
Impact of Science Process Approach on Secondary School Students' Academic Achievement and Retention in Physics

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Abstract

The study investigated the impact of science process approach on students' academic achievement and knowledge retention in Physics. It adopted the pretest-post-test non-equivalent quasi-experimental design with a sample of 80 students who offered Physics as one of their core subjects. A science process approach activity that works on strengthening basic science process skills was provided to students in the experimental group taught Physics concepts of friction using science process approach. These students were compared with control group, taught Physics concept of friction using the conventional teaching method. Two instruments; Physics Achievement Test (PAT) and Physics Knowledge Retention Test (PKRT) validated by three experts were used for data collection in the study. The instruments were pilot tested using Cronbach Coefficient Alpha with reliability indexes of 0.87 and 0.83 respectively which were considered good and reliable for the study. Descriptive statistics of mean, variance and standard deviation as well as inferential statistics of t-test were used in the data analysis. Findings revealed that students in the experimental group that used Science Process Approach showed greater academic achievement and knowledge retention than the control group that was taught using the conventional teaching method. The differences in gain scores in the experimental group were significant in the area of observing, communicating, classifying, measuring, inferring and predicting skills. This finding concludes that science process approach can boost academic achievement and enhance knowledge retention of science students in secondary schools; hence recommended for use in Science (Physics) classrooms.

Introduction

Science is the bedrock of engineering and technology that create modern world, and is crucial to the development of any society. Knowledge acquired through science and the subsequent applications equip humanity to subdue most natural challenges and enhance both technological and economic developments. Science as a practical subject provides students with an opportunity to interact with science process skills that can be used to solve problems in everyday life and contribute to national development.

Science process skills are activities, which students carry out in scientific investigations to enable the acquisition of scientific knowledge and skills. Science process skills enable students experience hands-on engagement with science materials which would help enhance students academic achievement.

Academic achievement according to Steinmayr, Meibner, Weidinger and Wirthwein (2014), is a measure of successful outcomes. The educators stressed further that academic achievement is generally perceived as a representation of performance outcome that indicates the extent to which a learner has accomplished specific goals that were the focus on activities of institutional environments. Explaining the importance of academic achievement as a key for successful development of young people in the society. Reiger (2011), observed that students who do well in school are better able to make the transition into adulthood and to achieve occupational and economic success, especially where the knowledge acquired is retained.

However, absorbing and retaining knowledge overtime has a strong link with the method of instruction (Growth Engineering, 2021). All instructional methods do not produce the same impact on achieving the content objectives. Physics remains one of the most challenging subjects for many students. Memorization of concepts is not enough like you can with other subjects. The learner really needs to understand it. As a discipline, Physics requires students to make use of variety of methods of teaching in order to make a successful outcome thereby achieving lesson objectives.

One of the most important objectives of the science curricula as opined by Yumusak, (2016) is to bring in science process skills. The science process skills are skills that lie under scientific thinking and decision-making. Thus it is important for a science curricula to be rationalized in such a way that it brings in science process skills. Science process skills are claimed to enable the individual improve their own life visions and give a scientific view/literacy as a standard of their understanding about the nature of science. The science process skills as opined by Yumusak, (2016), involve skills that requires more complex experiences such as the ability to observe the skills developed and utilized naturally even in our very early age, in addition to comparing the skills in data gathering, data interpretation and ability to hypothesize.

Science process skills are fundamental scientific method termed science process approach, which helps to achieve good knowledge of a subject matter; which in this case is Physics concepts. Science process skills can be categorized into two levels: basic and integrated. Learning SPS helps children to grow as individuals who can access knowledge and know how to acquire it. The primary outcomes of the scientific process in learning as opined by Hikmah, Yamtinah, Ashadi and Indriyanti, (2018) are the application of scientific processes, scientific reasoning, accurate knowledge, problem-solving, and understanding of the relationship between science, technology, society, and everyday life's events. Teachers' and students' understanding of science process skills is central to its application in a learning process of Physics concepts.

