students who were taught astrophysics using VBM retained their knowledge much better than those taught UTS.

Table 2: Mean and Standard Deviation of Experimental and Comparison Group

Intervention	N	Test	Mean	SD	Minimum	Maximum	Mean gained
VBM	144	Post-test	74.03	11.96	11	26	4.06
		Retention test	78.09	8.91	12	26	
UTS	150	Post-test	46.72	9.37	6	19	-0.31
		Retention test	46.41	8.83	3	12	

Data displayed in Table 2 revealed that the gained mean between the retention test and post-test was 4.06 for VBM and -0.31 for UTS. This implies that learners who were taught astrophysics using VBM had better retention than their counterparts in the UTS group.

Table 3: Statistical Significant Difference between Post-test and Retention Test

Intervention	Post-test	Retention test	AV std	D	<g>	t-test	p-value	Significant?
VBM	53.36	53.09	10.44	0.79	0.11	0	<0.001	Yes
UTS	30.46	20.06	8.52	0.16	0.01	0.22	>0.05	No

To determine the significance of the interventions, Table 3 revealed that the obtained Cohen's D effect size (0.83 for VBM and 0.11 for normal teaching), the average normalized gained (0.11 for VBM Vs 0.01 for normal teaching methods), the t-test and p-values calculated as shown in Table 3 shows that the group of learners taught astrophysics using VBM retained statistically higher than the group of learners taught the same subject using usually teaching strategies from post-test to retention test. Hence, based on results in Table 1, Table 2, and Table 3, we reject the null hypothesis, which states there is no statistically significant difference in retention mean scores in astrophysics of learners taught astrophysics using VBM and those taught astrophysics using the teachers' usual teaching strategies.

Table 4: Descriptive Statistics of Experimental Groups,
Post-test, Retention Test, Gender, and School Location

	Group	N	Post-test mean	SD	Retention test mean	SD	Mean gained
Gender	Boys	76	74.51	7.84	75.44	7.27	0.93
	Girls	68	70.42	7.36	71.32	6.76	0.9
School location	Urban	85	73.22	7.46	77.86	5.27	4.64
	Rural	59	71.72	7.24	72.59	6.42	0.87

Data displayed in Table 4 revealed that the post-test mean was 74.51 and 70.42 for boys and girls, respectively. The standard deviation was 7.84 for boys and 7.36 for girls. Moreover, the retention test mean was 75.44 and 71.32 for boys and girls, respectively. The standard deviation was 7.27 for boys and 6.76 for girls. The mean gained was 0.93 for boys and 0.90 for girls. The mean difference gained was 0.03 in favor of boys. This difference in mean gained, being too small, implies that there is no statistical difference between boys and girls in retention in the experimental group. In other words, Table 4 shows that there is no statistical difference in the retention of astrophysics between boys and girls when VBM is used as an instructional strategy. Hence, boys and girls retained slightly the same way. Therefore, null hypothesis two, which states that there is no statistically significant difference in retention mean score of astrophysics between urban students and rural students taught using VBM, is hereby accepted.

Furthermore, data presented in Table 4 revealed that the post-test mean was 73.22 for urban students and 71.72 for rural students, with a standard deviation of 7.46 and 7.24 for urban and rural students, respectively. Additionally, the retention test mean was 77.86 and 72.59 for urban and rural students, respectively, while the standard deviation was 5.27 for urban students and 6.42 for rural students. The mean gain was 4.64 for urban students and 0.87 for rural students. The mean difference gained of 3.77 in favor of urban students is substantial enough to conclude that urban students retain much better when VBM is used as an instructional strategy in teaching and learning astrophysics. So, we reject the null hypothesis three, which states that there is no statistically significant difference in the mean retention score of astrophysics between boys and girls taught using VBM.

5. Discussion

The results of this research show that learners who learnt astrophysics in the VBM group performed much better than learners in the UTS group. Recent studies echo the same findings that VBM is a good methodology for enhancing learners' retention of STEM subjects (Bayraktara *et al.*, 2019). The significant difference in success and retention of learners in astrophysics in the VBM group over UTS can be attributed to the fact that learners actively participated in teaching-learning related activities that seduce learners' attention and motivation, stimulate learners' critical thinking, and activate their prior knowledge. This result is consistent with recent research findings that reported the effectiveness of VBM in STEM education (Abdulrahman *et al*., 2020; Ismail *et al*., 2019; Ndihokubwayo *et al*., 2020). However, in the UTS group, the teaching was dominated by chalk and talk, and learning was based on memorization of concepts, which led to poor success compared to their counterpart of the VBM group. Recent studies reported similar findings that traditional methods of lecturing characterized by teacher-centered methods do not improve students' achievement in STEM subjects because learners' participation is limited (Akiri *et al*., 2021; Mukuka *et al*., 2019).

