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Improving Students' Performance on the Use of the Microscope Through Demonstration Method

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Abstract

This study became necessary following the difficulty in teaching the microbial aspect of biology with a single microscope at the Abetifi Presbyterian College of Education. The main objective of this research is to investigate the effectiveness of the demonstration approach in improving students' performance in using the only microscope at Abetifi Presbyterian College of Education. The population of this study which employed action research, consisted of all seventy (70) teacher candidates in this class. The study employed a simple random sampling method to select sixty respondents to represent this population. The research instruments in this study were tests and questionnaires. According to the study, students learn how to use a microscope more effectively when they are taught through a demonstration method as opposed to a lecture method even in a situation of woefully inadequate teaching-learning materials (TLMs). Therefore, the study recommends in-service training for science teachers on demonstration methods, particularly in resource-limited settings.

Keywords: *Biology teachers Demonstration method, Microscope, Students, Teacher trainees*

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INTRODUCTION

The role of science in national development is undeniable with scientific advancements driving robust economies (Fang et al., 2022; Radło and Tomeczek, 2022). This implies that each country at the cusp of national development ought to voice significant concerns about what is required to advance science education in its educational institutions (Wilmot, 2024; Aikenhead, 2023; Bryk et al., 2023). Educational activities, taking place in various settings, that aim to meet basic learning needs forms the basis of human resource development (Swanson, 2022; Stofkova and Sukalova, 2020; Mahapatro, 2021). This suggests that in the pursuit of human resource development in every country, the training of educators in colleges of education intended for basic schools to handle subjects including science must receive the utmost emphasis (Mahapatro, 2021; Piwowar-Sulej, 2021).

Biology is one of the many scientific fields which has the potential to influence our perceptions of the environment and provide answers to the major issues that the environment and society face including addressing the health needs of the people who are the workforce of the nation (Wegner and Schmiedebach, 2020; Heim and Holt, 2019). The field of microbial science is one of the aspects of biology that most students find challenging to comprehend because microbes cannot be seen with the human eye (Smyth et al., 2022; Wessner et al., 2020; Gregory, 2008; Bisen et al., 2012).

Microscopes which are instruments with powerful lenses used to appreciate these microbials are highly priced in Ghana (Jiji, 2024). Due to the demands of the kind of external exams that students are prepared for, as well as the inadequacy or lack of science equipment and supplies, such as microscopes among others, many science teachers have been forced to use the lecture method for a while now (Ayo and Ahmed, 2023; Clement et al., 2017: Ossei-Anto,1999). This suggests that the teacher takes the lead during these teaching sessions, causing the students to participate less actively. It is also possible that in these institutions where the microscopes are woefully inadequate, microbial aspects of the biology syllabus are taught in abstract or not even taught at all. This might have contributed to the inability of the students to make straightforward conclusions from their observations under the microscope as seen in Senior Secondary Schools (Tordzro et al., 2021).

The above situation might make the teachings in these areas extremely challenging for the learners to

understand, which would decrease their interest and turn them off of the subject. According to Jocz et al. (2014), lessons that involve students in practical exercises can increase their attention since they participate in learning experiences and the converse is also true for when the lessons are taught in abstract.