Science process skills are comprised of many skills groups from basic to complex. The basic science process skills are considered as the prerequisite of integrated science process skills; while the integrated science process skills may involve utilizing many basic level skill areas. According to Yildirim, Çalik, and Özmen (2016), the mostly recommended gradual approach called as basic process skills (e.g. observing, classifying, communicating, measuring, predicting, and inferring) and integrated process skills (i.e. controlling variables, formulating hypotheses, interpreting data, defining operationally, formulating hypotheses, interpreting data, defining operationally, experimenting and formulating models). Science process skills according to Feyzioglu, Demirdag, Akyildiz and Altun (2012) are claimed to enable individuals to improve their own life visions and give a scientific view/literacy as a standard of their understanding about the nature of science which is also applicable to Physics concepts.

Recent studies in teaching and learning undertakings have greatly focused on learner-centred methodologies (Renzaho, Twizeyimana, Dufitumukiza & Mujawimana, 2020; Twizeyimana, Renzaho, & Mujawimana, 2020) since most science classroom lessons have been dominated by the traditional or conventional teaching method. While considering improving knowledge retention in learners, Chinn (2017) opined that for many learners' knowledge gained through the conventional method of instruction can often prove hard to retain. This means that most learners who passed through such methods even those with the best effort fail to apply what they have learnt to real life situations which is largely due to lack of knowledge retention.

Several studies in the literature ((Addis & Powell-Coffman, 2018; Al-rabaani, 2014; Aydogdu, 2015; Feyzioglu et al. 2012; Hikmah et al. 2018; Nejla, 2016; Patonah, Nuvitalia & Saptaningrum, 2018; Rahayu, Yuliani & Wijaya, 2018; Rahardini, Suryadarma & Wilujeng, 2017; Ratnasari, Sukarmin, Suparmi & Aminah, 2017; Setiyo, Mohamad, Fatchur & Muhana, 2017; Susanti, Anwar & Ermayanti, 2018; Yildirim et al. 2016; Yumusak, 2016; Zeidan & Jayosi, 2015) had carried out empirical researches on related areas on science process skills. But, there still exist a gap on the impact of science process approach on students' academic achievement and retention in physics; which was filled by the present study.

Science process approach (SPA) is important for teaching science subjects in schools since it contributes to the understanding of abstract concepts in science, which would remain implicit if taught theoretically. The practical activities carried out by students in science class as opined by Abungu, Okere and Wachanga, (2014); motivate and prepare them for the pursuit of science related courses at higher levels. The science process skills investigated in this study using SPA were observing, communicating, classifying, measuring, and predicting.

Science process approach is student-activity centred which could help in reducing rote learning and students' interest, performance and knowledge retention in Physics is still not satisfactory. Educationalists attribute this failure to method of instruction used in teaching the subject. Hence Physics remains to be one of the most challenging subjects for many students. The traditional method of teaching science can only offer memorization of concepts which is not enough for in-depth understanding and knowledge retention overtime. This gives rise to lack of knowledge recall and low academic performance. As a discipline Physics requires students to make use of variety of methods of understanding in order to make a successful outcome. The problem of low performance and knowledge retention in Physics needs to be tackled by providing the students with educational activities that work on strengthening the acquisition of basic science process skills. The purpose of the study therefore, is to investigate the impact of science process approach on secondary school students' academic achievement and knowledge retention in Physics on the concept of friction.

In order to guide the study the following research questions were raised and answered:

1. What are students pre-test mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach?
2. What are students post-test mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach?
3. What are students post-test mean retention scores taught concept of friction in Physics using conventional teaching method and Science process approach?

To also guide the study the following hypotheses were tested at 0.05 level of significance:

H₀₁ There is no significant difference between students' pre-test mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach.

H₀₂ There is no significant difference between students' post-test mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach.

