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# To Establish Instructional Strategies that Supports Integration of Investigative Experiments on the Acquisition of Science Process Skills among Physics Learners in Secondary Schools in Tharaka Nithi County, Kenya

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**Abstract:- There is growing consensus on the integration of investigative experiments in teaching and learning of science subjects, but the implementation of this pedagogical practice continues to challenge many teachers. Investigative Laboratory Instruction is a collaborative process that involves the teacher helping the learners to attain specific skills, knowledge and scientific concepts. The study utilized Quasi-experimental Pretest-Posttest Design. The study sampled 4 sub- county schools, 120 form two physics learners and twenty physics teachers. Purposive sampling was used to select three physics teachers and three schools that were used for the pilot study. The learners who participated in the study were selected using simple random sampling. Physics Teachers Questionnaire, Interviews for Physics Teachers, Lesson Observation Guide and Physics Teacher's Logbook were used as research instruments. Quantitative data was analyzed using descriptive (means and frequencies) and inferential statistics (Wilxon test and Kruskal Walis test) in order to develop the expected conclusions. The study found out that most schools relied on group and individual activities to implement investigative instruction learning in physics lessons. Educators among them teachers adapt approaches which create an environment that is conducive and suit the needs of the students in their classes. Based on the findings of the study, it was found out that learners engaged in individual activities, group activities, and teacher demonstration every week at least once. According to the findings, the teachers were found to occasionally implement Investigative Experiments hence there was need for increase in frequency with which the investigative experiments were provided.**

***Keywords:-*** *Investigative Laboratory Instruction, Quasi-Experimental Pretest- Posttest Design, Teacher Demonstrations.*

## I. INTRODUCTION

➢ *Background Information*

Investigative Laboratory Instruction is a collaborative process that involves the teacher helping the learners to attain specific skills, knowledge and scientific concepts. The teacher becomes a clarifier rather than the instructor (pragana, Braganca, Silva & Martins, 2021). The teacher encourages learners to engage with the concepts and they contribute in undertaking the investigations together (Girase, Shanawaz, Jou, & Vaidyanathan, 2022). Key aspects of the supportive strategy for investigative experiments are discussed in the subheadings below. A study by Hosseini, Hytonen & Kinnunen (2021) designed a TPACK (Technological, Pedagogical, Content and Knowledge) model.

Problem-solving is among the most important skills that are essential for the 21$^{st}$ century. It has been considered as being very effective in teaching and learning of physics for instigating deeper conceptual understanding (Chen, Li-ting & Leping-Liu, 2019). Problem-solving requires the physics teacher to use his/her knowledge and experiences in order to address a particular problem in investigative experiments. When the teacher does not master effective problem-solving techniques, then the learners will have computational errors when analyzing the data obtained from investigative practical tasks (Syafril, Latifah, Engkizar, Damri, Asril & Yaumas, 2021).

A study published by Lucas and Lewis (2019) on secondary school physics, learner's ability on solving physics problems from the laboratory investigations. The study found out that learners who had higher problem-solving abilities were able to organize scientific knowledge more than the learners with lower problem-solving abilities in physics. The study involved 12 high ability problem-solving learners and 12 low ability problem solving learners. The study found out that high ability problem solving learners had a higher

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understanding of scientific concepts during laboratory investigative activities.

Another study by Fidan & Tuncel (2019), evaluated the strategies of physics learners in solving problems obtained from laboratory investigative practical data. The study found out those learners with deeper understanding of problem-solving used different strategies in solving problems in physics.

Shaklman & Barak (2019) also investigated the effects of cooperation in problem-solving among physics learners' problem-solving capabilities as well as on attitude, gender and strategy used. The findings showed that the experimental group had positive and significant impact on attitude, achievement and strategy use. Djudin , (2023) went further in an experimental study to establish the effects of male and female on the outcomes of cooperative groups of physics high school learners and their academic achievement in physics. The experimental group was given an achievement test as a pre-posttest. The study found out that gender factor has no effect on the effectiveness of problem-solving strategy on physics learners. The research studies carried out on problem solving does not factor in the effect of the teaching strategies on the acquisition of Science Process Skills (Shaheen & Pradhan, 2019).