There is a possibility that teachers may be deterred from planning practical exercises in lessons connected to microbes in these schools where there are lack or inadequate supply of microscopes. The situation calls for the resourcefulness of the teachers concerned to adopt certain strategies to address this problem at hand taking into consideration that even though teachers are considered the arbiters and possess final power over what occurs in the classroom, the learners are in control of what is truly conveyed and embraced from the curriculum (Reich et al., 2020; Doyle, 2023; Filgona et al., 2020; Muñoz-Restrepo et al., 2020). Isa et al. (2020) opined that the degree to which learners succeed academically is determined by the methods or the teaching strategies employed by the teacher in the teaching-learning process. The teacher's main motive in every instructional period is to get the student to exhibit a shift in behavior (London et al., 2023; Hopkins, 2023; Husna and Adriani, 2023). This is what must inform any instruction method adopted by the teacher. While some instruction methods are teacher-centered, others are learner-centered and others employ teacher-learner-centredness (Yoshida et al., 2023; Du Plessis, 2020; Bartlett and Mogusu, 2013). The learner is at the center of the learner-centered approach to teaching, whereas the instructor is, as the name suggests, at the center of the teacher-centered technique, in the teacher-learner method, the instruction revolves around both the teacher and the learner (Shah and Kumar, 2020; Bremner, 2019; Ubulom and Ogwunte, 2017; Mtitu, 2014;). Among the various methods of teaching science, the demonstration method has been contended to be the best (Pangaribuan et al., 2022; Umara, 2022; Muhammad, et al., 2016; Rahayu, 2024). The term "demonstration method" is an instructional strategy where a teacher performs a demonstration in the presence of the class to illustrate a concept or how something is done (Saleh, 2023; Kareem, 2019; Giridharan and Raju, 2016). The teacher must illustrate the demonstration before allowing the students to carry it out. However, while some believe that this method has the disadvantage of being expensive as every student needs their equipment (Olatunde-Aiyedun and Ogunode, 2020), others maintain that it is the ideal option when the lesson materials are in short supply (Frago and Janer, 2020; Mintah, 2016).

Therefore, it is undeniable that a teacher's decision on which teaching strategy to employ is influenced by the availability of teaching resources, among other factors (Mintii et al., 2023; Huda et al., 2023; Akram et al., 2022). Abetifi Presbyterian College of Education which is the only teacher trainee college on the Kwahu ridge in Ghana where this study was conducted is of no exception. Despite this, there is a dearth of information on effective teaching strategies for topics like “using a microscope” in this field of research. This study attempts to employ the demonstration method to determine whether it could be an appropriate strategy necessary to enhance students' comprehension of how to operate a microscope to address the problem of using only one microscope this institution has to teach the numerous teacher candidates preparing to teach in primary schools.

Based on the background described above, the problem that this study seeks to address is that it is challenging for biology teachers at Abetifi Presbyterian College of Education to teach many teacher candidates in biology using only one microscope provided at the college's science lab. As a result, students struggle to grasp the idea of microscopy and score badly on assessments of their lessons on using a microscope. The main purpose of this study is therefore to attempt to use a demonstration method to determine whether it could be an appropriate strategy necessary to enhance student's understanding of the use of the microscope at Abetifi Presbyterian College of Education.The research question that this research seeks to answer is “To what extent does the use of demonstration methods aid in enhancing students' proficiency with the use of microscopes?

This study is therefore worth doing because (1) the results of this study will assist biology instructors of Abetifi Presbyterian College of Education in overcoming the barrier of comfortably utilizing a single microscope to teach. (2) the findings of this study will support the Ministry of Education and Ghana Education Service in organizing in-service training for science instructors on teaching with inadequate science equipment. (3) further studies on the use of TLMs in schools where they are insufficient will also benefit from this study.

Their researcher of this current study hypothesizes that there is no significant difference between the performance of students in a lesson on the use of the microscope taught using the demonstration method and that taught in an abstract using the lecture method.

RESEARCH METHOD

Research Design

This study used an action research design since it deals with an inquiry that is carried out to understand, evaluate, and then adjust to enhance educational methods. In essence, action research is a technique that is carried out immediately to address a specific issue that arises in a particular scenario. The researcher finds this design appropriate because the primary goal of this study is to help a variety of students who are struggling to understand the use of a

microscope and therefore perform poorly in such lessons. In particular, the kind of action research used in this study is called practical action research, which aims to improve the researchers' professional performance as well as the students' learning to find answers to challenges they face in their classrooms. The processes involved in this type of research could be outlined as pre-intervention, intervention, and post-intervention

This means that in an ideal world, the sequential process would be continuously observed to translate the feedback that is received into necessary modifications, adjustments, directional changes, and redefinitions that will benefit the ongoing process in the long run. Even though action research may be a good fit for a problem being studied, the time and money commitment it demands might be substantial and needs to be acknowledged.

Population and Sample Selection

The study involved seventy level 100 students (30 female and 40 male) at Abetifi Presbyterian College of Education. Sixty students were selected using random sampling, ensuring a representative sample.