H0₃ There is no significant difference between students' post-test mean retention scores taught concept of friction in Physics using conventional teaching method and Science process approach.

Methodology

The study adopted the pretest-post-test non-equivalent group quasi-experimental design. A non equivalent group design is a between subjects design in which participants have not been randomly assigned to conditions. The rationale for employing this design is its aim to establish a cause-and-effect relationship between an independent and dependent variables (Thomas, 2020).

The target population is one hundred and fifty (150) students who study natural sciences in selected secondary schools in Bali education zone, Taraba State. Sample of eighty (80) students from two intact classes from two who study Physics as one of their core subjects were randomly selected from the target population. The students were grouped into control and experimental groups; that used conventional teaching method and science process approach respectively.

Two instruments; Physics Achievement Test (PAT) and Physics Knowledge Retention Test (PKRT) validated by three experts were used for data collection in the study. The instruments were pilot tested using Cronbach Coefficient Alpha with reliability indexes of 0.87 and 0.83 respectively which were considered good and reliable for the study. Each of the instruments contains fifteen (15) multiple choice and five (5) short answer-type, item questions carefully compiled from WAEC and NECO past question papers.

The topic discussed is concept of friction. At the beginning, pretest was administered to both students in control group and experimental group to determine the equivalent level. There after the control group was taught using the conventional teaching method (CTM). While the experimental group students were separated and taught using the science process approach (SPA). The Physics achievement test instrument was then applied to assess both the control group and the experimental group post-test level of achievement respectively. Two weeks after the treatment, the Physics achievement test questions were reshuffled and administered to both groups as Physics knowledge retention test. And the mean scores of the student groups were recorded and analyzed as well.

Data collected were analyzed using both descriptive and inferential statistics. Descriptive statistics include mean, variance and standard deviation. While inferential statistics is the t-test. These measures were used to analyze research questions 1, 2 and 3. On the other hand, the t-test statistics was used to verify null hypotheses (H₀) 1, 2 and 3. In the decision rule, any mean score above 2.50 shall be accepted, otherwise rejected. For t-test, if t-calculated < (less than) t-tabulated, H₀ is accepted. But, if t-calculated > (greater than) t-tabulated, H₀ is rejected.

Results

Answering Question 1: What are students pretest mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach?

Table 1: Mean Achievement Scores of Students' pre-test in Physics on the Concept of Friction in Control and experimental group

S/N	PROCESS SKILLS	CONTROL GROUP (CTM)			EXPERIMENTAL GROUP (SPA)		
		\bar{X}	V	SD	\bar{X}	V	SD
1.	Observing	2.88	3.45	1.85	2.72	3.21	1.79
2.	Communicating	2.77	3.30	1.74	2.62	3.12	1.76
3.	Classifying	2.68	3.15	1.77	2.60	3.09	1.75
4.	Measuring	2.55	3.05	1.75	2.54	3.04	1.74
5.	Inferring	2.53	3.03	1.74	2.50	3.01	1.73
6.	Predicting	2.50	3.01	1.73	2.50	3.01	1.73
	Weighted Score	2.65	3.17	1.76	2.58	3.07	1.75

The analysis of the control group and the experimental group mean score, variance and standard deviation level of achievement in the pre-test is presented in Table 1. Control group scored ($x=2.88$) on Observing skill, ($x=2.77$) in communicating skill, ($x=2.68$) in classifying skill, ($x=2.55$) in measuring skill, ($x=2.53$) in reference skill and ($x=2.50$) in prediction skill. While the experimental group as well scored ($x=2.72$), in observing skill, ($x=2.62$) in communicating skill,, ($x=2.60$) in classifying skill, ($x=2.54$) in measuring skill, ($x=2.50$) in inferring and ($x=2.50$) in predicting skill.

Answering Question 2: What are students post test mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach?