According to the study by Ugwoke et al (2020) on the effectiveness of GDIS found that learners who were exposed to GDIS registered improved academic performance as opposed to those who were only exposed to problem-solving and peer-led team learning. The study further points out that the learners exposed to GDIS attains HOT skills and the teachers and learners experiences a pleasant environment. Beichumila, Bahati and Kafanabo (2022) also participated in the same study on the effectiveness GDIS in teaching of science subjects among high school learners. The study found out that GDIS empowers the learners to have confidence and enhances critical thinking skills (Taiwo, 2022).

Adetunji & Tajudeen, (2020) carried out a comparative research study with high school chemistry learners on academic achievement when using GDIS and conventional methods on the topic of the rate of reactions. The study found out that learners performed poorly (mean score 23.7%) when conventional methods were used for teaching learners in science subjects. The experimental group of learners was exposed to GDIS on the same topic and the performance of the learners improved (54.3% mean score). The same study points out that the learners posted higher understanding of scientific concepts.

A similar study informs South Africa by Kibirige & Maake (2021) was undertaken with grade 9 high school learners on the topic of chemical reactions. The study found out that learners understood the concepts when GDIS was used and both teachers and learners posted higher level of confidence. Due to low academic achievement of learners in Limpopo province in South Africa, the study sought to investigate the critical factors associated this poor performance in science subjects. The study found out that non-completion of the syllabus, teaching strategies, lack of laboratory investigations and low content knowledge were the key factors

Njoka & Julius (2021) undertook a similar study on the academic achievement of high school learners in science subjects in KCSE. This was one of the case studies that were carried out in Embu District in Eastern Province in Kenya. The study found out those factors such as learners absenteeism, insufficient resources, peer pressure and physical facilities affected performance. The studies in South Africa and Kenya on low academic performance in science subjects point out that the low academic achievement may be attributed to the instruction used by the teacher. This study therefore picks from that point in order to determine whether Investigative Experiments can be the solution to the poor performance in physics through the acquisition of Science Process Skills.

According to a research study carried out in high schools in India, it concluded that learners understood abstract concepts more effectively when they were presented in CSSTL than when conventional strategies are used in teaching and learning (Kibirige & Tsamago, 2019). The results also indicated that learners are able to understand concepts in science more effectively and their motivation for learning science subjects is also boosted.

Several studies have been done that emphasize on the use of CSSTL in teaching science subjects. One of those studies was carried out by Celik (2022) on how to teach science subjects while using CSSTL in Secondary schools in Zambia. This study tried to explore on how physics learners can understand concepts on atomic physics and radioactivity while using computer simulations apart from using lecture method of instruction. The study found out that the learners' computer ratio in high schools is 143:1 hence making it difficult to use CSSTL as a tool for learning of science subjects in Zambian high schools. When the results for the treatment and control group were analyzed, it was found that the mean score for the treatment group ($E_{post\text{-}test}$ = 66.60%) was higher than that of the control group ($C_{post\text{-}test}$ = 45.68%). It was evident from these findings that integrating computer simulations and videos in teaching and learning of physics enhances academic achievement. Magen-Nagar & Firster (2019) point out that use of digital technology in teaching of physics while using computer simulations has greatly contributed to deeper understanding of concepts in physics.