Sample Procedure

The methodology utilized for the purpose of selecting study participants for the various processes at hand was simple random sampling. The researcher observed that this sampling method was more convenient and perfect because it allowed every student in the population an equal chance of being included in the study, hence minimizing biases to the greatest extent feasible. Yamane's formula, $n = N / (1 + Ne^2)$ (Yamane,1973), was applied to predict the minimum sample size of 60 for this study where n is the sample size, N is the population size (70), and e is the margin of error of 5%.

Research Instrument

A questionnaire was used as the research tool in this investigation. In this investigation, the questionnaire functioned as an inquiry tool, comprising a methodically assembled and neatly arranged set of inquiries meant to provide information to the researcher regarding the students' poor performance on the use of the microscope.

This data, which was provided by the respondents, teachers, and students offered additional insight into the nature of the issue being investigated. Sections 1, 2, 3, 4, and 5 made up the five sections of the questionnaire. Section 1 asked questions concerning the respondents' demographics. In section 2, the purpose of the items was to find out how the trainees, or students, perceived biology. Section 3 of this instrument solicited information regarding the challenges faced by teachers when teaching "the use of a microscope." In section 4, information was gathered regarding the methods teachers used to address the subject. The purpose of section 5 was to gather data regarding the tools and resources available for teaching and learning the microbial aspects of the biology course outline. In addition to the questionnaire, both before and after the intervention, tests were carried out. The intervention process describes the specifics of these.

Validity and Reliability

The supervisors evaluated the instrument's uniqueness and then authorized it after making adjustments to a few of the structures to ensure the instrument met the study's objectives. When the original instrument was modified, their feedback and recommendations were taken into account.

Another validity was ensured using a pilot study. The instrument was administered to fifty (50) targeted respondents in the analogous Colleges of Education in the Eastern part of Ghana who were not part of the study. The outcome of the pilot test called for some additional modifications.

Pre-intervention → intervention → post-intervention.

The problem was examined at the pre-intervention stage. It was noted that while the teacher conducted the majority of the class activities, the students were passive. As can be shown in Table 2 students performed poorly in the pre-test administered at this point after a lesson on the use of the microscope.

In the intervention stage, the researcher's demonstration method of teaching was introduced to teach a 2 hours lesson of the same class. The students were positioned so as to hear the teacher demonstrating the use of the microscope. The students were permitted to perform the demonstration in smaller groups one after the other under the guidance of the teacher. The students were observed to be very active and participative in class at this stage. Subsequently, the researcher conducted a post-intervention in which the impact of the intervention on students' performance was assessed using a post-test, with the collected data utilized to address the research questions.

Data analysis technique

Using the T-test, statistical differences between the student's performance in the pre-test and post-test were determined. P-value was used to evaluate the results statistically and determine the significance of the findings. P-values at the 95% confidence level less than 0.05 were regarded as significant**.**

RESULT AND DISCUSSION

This study aims to gather information to assess and enhance students' achievement through the use of the demonstration method. The students were taught with the lecture method on the use of the microscope. Students were given a pretest to determine their initial ability before the introduction of the intervention.

After this stage, the demonstration method was used to teach the participants and the lesson was evaluated with a post-test. It was observed that the level of students' ability the use the microscope was significantly low in the pre-test compared to the post-test.

Students' Achievement before Intervention.

Out of the 60 study participants, only 3.33% (n/N= 2/60) of them had an average mark of 50%. This means that 97.67% (n/N= 58/60) of the students in this class scored below the pass mark of 50%. The average score of the students before the intervention was $\sum fx/\sum x = 826/60 = 13.77\%$. Table 1 illustrates the performance of the teacher trainees in the pre-test.

Table 1. Performance of students in pre-test

Scores (x)	**50**	**30**	**20**	**15**	**10**	**2**	**Total (∑)**
No of students (f)	2	3	19	2	40	3	60
Fx	100	90	200	30	400	6	826

Students' Achievements After Intervention

None of the participants scored less than the pass mark of 50% after the intervention (Demonstration method) was introduced to teach the use of the microscope. Also, 95% (n/N =57/60) of the student participants scored not less than 75% out of the total mark of 100%. The average score of the participants after the intervention was as deduced below: $\sum fx/\sum x = 5300/60 = 88.33\%$. The achievement of the students after the intervention is shown in Table 2.