Table 2: Mean Achievement Scores of Students' Post-test in Physics on Concept of Friction in Control and experimental group

S/N PROCESS SKILLS	CONTROL GROUP			EXPERIMENTAL GROUP		
	\bar{X}	V	SD	\bar{X}	V	SD
1. Observing	2.90	3.51	1.87	6.01	8.11	2.84
2. Communicating	2.79	3.35	1.83	5.54	7.23	2.69
3. Classifying	2.71	3.20	1.79	5.32	7.20	2.68
4. Measuring	2.68	3.15	1.77	5.24	7.17	2.67
5. Inferring	2.60	3.09	1.75	5.05	7.09	2.66
6. Predicting	2.55	3.05	1.74	4.85	6.04	2.45
Weighted Score	2.71	3.23	1.79	5.34	7.14	2.67

The analysis of the control group and the experimental group mean score, variance and standard deviation level of achievement in the post-test is presented in Table 2. Control group scored ($x=2.90$) in observing skill, ($x=2.79$) in communicating skill, ($x=2.71$) in classifying skill, ($x=2.68$) in measuring skill, ($x=2.60$) in inferring and ($x=2.55$) in predicting skill. Whereas the experimental group scored ($x=6.01$) in observing skill, ($x=5.54$) in communicating skill, ($x=5.32$) in classifying, ($x=5.24$) in measuring skill, ($x=5.05$) in inferring skill and ($x=4.85$) in predicting skill.

Answering Question 3: What are students post-test mean retention scores taught concept of friction in Physics using conventional teaching method and Science process approach?

Table 3: Mean Retention Scores of Students' Posttest in Physics on Concept of Friction in Control and experimental group

S/N PROCESS SKILLS	CONTROL GROUP			EXPERIMENTAL GROUP		
	\bar{X}	V	SD	\bar{X}	V	SD
1. Observing	2.68	3.15	1.77	5.46	7.20	2.68
2. Communicating	2.60	3.09	1.75	5.34	7.15	2.67
3. Classifying	2.45	3.00	1.73	5.28	7.09	2.66
4. Measuring	1.50	2.95	1.71	5.20	7.00	2.64
5. Inferring	1.36	2.80	1.67	5.12	6.55	2.55
6. Predicting	1.20	2.53	1.59	4.16	6.01	2.45
Weighted Score	1.96	2.92	1.70	5.09	6.83	2.61

The analysis of the control group and the experimental group mean score, variance and standard deviation of the extent of knowledge retention post-test test in Physics on concept of friction in presented in the table 3. The control group retained ($x=2.68$) of the observing skill, ($x=2.60$) of the communicating skill, ($x=2.45$) of the classifying skill, ($x=1.50$) of the measuring skill, ($x=1.36$) of the inference skill and ($x=1.20$) of the prediction skill. On the other hand, the experimental group maintained ($x=5.46$), of the observing skill, ($x=5.34$) of the communicating skill, ($x=5.28$) of the classifying skill ($x=5.20$) of the measuring skill, ($x=5.12$) of the inference skill and ($x=4.16$) of the prediction skill.

Testing Hypothesis 1

H₀: There is no significant difference between students' pretest mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach.

Table 4: t-test Analysis of the Control Group and the experimental group Pretest Level of achievement in Physics on Concept of Friction

Group	N	\bar{X}	Df	t-cal	t-tab	Decision
Control (CTM)	40	2.65	39	0.07	1.85	Accepted
Experimental (SPA)	40	2.58				

Table 5, showed that the $t\text{-cal} = 0.07$, $df = (40-1) = 39$, $\alpha\text{ level} = 0.05$, $t\text{-tab} (39:0.05) = 1.85$. Since, $t\text{-cal}$ value (0.07) is < (less than) $t\text{-tab}$ value (1.85), the null hypothesis (H_0) is

accepted. This implies that there is no significant difference between the pre-test level of students achievement in Physics concepts in the experimental and control group; in favour of the experimental group taught using Science process approach.