In another study by Ayasrah, Alarabi, Mansouri, Fattah & Alsaid (2024) on science teachers' computer competencies in Kenyan secondary schools, evaluated the application of such in the classroom. The study found that science teachers had low computer competencies hence hindering the effective use of CSSTL. The study further point out that CSSTL is a necessary tool for classroom instruction and for laboratory investigations (Julius, 2018). Aabergsjo, (2022) further explains that unlike laboratory hands on experiments that take two hours for completion, CSSTL experiments take about only forty minutes for completion. Ayasrah, et al., (2024) support the findings of Beichumila et al., (2022) and further

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says that CSSTL changes the learners' negative attitude towards science subjects and also help them in acquisition of content and procedural knowledge in addition to acquisition of Science Process Skills (Ugwoke, et al., 2017).Considering the findings of Lucas & Lewis, (2019) this study sought to determine the strategies used by physics teachers that utilize Investigative Experiments and how they expose the learners to acquisition of Science Process Skills.

## II. STATEMENT OF THE PROBLEM

Science subjects are critical in the academic achievement of high school students and consequently in their career growth because they act as a pre-requisite for technological and industrial development. However, there has been persistent low KCSE academic achievement in physics at national and county levels attributed to the use of conventional instructional methods. The Ministry of Education in Kenya has come up with many interventional strategies that are geared towards improving the academic achievement of learners in KCSE. Some of the strategies include ensuring that the teachers handling STEM subjects are qualified, providing schools with the necessary science laboratory equipments and construction of laboratories. Despite these interventions, the performance of learners in physics in high schools has still been declining. The low achievement in physics (see table 1.1) is very evident in Tharaka Nithi County, Kenya. The “topic Hookes' Law” is one of the topics in physics that has been frequently examined all through the years and has persistently registered poor results

- *Objectives of Study*

To establish instructional strategies that supports Integration of Investigative Experiments on the acquisition of Science Process Skills among physics learners in secondary schools in Tharaka Nithi County, Kenya.

- *Research Question*

What are some of the strategies that are utilized by physics teachers in the implementation of Investigative Experiments for acquisition of Science Process Skills among learners of physics in secondary schools?

## III. METHODOLOGY

A mixed-method approach is considered for this study because of the qualitative and quantitative nature of the data that will be generated. This emphasizes objective measurements and the statistical, mathematical, or numerical analysis of data collected through questionnaires.

The sample population targeted 236 physics teachers from the 135 public secondary schools from Tharaka Nithi County. 24 physics teachers were selected purposefully from the sampled schools that comprised 10.17% of the targeted population of the teachers.

Research instruments that were used to collect data on strategies that physics teachers use include physics questionnaires, lesson observation guide, interviews and log books. The questionnaires contain open-ended questions, which provided the physics teachers with the opportunity to present their views and opinions concerning the Investigative Experiments and the efficacy of the instructional materials used in the intervention. Lesson Observation Guide entailed observing teachers in the experimental group as they facilitated physics leaners on how to devise experiments, how to work on their own, how to solve practical problems and how to analyze and interpret the data obtained from the experiments. According to Xerri, (2018) interviews allow researchers to probe further in order to attain more detailed information from the respondents each of the physics teachers in the sampled schools will be interviewed. The researcher was guided by the interview schedule that contained open-ended questions. The data obtained from the physics teachers' logbooks was used to establish the frequency of the Investigative Experiments and the teachers' experiences concerning the integration of the Investigative Experiments for teaching physics.

The data obtained in this study was both quantitative and qualitative. The quantitative data was analyzed using both descriptive and inferential statistics. Responses from interviews and logbooks were analyzed using inductive analysis while physics practical lesson observations were analyzed using summation and categorization of responses.

## IV. RESULTS AND DISCUSSIONS

This section deals with the results on teachers' utilization of strategies that use Investigative Experiments that helps physics learners in the acquisition of Science Process Skills. The results below explore the different strategies that this study employed in enhancing efficacy and efficiency with which the learning outcomes are achieved by learners from Tharaka-Nithi County schools in investigative practical based activities in physics.