The findings of this research also revealed that there is a statistically significant difference in retention between learners taught astrophysics using VBM and those taught UTS. The substantial difference in retention between the VBM group and the UTS group could be attributed to the fact that learners in the VBM group had the chance to actively participate in the teaching-learning process while learners in UTS were passive listeners. Recent studies reported similar findings that learners who are exposed to VBM retain much better in STEM subjects (Tugirinshuti *et al*., 2021). Moreover, literature in educational technology is extremely reported that VBM in the education setting stems from the constructivism theory, which involves and interacts with learners with knowledge construction (Bull, 2013).

Results of this study also revealed that there is no statistical difference in boys' and girls' mean retention scores when VBM is used to teach astrophysics. This could be attributed to the fact that the social construction difference between masculinity and femininity is less of a concern in the Rwandan education system due to different policies to promote girls' education (Mineduc, 2008). Previous studies reported, to a great extent, the same findings that when girls have the same opportunities in STEM education and ICT, like equal access to digital tools, increase their performance and are likely to perform much better than boys (Castro *et al*., 2021; Dousay & Trujillo, 2018). However, this study contradicts the findings of Heo & Toomey (2020), who reported that girls do not perform well like boys when technology-related instructions are used in teaching STEM subjects. This poor performance of girls in STEM subjects when learning using multimedia-related instructional strategies related to technology was the result of lack/poor access of girls to digital tools like the computer that led to poor competence in digital tools, which is not the case in Rwanda due to gender accountability at all levels in the country (GMO, 2019).

Finally, the findings of this study also point out that there is a statistically significant difference between rural and urban students' retention mean score in favor of urban students when learning astrophysics using VBM. These findings coincide with previous studies that urban students perform and retain better than rural students when exposed to ICT-related instructional strategies (Wang, 2013). Moreover, a recent study reported that urban students have access to ICT tools more than their counterparts of rural students (Kormos & Wisdom, 2021). This access to ICT tools enshrines urban students' intrinsic motivation and hence increases their performance and retention when used to teach STEM subjects such as physics.

6. Conclusion

This study aimed to test the usefulness of VBM on learners' retention in astrophysics. Drawing on the results of this research, it has been noted that learners from the selected schools benefit more from using VBM as an instructional tool than using UTS. The results of this study revealed that learners exposed to VBM benefit more in terms of learning, understanding, achievement, and retention. Moreover, the results of this study showed that the VBM reduces girls' backlash, improves gender sensitivity, and encourages girls to pursue STEM education. However, the results of this study showed a very big gap between urban and rural students in terms of achievement and retention of astrophysics when VBM is used as an instructional tool. Thus, it follows that VBM is an effective instructional tool that can be used by physics teachers and other STEM teachers to nurture and promote learners' retention in abstract disciplines such as astrophysics. However, special attention could be given to rural students.

6.1 Recommendation

STEM teachers, especially physics teachers, are recommended to use VBM as an instructional tool. This will help learners interact and get engaged in knowledge construction by using modern and innovative methodology that is likely to improve teaching and learning, increasing learners' performance and promoting learners' retention of the concepts. Although some topics in physics have been considered isolated and abstract disciplines, which led to learners' misconceptions, the incorporation of VBM in the classroom setting might solve this problem. Moreover, adopting VBM as an instructional tool will decrease the dependence on UTS, which does not guarantee the students' retention in STEM subjects such as physics. This study provides a reference and adds value to the existing literature on the usefulness of VBM in promoting learners' retention in astrophysics. Even if the results of this study do not considerably differ from what has been reported in other countries, this study provides a benchmark on what is going on in less developed countries like Rwanda in terms of integrating ICT in education. For that purpose, further research should explore the teachers' beliefs about the use of VBM because teachers are the agents of change in education. Further research could also examine the barriers to effectively incorporating VBM in the classroom setting.