Table 2. Performance of students in post-test

Scores (x)	**100**	**95**	**90**	**85**	**80**	**75**	**70**	**65**	**Total (∑)**
No of students (f)	15	7	10	10	12	3	1	2	60
Fx	1500	665	900	850	960	225	70	132	5300

Using the T-test, statistical differences between the students' performance in the pre-test and post-test were determined. P-value was used to evaluate the results statistically and determine the significance of the findings. P-values at the 95% confidence level less than 0.05 were regarded as significant. The study observed that statistically, the difference between the pre-test and the post-test results was significant($p<0.05$). Therefore, the null hypothesis is rejected. Table 3 shows the pre-test and post-test findings.

Table 3. Pre-test and post-test result compared

Test	**Mean**	**Variance**	**t-value**	**Df**
Pre-test	3.15	44.1	2.00	59
Post-test	88.33	89.55		

The results of the study showed that when the students were taught using the demonstration approach as an intervention instead of the lecture method, their achievement was improved greatly. A detailed analysis of the data in Tables 1, 2, and 3 indicates that the researcher's involvement of the demonstration method was the reason for the discrepancy. This can be explained by the fact that, during the pre-intervention and intervention phases, all other conditions remained the same, except for the teaching approach that was switched from lectures to demonstrations for the students' education.

The improved performance of the students can be explained by the fact that the demonstration of the use of the microscope by the researcher and their own classmates made the students to be good observers and caught their attention. This piqued students' interest and eliminate boredom. Thus, the students gained from the instruction which was reflected in their better performance in the post-test. Students gain from classes that are designed to increase their interest. The primary individual variables contributing to low engagement among students are their disinterest in and bad attitudes toward science (Msambwa *et al*. 2024). Since the students became interested in the lesson through the demonstration method as an intervention to the poor performance in the pre-test, they participated fully in the lesson at this stage. This indicates that when a lesson captures their interest and gives them a chance to watch, students perform better (Einstein, 2023; Cicekci and Sadik, 2019; O'Leary, 2020; Bdiwi *et al*., 2019;).

The students divided into smaller groups, accessing the microscope one group after the other

coupled with giving them the chance to perform the demonstration made the lesson very practical hence promoted their ability to think and work. This assertion made by this study conforms to an earlier observation made by Jocz *et al*. (2014) and Pangaribuan *et al*. (2022) who indicated that providing hands-on learning opportunities helps foster students' critical thinking abilities and productivity. In this instance, the students took an active rather than a passive role in the teaching and learning process, which helped them learn more and achieve more. In this case, the students' active participation in the instruction and learning process contributed to their success in the classroom. The current study's finding is consistent with previous claims made by numerous other authors that students perform better academically when they are more engaged in a lesson because it increases their motivation to learn (Hourigan and Leavy, 2023; Umara, 2022; Havik and Westergård, 2020; Barkley and Major, 2020).

Another contributory factor to the improvement in the performance of the students after the introduction of the intervention could be by the fact that through the demonstration method the lesson was appealed to the senses of the students. Humans use their senses to gather information about their surroundings and improve their ability to learn (Septiawan and Nandiyanto, 2022; Ponticorvo *et al*. 2019; Ackerman, 2020).

It should be mentioned that because they were using their hands, feeling and touching the microscope, and participating physically in the lesson, it catered to their cognitive, psychomotor, and emotional domains, which improved their learning. Student learning outcomes are improved when instruction gears towards improving cognitive, emotional, and psychomotor skills (Suwannatrai, 2022; Noor *et al*., 2020; Dorji *et al*., 2020).