### *A. Practical Activities Mostly Used by Physics Teachers*

The schools mostly relied on group and individual activities to implement investigative instruction learning in physics lessons. Educators among them teachers adapt approaches which create an environment that is conducive and suit the needs of the students in their classes (Bodner & Elmas, 2020). In the recent educational researches, researchers have continuously encouraged the use of student-centered instructional techniques that involve an inquiry-based technique to help learners remain active. Investigations which promote maximum peer-peer interactions and instructor guidance result in more effective learning.

Apart from the group and individual student activities, the teachers employed other activities such as project and teacher demonstrated activities. Research shows that adoption of inquiry-based approaches which promote interactions with either peers or teachers promote the mutual exchange of experiences and concept explanations. These

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methods create active learning environments that promote the academic achievement of students.

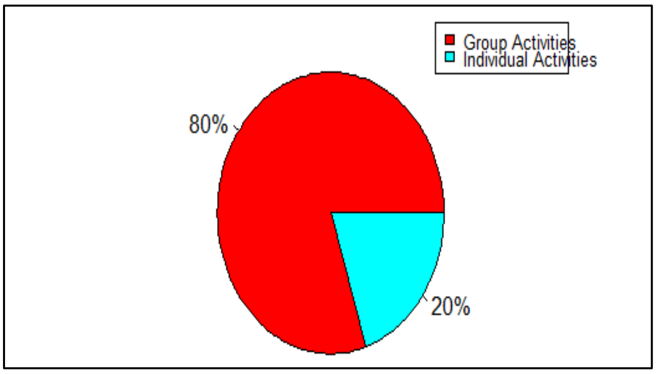


Fig 1: Distribution of Practical Activities used by Physic Teachers

Table 1 below shows the frequency at which inquiry based strategies are utilized by different schools in conducting the investigative instruction lessons for physics learners.

Exploring the level of student engagement in investigative instruction activities was important for this study because of the role it has in successful teaching and learning process. The continuous quest to transition from traditional teaching methods to modern approach has led to embracing of student engagement in inquiry-based instruction to promote learning experiences. The results are in Table 1 below.

Table 1: Learners' Engagement in Investigative Laboratory Instruction Activities

| Activity | Never | Sometimes | Most Times | Always |
|---|---|---|---|---|
| I allow learners to perform the practical in small groups | 0(0%) | 0(0%) | 3(75%) | 1(25%) |
| The learners are allowed to design their own procedures | 2(50%) | 2(50%) | 0(0%) | 0(0%) |
| The teacher gives the experimental procedures | 0(0%) | 0(0%) | 1(25%) | 3(75%) |
| The students are provided with the materials needed for the experiments | 0(0%) | 1(25%) | 0(0%) | 3(75%) |
| The students were encouraged to embrace self-discoveries by the teacher | 0(0%) | 2(50%) | 0(0%) | 2(50%) |

Results in Table 1 show that teachers from the four schools allow learners to perform the practical in small groups most times (75%) and always (25%). Two of the schools (50%) showed that learners are not allowed (50%) to generate procedures on their own. However, the remaining two indicated that they sometimes (50%) engage students in designing of their own procedures. The experimental procedures among the students are common as indicated by 25% and 75% as most times and always, respectively. The materials need for the experiments are always provided to the students in three of the schools (75%) with the remaining one school reporting to sometimes (25%) provide the required materials for the experiments. Half of the schools sometimes (50%) encouraged self-discoveries among learners with the other half (50%) encouraging the discoveries always. The findings of this study are supported by the available literature review such that, learners gain significant skills when they are actively involved in scientific investigations, (Guido, 2018). The learners gain skills and processes such as HOT, scientific method, problem-solving, collaboration, self-directed learning, and scientific communication which are only attained when they are actively involved in planning and executing the scientific investigations (Chekour & Janati-Idrissi, 2018). Learners' engagement in investigative laboratory activities was essential due to the role it performs in the understanding of the physics concepts since the learners' are actively involved in carrying out the investigative experiments.