6.2 Limitations

Some limitations, such as environmental conditions, data collection, data analysis, and diverse teaching experiences, make it difficult to generalize the study findings to other learner populations, especially those not in STEM education. Moreover, the study has looked explicitly at the upper secondary school level (senior five). At the same time, ICT and technology are integrated at various levels of schooling, including primary and university levels. Therefore, the limitations are that the study focused only on one level (senior five) of the upper secondary level and on one topic (astrophysics), while senior five has many topics.

Acknowledgements
This research was financially supported by the African Center of Excellence for Innovative Teaching and Learning of Mathematics and Science (ACEITLMS) of the University of Rwanda-College of Education. We would like to thank the local leaders of the Rutsiro and Rubavu districts for their support while conducting this study. We would also like to thank Dr. Leon R. Mugabo and Prof Alexis Banuza for their supervision, constructive comments, and suggestions on the manuscript.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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References

Abdulrahaman, M., Faruk, N., Oloyede, A., Bakinde, N. S., Olawoyin, L., Mejabi, O., . . . Azeeze, A. (2020, November). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon, 6*(11). https://doi.org/10.1016/j.heliyon.2020.e05312

Acker, S., & Oatley, K. (1993). Gender issues in education for science and technology: current situation and prospects for change *Canadian Journal of Education*. *Revue canadienne de l'éducation*, 255-272. https://doi.org/10.2307/1495386

Adonu, C. J., Nwagbo, C. R., Christian, S., & Okeke, C. (2021). Improving students' achievement and retention in biology using flipped classroom and PowerPoint instructional approaches: implication for physics teaching. *International Journal of Psychosocial Rehabilitation, 25*(2). http://bitly.ws/CoMr

Akiri, E., Tor, H. M., & Dori, Y. J. (2021, May). Teaching and assessment methods: STEM teachers' perceptions and implementation. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(6), 1-22. https://doi.org/10.29333/ejmste/10882

Alokan, F. B., & Arijesuyo, A. E. (2013, September). Rural and Urban Differential in Student's Academic Performance among Secondary School Students In Ondo State, Nigeria. *Journal of Educational and Social Research*. https://doi.org/10.5901/jesr.2013.v4n3p213

Anthony, A., & Anka, S. S. (2020). Effects of two modes of computer-assisted instruction on pupils' achievement and retention in English language spelling in Niger state-Nigeria. *International Journal of Innovative Research in Computer Science & Technology, 8*(3), 231-241. https://doi.org/10.21276/ijircst.2020.8.3.35

Avery, L. M. (2013). Rural science education: valuing local Knowledge. *Theory into Practice, 52*(1), 28-35. https://doi.org/10.1080/07351690.2013.743769

Bayraktara, D. M., Cosgunb, V., & Altanc, T. (2019). Cognitive load in multimedia learning environments: A systematic review. *Computers & Education, 141*. https://doi.org/10.1016/j.compedu.2019.103618

Bizimana, E., Mutangana, D., & Mwesigye, A. (2022, November). Fostering Students' Retention in Photosynthesis Using Concept Mapping and Cooperative Mastery Learning Instructional Strategies. *European Journal of Educational Research, 11*(1), 103-116.:https://doi.org/10.12973/eu-jer.11.1.107

Bull, P. H. (2013). Cognitive constructivist theory of multimedia: designing teacher-made interactive digital. *Creative Education, 4*(9), 614-619. https://doi.org/10.4236/ce.2013.49088

Casselman, M. D., Eichler, J. F., & Atit, K. (2021). Advancing multimedia learning for science: Comparing the effect of virtual versus physical models on student learning about stereochemistry. *Science Education*, 1285-1314. https://doi.org/10.1002/sce.21675

Castro, S. V., Holgado, A. G., Gómez, M. C., & Peñalvo, F. J. (2021). Multimedia analysis of Spanish female role models in science, technology, engineering and mathematics. *Sustainability, 13*, 1-19. https://doi.org/10.3390/su132212612

Chen, Y.-H. (2012). Cognitive diagnosis of mathematics performance between rural and urban students in Taiwan. *Assessment in education: Principles, Policy & Practice, 19*(2), 193-209. https://doi.org/10.1080/0969594X.2011.560562

Dousay, T. A., & Trujillo, N. P. (2018). An examination of gender and situational interest in multimedia learning environments. *British Journal of Educational Technology, 50*(2). https://doi.org/10.1111/bjet.12610