CONCLUSION

This current study offered proof that in situations of scarcity of TLMs, with the right planning, the demonstration method may be a useful tool for raising students' desire and interest in learning biology while also improving their comprehension of certain biology concepts. Despite the students' subpar performance in the pre-test, their performance significantly improved following the introduction of the intervention. This suggests that compared to the lecture method in the abstract, the teacher-trainees when exposed to the demonstrative form of instruction recalled noticeably more scientific concepts regarding the usage of the microscope. The use of a microscope was the focus of this study; additional fundamental concepts should be investigated to provide a more complete view of the application of the demonstration method.

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REFERENCES

Ackerman, D. (2020). Engaging the Five Senses. *The Handbook of Wellness Medicine*, 448. https://doi.org/10.1017/9781108650182.037

Aikenhead, G. S. (2023). Humanistic school science: Research, policy, politics and classrooms. *Science Education*, *107*(2), 237-260. https://doi.org/10.1002/sce.21774

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Frontiers in psychology*, *13*, 920317. 10.3389/fpsyg.2022.920317

Armstrong, T. (2006). *The best schools: How human development research should inform educational practice*. *Association for Supervision and Curriculum Development* .

Ayo, V. A., & Ahmed, F. M. (2023). Implementation of Science Curriculum in Nigerian Tertiary Education: Problems and Way Forward. *International Journal on Integrated Education(IJIE)*, *6*(4), 22-31. https://doi.org/10.17605/ijie.v6i4.4221

Barkley, E. F., & Major, C. H. (2020). *Student engagement techniques: A handbook for college faculty*. HobokenJohn Wiley & Sons.

Bartlett, L., & Mogusu, E. (2013). Teachers' understandings and implementation of learner-centered pedagogy. In *Teaching in Tension* (pp. 61-74). 10.1007/978-94-6209-224-2_4

Bdiwi, R., de Runz, C., Faiz, S., & Ali-Cherif, A. (2019). Smart learning environment: Teacher's role in assessing classroom attention. *Research in Learning Technology*, *27*. https://doi.org/10.25304/rlt.v27.2072

Bisen, P. S., Debnath, M., & Prasad, G. B. (2012). *Microbes: concepts and applications*. John Wiley & Sons. https://doi.org/10.1002/9781118311912.index

Bremner, N. (2019). From learner-centred to learning-centred: Becoming a 'hybrid'practitioner. *International Journal of Educational Research*, *97*, 53-64. https://doi.org/10.1016/j.ijer.2019.06.012

Bryk, A. S., Greenberg, S., Bertani, A., Sebring, P., Tozer, S. E., & Knowles, T. (2023). *How a city learned to improve its schools*. Cambrdge, United States: Harvard Education Press.

Cicekci, M. A., & Sadik, F. (2019). Teachers' and Students' Opinions about Students' Attention Problems during the Lesson. *Journal of Education and Learning*, *8*(6), 15-30. https://doi.org/10.5539/jel.v8n6p15

Clement, I., Bello, M., & Sunusi, S. A. (2017). Science education and Nigeria national development effort: The missing link. *International Journal of Education and Evaluation*, *3*(5), 46-56. Retrieced from https://www.iiardjournals.org/get/IJEE/VOL.%203%20NO.%205%202017/SCIENCE%20EDUCATION.pdf on 09/04//2024

Dorji, P., Gyeltshen, C., Sanyasi, G. D., Sithub, P., Dema, T., & Choden, Y. (2020). The impact of early child care and development education on cognitive, psychomotor, and affective domains of learning. *Asian Journal of Education and Social Studies*, 29-38. https://doi.org/10.9734/ajess/2020/v12i130303

Doyle, T. (2023). *Helping students learn in a learner-centered environment: A guide to facilitating learning in higher education*. Abingdon: Taylor & Francis.