*B. Effectiveness of Learning Materials Used in Supporting Instructional Integration of Investigative Experiments for acquiring Science Process Skills among physics learners*

While each of the teacher's response on the effectiveness of materials used for promoting instructional integration of investigative experiments was different, several common themes were raised. Summation and categorization of themes from the materials' appraisal guide and teachers' logbook was guided by the goal of relating themes to the Diffusion of Innovations Theory (Appendix VI and VII). The themes providing insights into the diffusion rate of the laboratory investigative tasks were included in the study. The themes assess the rate of adoption of the investigative experiments among physics learners determining the success or failure of the inquiry-based procedures.

- *Physics Instructional Material Guide*

The three physics teachers assessing the material guide provided insightful information that is essential in future improvement of the instructional materials for inquiry-based learning. The teachers agreed that the guide had comprehensive and well-outlined procedures that provided the necessary information to help in preparation of the physics lesson. They believed that the guide had content that is aligned to the syllabus requirement. One of the teachers felt that the guide did not provide a specific role of the teacher during practical work but was rather open-ended providing a passive role for teachers. However, two teachers felt that the whole process of teachers' role in the practical work was well stipulated in the guide. There was a unanimous response from the teachers that the guide was student-oriented and provided learners and opportunity for discovery and learning.

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However, one of the teachers stated "There is need to have more detailed student guide to direct on what is required by the learners".

The teachers pointed out that the materials designed to be used during physics practical work because they met the syllabus requirement and were important in promoting demonstration of concepts and principles. One of the teachers indicated that there was need to highlight clearly what the learners are expected to achieve in the materials for improvement. Among the benefits of using the practical guide as a strategy to support instructional integration of investigative experiments included; clear procedures for teachers, preparing teachers on the expected practical results, and learner-centered approach promoting learning. One teacher felt that the guide was shallow in terms of organization and directing learners and there was need for improvement. Among the suggestions provided were; including prompting questions for practical aligned to the content and considering coverage of the topic before practical to improve learning outcomes.

These results concur with available review information which asserts that practical tasks chosen by the teacher encourages learners to reason as they measure quantities, recording data and interpretation of the results (Wilson, 2020). Furthermore, the investigative practical tasks help students to work more independently and responsibly as they own their work and thus develop essential skills such as problem solving (Coccia, 2020). The physics practical guide was assessed as a learning tool in this study to determine whether it's effective in enhancing the learners' understanding of the SPS, that is, acquisition of the knowledge on physics concepts.

➢ *Laboratory Manual Worksheet*

Teachers were required to provide their experiences with the laboratory materials during lesson preparation and during the lesson. During preparation, they all agreed that the materials were helpful for conducting the experiments. The teachers reported presence of necessary information to help in facilitation of the investigative instruction. They reported that the laboratory manual worksheet guided on the expected results during the practical. Some teachers identified several challenges with the materials including; lack of consistency in helping students follow procedures and inability to promote creativity among learners. One of the teachers stated that the materials made it difficult for learners to effectively interpret data because they had minimal understanding of the science language and lacked adequate mastery of the formulae. Some stated the need to use simpler expressions to promote understanding among learners and promote data interpretation.

During the lesson the teachers agreed that their main role in investigative experimental lessons is to facilitate and help students with interpretation of questions and procedures. Among the challenges experienced by the teachers during the investigative practical-based physics lessons was learners' failure to effectively perform the procedures and collect relevant data, inability to link theory to practical concept, inadequate resources for the practical and tedious preparation of the experiment. Teachers suggested improvement of laboratory and provision of resources, need to bridge the theory-practical gap, and designing of step-by-step procedures to make the experiment effective among learners. The teachers felt that the practical manual worksheet had a gap in terms of having student-guided procedures. However, they agreed that the activities carried out during physics practical encouraged self-discovery and scientific communication among the learners. They felt that implementation of investigative practical-based instruction had a significant cost implication given the inadequate resources in the laboratory during practical lessons.