Dusen, B. V., & Nissen, J. (2020). Equity in College Physics Student Learning: A Critical Quantitative Intersectionality Investigation. *Journal of Research in Science Teaching*. https://doi.org/10.1002/tea.21584

GMO. (2019). *The State of gender equality in Rwanda, from transition to transformation.* Gender Monitoring Office-Rwanda. http://bitly.ws/CoNa

Harris, R. S., & Hodges, C. B. (2018). STEM education in rural schools: implications of untapped potential. *National Youth Advocacy and Resilience Journal*. https://doi.org/10.20429/nyarj.2018.030102

Heo, M., & Toomey, N. (2020). Learning with multimedia: The effects of gender, type of multimedia learning resources, and spatial ability. *Computers & Education, 146*. https://doi.org/10.1016/j.compedu.2019.103747

Ismail, M. Z., Mansor, A. N., Iksan, Z. H., & Mamad, N. (2019). The impact of using stem video in teaching on students' learning engagement in Malaysia. *International Journal of Recent Technology and Engineering*, 159-165. http://bitly.ws/CoND

Jia, C., Yang, T., Qian, Y., & Wu, X. (2020). The gender differences in science achievement, interest, habit, and creativity. *Science Education International, 31*(2), 195-202. https://doi.org/10.33828/sei.v31.i2.9

Kahle, J. B., Parker, L. H., Rennie, L. J., & Riley, D. (2010). Gender differences in science education: building a model. *Educational Psychologist, 28*(4), 379-404. https://doi.org/10.1207/s15326985ep2804_6

Khalaf, B. K., & Zin, Z. B. (2018). Traditional and inquiry-based learning pedagogy: A systematic critical review. *International Journal of Instruction, 11*(4), 545-564. https://doi.org/10.12973/iji.2018.11434a

Khishfe, R. (2020). Retention of acquired argumentation skills and nature of science conceptions. *International Journal of Science Education, 42*(13), 2181-2204. https://doi.org/10.1080/09500693.2020.1814444

Kormos, E., & Wisdom, K. (2021). Rural Schools and the Digital Divide: Technology in the Learning Experience and Challenges to Integration. *Theory & Practice in Rural Education, 11*(1), 25-39. https://doi.org/10.3776/tpre.2021.v11n1

Lindner, M. A., Schult, J., & Mayer, R. E. (2020). A multimedia effect for multiple-choice and constructed-response test items. *Journal of Educational Psychology*. https://doi.org/10.1037/edu00006461

Makarova, E., Aeschlimann, B., & Herzog, W. (2019, July). The gender gap in STEM fields: the impact of the gender stereotype of math and science on secondary students' career aspirations. *Frontiers Education*. https://doi.org/10.3389/feduc.2019.00060

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education*. https://doi.org/10.1186/s40594-018-0151-2

Mayer, R. (2014). Cognitive theory of multimedia learning. In R. Mayer, *The Cambridge handbook of multimedia learning* (pp. 43-71). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.005

McGuire, C. (2018). Transforming traditional teaching practices with 21st century skills in K-12 classrooms. *Culminating Projects in Information Media, 16*. http://bitly.ws/CoP9

Mineduc. (2008). *Girls' education policy.* Ministry of Education-Rwanda. http://bitly.ws/CoPh

Morris, J., Slater, E., Fitzgerald, M. T., Lummis, G. W., & Etten, E. v. (2021). Using local rural knowledge to enhance STEM learning for gifted and talented students in Australia. *Research in Science Education, 51*, 61–79. https://doi.org/10.1007/s11165-019-9823-2

Mukuka, A., Mutarutinya, V., & Balimuttajjo, S. (2019). Exploring the barriers to effective cooperative learning implementation in school mathematics classroom. *Problem of Education in the 21st century, 77*(6), 745-757. https://doi.org/10.33225/pec/19.77.745

Munna, A. S., & Kalam, M. A. (2021). Teaching and learning process to enhance teaching effectiveness: a literature review. *International Journal of Humanities and Innovation, 4*(1), 1-4. https://doi.org/10.33750/ijhi.v4i1.102

Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2020). Effectiveness of PhET simulations and YouTube videos to improve the learning of optics in Rwandan secondary schools. *African Journal of Research in Mathematics, Science and Technology Education, 24*(2), 253-265. https://doi.org/10.1080/18117295.2020.1818042