Du Plessis, E. (2020). Student teachers' perceptions, experiences, and challenges regarding learner-centred teaching. *South African Journal of Education*, *40*(1). https://doi.org/10.15700/saje.v40n1a1631

Einstein, A. (2023). Teaching students how to learn. *Educational Utopias*, *227*. Retrieved from https://assets.pubpub.org/11rd6fvz/31686042606406.pdf#page=239

Fang, W., Liu, Z., & Putra, A. R. S. (2022). Role of research and development in green economic growth through renewable energy development: empirical evidence from South Asia. *Renewable Energy*, *194*, 1142-1152. https://doi.org/10.1016/j.renene.2022.04.125

Filgona, J., Sakiyo, J., Gwany, D. M., & Okoronka, A. U. (2020). Motivation in learning. *Asian Journal of Education and social studies*, *10*(4), 16-37. : https://doi.org/10.9734/ajess/2020/v10i430273

Frago, R. L., & Janer, S. S. (2020). Effect of demonstration method and laboratory method in enhancing the conceptual understanding of grade ten (10) students in chemistry. *International Journal of Engineering Science and Computing*, *10*(5), 25784-25790. Retrieved from https://www.academia.edu/66541642/Effect_of_Demonstration_Method_and_Laboratory_Method_in_Enhancing_the_Conceptual_Understanding_of_Grade_Ten_10_Students_in_Chemistry on 12/04/2024

Giridharan, K., & Raju, R. (2016). Impact of teaching strategies: demonstration and lecture strategies and impact of teacher effect on academic achievement in engineering education. *International Journal of Educational Sciences*, *14*(3), 174-186. Retrieved from https://api.semanticscholar.org/CorpusID:158499431 on 04/03/2024

Gregory, C. K. K. (2008). *An investigation into microbiology students' understanding of microbes* (Doctoral dissertation, Durham University).

Havik, T., & Westergård, E. (2020). Do teachers matter? Students' perceptions of classroom interactions and student engagement. *Scandinavian journal of educational research*, *64*(4), 488-507. https://doi.org/10.1080/00313831.2019.1577754

Heim, A. B., & Holt, E. A. (2019). Benefits and challenges of instructing introductory biology course-based undergraduate research experiences (CUREs) as perceived by graduate teaching assistants. *CBE—Life Sciences Education*, *18*(3), ar43. https://doi.org/10.1187/cbe.18-09-0193

Hopkins, B. (2023). *The restorative classroom: Using restorative approaches to foster effective learning*. London: Routledge.

Hourigan, M., & Leavy, A. M. (2023). Elementary teachers' experience of engaging with teaching through problem solving using lesson study. *Mathematics Education Research Journal*, *35*(4), 901-927. https://doi.org/10.1007/s13394-022-00418-w

Huda, M., Taisin, J. N., Muhamad, M., Kiting, R., & Yusuf, R. A. (2023, December). Digital technology adoption for instruction aids: insight into teaching material content. In *International Conference on Information and Communication Technology for Competitive Strategies* (pp. 59-68). Singapore: Springer Nature Singapore.

Husna, S. M., & Adriani, F. (2023). Analysis of the Application and Correlation of the Murder Type Collaborative Learning Model on Student Learning Outcomes at Senior High School Jambi. *Journal Evaluation in Education (JEE)*, *4*(1), 21-30. https://doi.org/10.37251/jee.v4i1.293

Jiji. (2024). Microscope in Ghana. Retrieved from https://jiji.com.gh/302-microscopes on 02/03/2024

Jocz, J. A., Zhai, J., & Tan, A. L. (2014). Inquiry learning in the Singaporean context: Factors affecting student interest in school science. *International Journal of Science Education*, *36*(15), 2596-2618.

https://doi.org/10.1080/09500693.2014.908327

Kareem, O. S. (2019). *Effects of Demonstration and Project Methods of Teaching on Senior Secondary School Chemistry Students'Achievement In Minna Municipal, Niger State* (Doctoral dissertation, Federal University of Technology Minna, Niger State)

London, M., Sessa, V. I., & Shelley, L. A. (2023). Developing self-awareness: Learning processes for self-and interpersonal growth. *Annual Review of Organizational Psychology and Organizational Behavior*, *10*, 261-288. https://doi.org/10.1146/annurev-orgpsych-120920-044531

Mahapatro, B. (2021). *Human resource management*. New Delhi: New Age International (P) ltd..

Minta E. (2016). Instructional methods. [Unpublished manuscript]. Retrieved from https://mingycomputersgh.wordpress.com/2016/10/19/instructional-methods/ on 29/05/2024.