Testing Hypothesis 2

H0₂: There is no significant difference between students' post test mean achievement scores taught concept of friction in Physics using conventional teaching method and Science process approach.

Table 5: t-test Analysis of the Control and experimental group Post-test Level of achievement in Physics on Concept of Friction

Group	N	X	Df	t-cal	t-tab	Decision
Control (CTM)	40	2.71	39	2.63	1.91	Rejected
Experimental (SPA)	40	5.34				

Table 7, showed that the $t\text{-cal} = 2.63$, $df = (40-1) = 39$, α level = 0.05, $t\text{-tab} (39:0.05) = 1.91$. Since, $t\text{-cal}$ value (2.63) is > (greater than) $t\text{-tab}$ value (1.91), the null hypothesis (H0₂) is rejected. This implies that there is a significant difference between the post-test level of students achievement in Physics concepts in the experimental and control group; in favour of the experimental group taught using Science process approach.

Testing Hypothesis 3

H0₃: There is no significant difference between students' post-test mean retention scores taught concept of friction in Physics using conventional teaching method and Science process approach.

Table 6: t-test Analysis of the Control and the experimental group post-test test knowledge Retention in Physics on Concept of Friction.

Group	N	X	Df	t-cal	t-tab	Decision
Control (CTM)	40	1.96	39	3.63	1.98	Rejected
Experiment (SPA)	40	5.09				

Table 9, showed that the $t\text{-cal} = 3.13$, $Df = (40-1) = 39$, α level = 0.05, $t\text{-tab} (39:0.05) = 1.98$. Since, $t\text{-cal}$ value (3.13) is . (greater than) $t\text{-tab}$ value (1.98), the null hypothesis (H0₃) is rejected. This implies that there is a significant difference between the post-test level of students

retention in Physics concepts in the experimental and control group; in favour of the experimental group taught using Science process approach.

Discussion of Findings

In the pretest on the process skills of observing, communicating, classifying, measuring, inferring and predicting, both control group and experimental group of student's level of achievement was obtained. Even though the control group seems to perform better than the experimental group as revealed by their mean scores of ($X=2.65$) and (2.58) in both groups respectively. This implied that there is no significant difference between the control group and the experimental group, student's level of achievement in the pretest in Physics on concept of friction. Hence the null hypothesis (H_{01}) is accepted to be true. This suggest that, at first when both groups have not been separated for treatment, there was little or difference in their science process skills of observing, communicating, classifying, measuring, inferring and predicting in Physics on concept of friction. This is in consonance with Nejlá, (2016) who revealed that teachers are more successful in identifying skills of observing, predicting, experimenting, and inference than other skills.

The post-test on the science process skills of observing, communicating, classifying, measuring, inferring and predicting, the level of achievement of the experimental group students is much higher ($X=5.34$) than that of the control group students ($X=2.71$). As a result, the null hypothesis (H_{02}) is rejected because there is a significant difference between the control group and the experimental group mean scores. This is reflected in the t-calculated value (2.63) which is greater than the tabulated or critical value (1.91). This reasonable difference in the level of achievement between the control group and the experimental group might have arose as a result of treatment administered to the experimental group.

While the control group students were taught using the conventional teaching method. The experimental group students were taught using science process approach. But it is, observed from the analysis of the pretest result, that the level of achievement of both groups seem the same, a little mark above (2.50) acceptable mean score. Nevertheless, after the experimental group was taught with the science process approach the was high gain score. The gain scores was significant in the area of observing, communicating, classifying, measuring, inferring and predicting skills. This implies that science process approach in this study has more positive impact on the students academic achievement than the conventional teaching method. The finding supports Abungu et al. (2014) and Muhammad and Sabiru, (2016) who revealed that the students exposed to science process skills approach, achieved significantly better than their counterparts exposed to lecture method of instruction. The findings also supports Obochi and Samuel, (2018) who revealed that laboratory activities should be used consistently in teaching science as it enhances achievement and science process skills acquisition.