Biggozi et al., (2018) asserts that learners make many errors in performing, interpreting and analyzing the data from science practical. These errors are said to arise from misapplication and misrepresentation of the data gathered during science practical activities. This links to the study such that students are unable to interpret the laboratory practical manuals and thus fail to carry out the investigative practical properly. The students are to be provided with the laboratory practical manuals they can understand with ease and perform the experiments with little or no reliance on the teacher given they have done the theoretical aspect of the content and their understanding of the content especially the formulas is thorough.

## V. CONCLUSION

Majority of the secondary schools used group and individual activities to implement investigative instruction learning in physics lessons. Adoption of inquiry-based approaches enhances interactions between learners and with the teachers thus promoting a mutual exchange of experiences and concept explanations. According to the results, the teachers were found to occasionally implement Investigative Experiments hence there was need for increase in frequency with which the investigative experiments were provided.

On the other hand, teachers were found to encourage student engagement in Investigative Experiments although not to a greater extent as the investigative experiments were majorly teacher guided and putting into consideration the fact that they were occasionally carried out, the performance of physics had not improved as expected. Therefore, there is need to encourage more student inquiry-based instruction with the aim of increasing learners' participation so as to enhance the understanding of the physics concepts. The physics practical guide was assessed as a learning tool in this study to determine whether it's effective in enhancing the learners' understanding of SPS, that is, acquisition of the knowledge on physics concepts. The results showed that the physics practical guide was in accordance with the syllabus requirement and that it was student-oriented providing learners with an opportunity for self-discovery and learning. Nevertheless, the teachers suggested that the practical guide should be made more detailed in terms of clarification of procedures for teachers, preparing teachers on the expected practical results, and learner-centered approach promoting learning, inclusion of prompting questions for practical aligned to the content and considering coverage of topic before practical to improve learning outcomes.

On the other hand, laboratory practical manuals were essential in this study since they enable learners to understand with ease and carry out the experiments on their own given they have done the theoretical aspect of the content and their understanding of the content especially the formulas was thorough. The results showed that the manual was essential in preparation and conduction of experiments as it had the required content to facilitate the conduction of Investigative Experiments. Although the manual was found to lack consistency in helping students follow procedures, inability to promote creativity among learners, the complex science language and expressions was tougher for learners to understand thus making it difficult for learners to interpret the data. Due to engagement of learners in investigative experiments either in groups or as individuals and availability of the physics practical guide and laboratory practical worksheet, the understanding of the physics concepts has improved thus leading to enhanced self-discovery. Although it can be said with certainty that the optimal results have not been attained yet and that there is need to increase laboratory resources and simplify the physics practical guide and the laboratory worksheet and make them student oriented so as to enhance students understanding to yield greater results.

## REFERENCES

[1]. Acharya, S., Adamová, D., Adhya, S. P., Adler, A., Adolfsson, J., Aggarwal, M. M., ... & Casula, E. A. R. (2019). Investigations of Anisotropic Flow Using Multiparticle Azimuthal Correlations in p p, p− Pb, Xe-Xe, and Pb-Pb Collisions at the LHC. *Physical review letters*, *123*(14), 142301.

[2]. Adetunji, A. A., & Tajudeen, A. (2020). effects of guided discovery and reciprocal peer-tutoring instructional strategies on biology students' learning outcomes in ile-ife, nigeria.

[3]. Ayasrah, F. T. M., Alarabi, K., Al Mansouri, M., Fattah, H. A. A., & Al-Said, K. (2024). Enhancing secondary school students' attitudes toward physics by using computer simulations.

[4]. Beichumila, F., Bahati, B., & Kafanabo, E. (2022). Students' Perceptions toward the Use of Computer Simulations and Animations in Chemistry Teaching and Learning. *The International Journal of Science, Mathematics and Technology Learning*, *30*(1), 1.