Mintii, M. M., Sharmanova, N. M., Mankuta, A. O., Palchevska, O. S., & Semerikov, S. O. (2023, October). Selection of pedagogical conditions for training STEM teachers to use augmented reality technologies in their work. In *Journal of Physics: Conference Series* (Vol. 2611, No. 1, p. 012022). IOP Publishing.

Mtitu, E. A. (2014). *Learner-centred teaching in Tanzania: Geography teachers' perceptions and experiences* (Doctoral dissertation, Open Access Te Herenga Waka-Victoria University of Wellington).

Muhammad, A. U., Bala, D., & Ladu, K. M. (2016). Effectiveness of Demonstration and Lecture Methods in Learning Concept in Economics among Secondary School Students in Borno State, Nigeria. *Journal of Education and Practice*, *7*(12), 51-59. Retrieved from https://files.eric.ed.gov/fulltext/EJ1099610.pdf on 12/04/2024

Muñoz-Restrepo, A., Ramirez, M., & Gaviria, S. (2020). Strategies to enhance or maintain motivation in learning a foreign language. *Profile Issues in TeachersProfessional Development*, *22*(1), 175-188. https://doi.org/10.15446/profile.v22n1.73733

Noor, N. A. M., Saim, N. M., Alias, R., & Rosli, S. H. (2020). Students' performance on cognitive, psychomotor and affective domain in the course outcome for embedded course. *Universal Journal of Educational Research*, *8*(8), 3469-3474. doi: 10.13189/ujer.2020.080821.

Olatunde-Aiyedun, T. G., & Ogunode, N. J. (2020). School administration and effective teaching methods in science education in north central nigeria. *Olatunde-Aiyedun, TG & Ogunode, NJ (2021). School Administration and effective teaching methods in Science Education in Nigeria. International Journal on Integrated Education*, *4*(2), 145-161. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3927799 on 06/04/2024

O'Leary, M. (2020). *Classroom observation: A guide to the effective observation of teaching and learning*. London: Routledge.

Ossei-Anto, T. A. (1999). Management and integration of science resources in Ghana's educational reform programme. *Journal of Educational Management*, *2*(2), 42-66. https://doi.org/10.47963/jem.v2i.370

Pangaribuan, B. W., Purba, N., Siahaan, K. W. A., Sidabutar, E. F., Sihombing, V. T., Simamora, D. F., & Matondang, J. R. (2022). The Implementation of Demonstration Method to Increase Learning Outcome in Natural Science Lessons. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *6*(4), 3680-3692. doi: 10.31004/obsesi.v6i4.1711

Piwowar-Sulej, K. (2021). Human resources development as an element of sustainable HRM–with the focus on production engineers. *Journal of Cleaner Production*, *278*, 124008. https://doi.org/10.1016/j.jclepro.2020.124008

Ponticorvo, M., Di Fuccio, R., Ferrara, F., Rega, A., & Miglino, O. (2019). Multisensory educational materials: five senses to learn. In *Methodologies and Intelligent Systems for Technology Enhanced Learning, 8th International Conference 8* (pp. 45-52). , Switzerland: Springer International Publishing.

Radło, M. J., & Tomeczek, A. F. (2022). Factors influencing labor productivity in modern economies: A review and qualitative text analysis. *WSEAS Transactions on Environment and Development*, *18*. doi: 10.37394/232015.2022.18.30

Rahayu, S. U. (2024). Improving Learning Outcomes of SD Negeri 4 Sembawa Students on Materials in Various Styles of Science Subjects Using Demonstration Methods. *PPSDP International Journal of Education*, *3*(1), 48-56. https://doi.org/10.59175/pijed.v3i1.187

Reich, J., Buttimer, C. J., Coleman, D., Colwell, R. D., Faruqi, F., & Larke, L. R. (2020, July 22). What's Lost, What's Left, What's Next: Lessons Learned from the Lived Experiences of Teachers during the 2020 Novel Coronavirus Pandemic. https://doi.org/10.35542/osf.io/8exp9

.