The analysis of the post-test, test result of the groups' extent of knowledge retention revealed that, the mean score of the control group is ($X=1.96$). While the mean score of the experimental group is ($X=5.09$). Also the calculated value (3.13) is greater than the critical value (1.98). Hence, the null hypothesis (H_0) is rejected. Indicating that there is a significant difference between both groups extent of knowledge retention. Suggesting that the experimental group had a mean score gain of ($X=3.59$) as a result of the science process approach. It implies that the science process approach has greater impact on the students' knowledge retention in the areas of observing communicating, classifying, measuring, inferring and predicting skills than the conventional teaching method. This supports findings by Chinn, (2017), Lloyd and Bahr (2020), and Obochi and Samuel, (2018) who revealed that laboratory activities should be used consistently in teaching science as it enhances students' retention and science process skills acquisition.

Conclusion

Based on the findings, the study concludes that science process approach has high impact on secondary school students' academic achievement and retention on concept of friction in physics, in Bali education zone Taraba State. This also substantiates that science process approach has a positive impact on students' achievement and knowledge retention in Physics in the areas of observing, communicating, classifying, measuring, inferring and predicting skills.

Recommendations

Based on the findings and conclusions drawn, the following recommendations are made:

1. Teachers of Physics should be trained on the use of science process approach since it has high impact on secondary school students' academic achievement and retention on concept of friction.
2. Teachers of physics, should engage in laboratory experiment that help promotes students acquisition of science process skills such as observing, communicating, classifying, measuring, inferring and predicting skills.
3. Curriculum developers should also increase the number of science activities in Physics curriculum that promotes students' acquisition of science process skills.

References

- Abungu, H.E.; Okere, M.I.O. & Wachanga, S.W. (2014). The Effect of Science Process Skills Teaching Approach on Secondary School Students' Achievement in Chemistry in Nyando District, Kenya. *Journal of Educational and Social Research*, 4 (6), 359-372.
- Addis, E.A.; Powell-Coffman, J.A. (2018). Student and Faculty Views on Process of Science Skills at a Large, Research-Intensive University. *Journal of College Science Teaching*, 47 (4), 72-82.

- Al-rabaani, A. (2014). The Acquisition of Science Process Skills by Omani's Pre-Service Social Studies' Teachers. *European Journal of Educational Studies*, 6(1),13-19.
- Aydogdu, B. (2015). [The Investigation of Science Process Skills of Science Teachers in Terms of Some Variables](#). *Educational Research and Reviews*, 10 (5), 582-594.
- Chinn, K.A. (2017). Improving Knowledge Retention in Learners. Learning and Development, Retrieved February 10, 2021 from [goi.com/blog/post.Knowledge.retention](http://goi.com/blog/post/Knowledge.retention).
- Feyzioglu, B.; Demirdag, B.; Akyildiz, M. & Altun, E. (2012). [Developing a Science Process Skillstest for secondary students: Validity and reliability study](#). *Educational Sciences: Theory and Practice*, 12 (3),1899-1906.
- Growth Engineering (2021). Knowledge Retention. Retrieved February 10,2021 from growthengineering.co.uk/5-great-knowledge-retention-tips.
- Hikmah, N.; Yamtinah, S.; Ashadi, M.; Indriyanti, N.Y. (2018). Chemistry teachers' understanding of science process skills in relation of science process skills assessment in chemistry learning. *Journal of Physics: Conference Series*, 1022 (1), id. 012038.
- Lloyd, M. & Bahr, N. (2020). Thinking Critically About Critical Thinking in Higher Education. *International Journal for the Scholarship of Teaching and Learning*, 492, P55-66.
- Muhammad, B.A. & Sabiru, D.Y. (2016). Effects of Science Process Skills Approach and Lecture Method on Academic Achievement of Pre-Service Chemistry Teachers in Kaduna State, Nigeria. *ATBU, Journal of Science, Technology & Education (JOSTE)*, 4 (2), 68-72.
- Nejla, G. (2016). High School Science Teachers' Views on Science Process Skills. *International Journal of Environmental & Science Education*, 11(5), 779-800.
- Obochi, M.U. & Samuel, E. (2018). Impact of Laboratory activities and acquisition of process skills on attitude and academic performance in science among Senior Secondary School Students in Zaria, Kaduna State. *ATBU, Journal of Science, Technology & Education (JOSTE)*, 6 (4), 20-27.
- Patonah, S.; Nuvitalia, D. & Saptaningrum, E. (2018). [Content analysis of science material in junior school-based inquiry and science process skills](#). *Journal of Physics: Conference Series*, 983(1). DOI: [10.1088/1742-6596/983/1/012167](https://doi.org/10.1088/1742-6596/983/1/012167).
- Rahardini, R.R.B.; Suryadarma, I.G.P. & Wilujeng, I. (2017). [The effect of science learning integrated with local potential to improve science process skills](#). AIP Conference Proceedings, 1868 (1), id.080008.
- Rahayu, Y.S.; Yuliani, Y. & Wijaya, B.R. (2018). [Implementation of science process skills using ICT-based approach to facilitate student lifeskills](#). *IOP Conference Series: Materials Science and Engineering*, 296 (1),012-035.