Nyirahabimana, P., Minani, E., Nduwingoma, M., & Kemeza, I. (2022). Instructors and Students' Practices and Behaviours during a Quantum Physics class at the University of Rwanda: Exploring the Usage of Multimedia. *International Journal of Learning, Teaching and Educational Research, 21*(9), 309-326. https://doi.org/10.26803/ijlter.21.9.18

Oyelekan, O. S., Igbokwe, E. F., & Olorundare, A. S. (2017). Science teachers' utilisation of innovative strategies for teaching senior school science in Ilorin, Nigeria. *Malaysian Online Journal of Educational Sciences, 5*(2), 49-65. http://bitly.ws/CoPu

Palermo, M., Kelly, A. M., & Krakehl, R. (2021). Physics teacher retention, migration, and attrition. *Journal of Science Teacher Education*. https://doi.org/10.1080/1046560X.2021.1946638

Park, Y. S., Konge, L., & Artino, A. R. (2019, November). The Positivism Paradigm of Research. *Journal of the Association of American Medical Colleges, 95*(5). https://doi.org/10.1097/ACM.0000000000003093

Petrus, R. M. (2018). A comparison of teachers' and students' perceptions of the factors contributing to poor performance in physical sciences: A case of South Africa. *Turkish Science Education, 15*(4), 93-103. https://doi.org/10.12973/tused.10248a)

Pmp, N. M. (2019, April). 21st century teaching: integrating innovation in a traditional classroom. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3375460

Puente, S. M., & Kroesen, G. M. (2020). Facilitating retention and transfer of physics concepts with challenging assignments in design-based learning projects. *Open Journal of Social Sciences, 18*(12), 366-387. https://doi.org/10.4236/jss.2020.812030

REB. (2015). *Advanced Level Physics Syllabus.* Rwanda Education Board. http://bitly.ws/CoPy

Saw, G. K., & Agger, C. A. (2021). STEM Pathways of Rural and Small-Town Students: Opportunities to Learn, Aspirations, Preparation, and College Enrollment. *Educational Researcher*. https://doi.org/10.3102/0013189X211027528

Serrano, M. J., & Rodríguez, J. M. (2020). Interest in STEM disciplines and teaching methodologies. Perception of secondary school students and preservice teachers. *Educar 2020, 56*(2), 369-386. https://doi.org/10.5565/rev/educar.1065

Seyranian, V., Madva, A., Duong, N., Abramzon, N., Tibbetts, Y., & Harackiewicz, J. M. (2018). The longitudinal effects of STEM identity and gender on flourishing and achievement in college physics. *International Journal of STEM Education, 5*, 40-47. https://doi.org/10.1186/s40594-018-0137-0

Stoet, G., & Geary, D. C. (2018). The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education. *Psychological Science*. https://doi.org/10.1177/0956797617741719

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education, 48*, 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tuckman, B. W. (1975). *Measuring Educational Outcomes: Fundamentals Of Testing.* Houghton Mifflin Harcourt P. http://bitly.ws/CoRr

Tugirinshuti, G. J., Mugabo, L. R., & Banuza, A. (2021). Integrating Video-Based Multimedia in Teaching Physics in Context of Covid-19 in Rwandan Secondary Schools. *International Journal of Learning, Teaching and Educational Research, 20*(12), 49-63. https://doi.org/10.26803/ijlter.20.12.4

Wang, P.-Y. (2013). Examining the Digital Divide between Rural and Urban Schools: Technology Availability, Teachers' Integration Level and Students' Perception. *Journal of Curriculum and Teaching,* 2(2), 127-139. https://doi.org/10.5430/jct.v2n2p127

White, J. L., & Massiha, G. (2016). The Retention of women in science, technology, engineering, and mathematics: A framework for persistence. *International Journal of Evaluation and Research in Education (IJERE), 5*(1), 1-8. http://bitly.ws/CoRB

Wolf, S., McCoy, D. C., & Godfrey, E. B. (2016, June). Barriers to school attendance and gender inequality: empirical evidence from a sample of Ghanaian school children. *Research in Comparative and International Education, 11*(2), 178 –193. https://doi.org/10.1177/1745499916632424

Zendler, A., Seitz, C., & Klaudt, D. (2018). Instructional methods in STEM education: A cross-contextual study. *EURASIA Journal of Mathematics, Science and Technology Education, 14*(7), 2969-2986. https://doi.org/10.29333/ejmste/91482