Saleh, H. (2023). Effects of Demonstration Method of Teaching on Students' Achievement in Building Construction in North East Technical Colleges. *International Journal of Innovative Social & Science Education Research*,

11(3):57-64. Retrieved from https://www.seahipublications.org/wp-content/uploads/2024/06/IJISSER-S-7-2023.pdf 04/202024.

Septiawan, A., & Nandiyanto, A. B. D. (2022). Learning the Five Senses of Humans in Children aged 11-15 Years through Digital-Based Media in LubukPandan Village. *Jurnal Nusantara Mengabdi*, *1*(3), 183-189. https://doi.org/10.35912/jnm.v1i3.1322

Shah Ph, D., & Kumar, R. (2020). Concepts of learner-centred teaching. *Shah, RK (2020). Concepts of Learner-Centred Teaching. Shanlax International Journal of Education*, *8*(3), 45-60. https://doi.org/10.34293/education.v8i3.2926

Smyth, D. S., Chen, S., Sompanya, G., Metz, M., & Conefrey, T. (2022). How Getting Friendly with Bacteria Can Promote Student Appreciation of Microbial Diversity and Their Civic Scientific Literacy. *Journal of Microbiology & Biology Education*, *23*(2), e00055-22. https://doi.org/10.1128/jmbe.00055-22

Stofkova, Z., & Sukalova, V. (2020). Sustainable development of human resources in globalization period. *Sustainability*, *12*(18), 7681. Retrieved from https://scholar.google.com/scholar?cluster=6793772907917665&hl=en&as_sdt=0,5 on 02/04/2023.

Suwannatrai, B. (2022). The perspective of 3 domains of learning: cognitive, psychomotor, and affective in english learning of higher education in Thailand. *NeuroQuantology*, *20*(22), 1963. doi:10.48047/nq.2022.20.22.NQ10184

Swanson, R. A. (2022). *Foundations of human resource development*. San Francisco: Berrett-Koehler Publishers.

Tordzro, G., Asamoah, E., & Ofori, K. N. (2021). Biology education in perspective: An inquiry into Ghanaian senior high school students' attitude towards Biology practical lessons. *Asian Research Journal of Arts & Social Sciences*, *15*(4), 82-94. doi:10.9734/arjass/2021/v15i430270

Ubulom, W. J., & Ogwunte, C. P. (2017). Evaluation of teacher-centered and learner-centered methods for instructional delivery of senior secondary schools financial accounting in Rivers State. *International Journal of Innovative Finance and Economics Research*, *5*(3), 81-88. Retrieved from https://scholar.google.com/scholar?cluster=18702374634424493 69&hl=en&as_sdt=0,5. On 05/05/2024.

Umara, R. (2022). The effectiveness of the demonstration method to improve student learning outcomes. *East Asian Journal of Multidisciplinary Research*, *1*(9), 1997-2006. doi: https://10.55927/eajmr.v1i9.1513

Wegner, C., & Schmiedebach, M. (2020). Interest in Biology: Grade-Dependent Differences and Benefits of Participating in Out-of-School Interventions. *International Journal of Research in Education and Science*, *6*(3), 427-434. Retrieved from https://eric.ed.gov/?id=EJ1258529 on 02/04/2024.

Wessner, D., Dupont, C., Charles, T., & Neufeld, J. (2020). *Microbiology*. Singapore: John Wiley & Sons.

Wilmot, A. M. (2024). Rural School Leadership and Digital Technologies: Understandings, Applications, Challenges, and Solutions. In *The Power of Technology in School Leadership during COVID-19: Insights from the Field* (pp. 77-104). Switzerland: Cham: Springer International Publishing.

Yamane, T. (1973). Statistics: An introductory analysis. Retrieved from https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Yamane%2C+Taro.+%281967%29.+Statistics%3A+An+Introductory+Analysis&btnG= on 12/05/2024.

Yoshida, F., Conti, G. J., Yamauchi, T., & Kawanishi, M. (2023). Learner-Centeredness vs. Teacher-Centeredness: How Are They Different?. *Journal of Education and Learning*, *12*(5), 1-12. https://doi.org/10.5539/jel.v12n5p1