- Ratnasari, D.; Sukarmin, S.; Suparmi, S. & Aminah, N.S. (2017). [Students Conception on Heat and Temperature toward Science Process Skill](#). *Journal of Physics: Conference Series*, 895, (1), 12-044.
- Regier, J. (2021). Why is Academic Success Important? Saskatchewan School Board Association? Retrieved on February 14, 2021 from saskschoolboards. Ca/wp-content/uploads/2015/08/20115/ast.pdf
- Renzaho, A.; Twizeyimana, E.; Dufitumukiza, B., & Mujawimana, E. (2020). Cooperative learning approach: a learner-centred methodology for alleviating the non-representational nature of science education among learners of secondary schools in Rwanda. *Journal of Global Research in Education and Social Science*, 14(2), 45-56.
- Setiyo, P.; Mohamad A.; Fatchur, R. & Muhana, G. (2017). The Usage of Recycle Materials for Science Practicum: Is There Any Effect on Science Process Skills? *International Journal of Evaluation and Research in Education (IJERE)*, 6 (1),1-8.
- Steinmayr, R.; Meibner, A.; Weidinger, A.F. & Wirthwein, L. (2014). Academic Achievement. Oxford Bibliographies in Education. Retrieved February 15th, 2021 from doi:10.1093/obo/9780/199756810-0108.
- Susanti, R.; Anwar, Y. & Ermayanti, E. (2018). [Profile of science process skills of Preservice Biology Teacher in General Biology Course](#). *Journal of Physics: Conference Series*, 1006, (1), article id. 012003.
- Thomas, L. (2020). An introduction to quasi-experimental design. The Scriber. Published on July, 2020. Revised on March, 2021 from: <https://www.scribbr.com/methodology/quasi-experimental-design/>.
- Twahirwa1, J.N. & Twizeyimana, E.T. (2020). Effectiveness of Practical Work in Physics on Academic Performance among Learners at the selected secondary school in Rwanda. *African Journal of Educational Studies in Mathematics and Sciences*, 16 (2), 97-10.
- Yildirim, M.; Çalik, M. & Özmen, H. (2016). A Meta-Synthesis of Turkish Studies in Science Process skills. *International Journal of Environmental & Science Education*, 11(14), 6518-6539.
- Yumusak, G.K. (2016). [Science Process Skills in Science Curricula Applied in Turkey](#). *Journal of Education and Practice*, 7(20), 94-98. www.iiste.org
- Zeidan, A. H. & Jayosi, M. R. (2015). Science Process Skills and Attitudes toward Science among Palestinian Secondary School Students. *World Journal of Education*, 5, (1) 2015.