[5]. Bigozzi, L., Tarchi, C., Fiorentini, C., Falsini, P., & Stefanelli, F. (2018). The influence of teaching approach on students' conceptual learning in physics. *Frontiers in psychology*, *9*, 2474.

[6]. Bodner, G., & Elmas, R. (2020). The impact of inquiry-based, group-work approaches to instruction on both students and their peer leaders. *European Journal of Science and Mathematics Education*, *8*(1), 51-66.

[7]. Çelik, B. (2022). The effects of computer simulations on students' science process skills: Literature review. *Canadian Journal of Educational and Social Studies*, *2*(1), 16-28.

[8]. Chen, Li-Ting, and Leping Liu. "Content Analysis of Statistical Power in Educational Technology Research: Sample Size Matters." *International Journal of Technology in Teaching and Learning* 15, no. 1 (2019): 49-75.

[9]. Chekour, M., Laafou, M., & Janati-Idrissi, R. (2018). What are the adequate pedagogical approaches for teaching scientific disciplines? Physics as a case study. *Journal of Educational and Social Research*, *8*(2), 141-148.

[10]. Coccia, M. (2020). The evolution of scientific disciplines in applied sciences: dynamics and empirical properties of experimental physics. *Scientometrics*, *124*(1), 451-487.

[11]. Djudin, T. (2023). Transferring of Mathematics Knowledge into the Physics Learning to Promote Students' Problem-Solving Skills. *International Journal of Instruction*, *16*(4).

[12]. Fidan, M., & Tuncel, M. (2019). Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education. *Computers & Education*, *142*, 103635.

[13]. Girase, J. D., Shahnawaz, Jou, J. H., & Vaidyanathan, S. (2022). Deep-blue Fluorophores Based on Phenanthroimidazole Integrated with Benzo [d] thiazole: Experimental and Theoretical Investigation. *ChemistrySelect*, *7*(27), e202201514.

[14]. Hosseini, Z., Hytönen, K., & Kinnunen, J. (2021). Introducing technological pedagogical content design: A model for transforming knowledge into practice.

[15]. Kibirige, I., & Tsamago, H. (2019). Grade 10 learners' science conceptual development using computer simulations. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(7), em1717.

[16]. Lucas, L. L., & Lewis, E. B. (2019). High school students' use of representations in physics problem solving. *School Science and Mathematics*, *119*(6), 327-339.

[17]. Njoka, N. M., Julius, J. K., & Julius, J. K. (2021). Original Paper Integration of Investigative Science Process Skills Teaching Strategy on Students' Achievement at Secondary School Level Physics in Embu County, Kenya. *World*, *8*(1).

[18]. Pragana, J. P., Bragança, I. M., Silva, C. M., & Martins, P. A. (2021). Integration of tube end forming in wire arc additive manufacturing: An experimental and numerical investigation. *The International Journal of Advanced Manufacturing Technology*, *117*(9-10), 2715-2726.

[19]. Shaheen, M., & Pradhan, S. (2019). Sampling in qualitative research. In *Qualitative techniques for workplace data analysis* (pp. 25-51). IGI Global.

[20]. Shakhman, L., & Barak, M. (2019). The Physics Problem-Solving Taxonomy (PPST): Development and Application for Evaluating Student Learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(11).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV508

[21]. Syafril, S., Latifah, S., Engkizar, E., Damri, D., Asril, Z., & Yaumas, N. E. (2021, February). Hybrid learning on problem-solving abiities in physics learning: A literature review. In *Journal of Physics: Conference Series* (Vol. 1796, No. 1, p. 012021). IOP Publishing.

[22]. Taiwo, W. F. (2022). Guided Discovery Instructional Strategy and Students' Attainment in Financial Accounting Concepts. *Pedagogika*, *147*(3), 147-163.

[23]. Ugwoke, E. O., Olulowo, T. G., & Adedayo, I. O. (2020). Using Guided Discovery to Improve Students' Retention and Academic Attitudes to Financial Accounting Concepts. *Education Research International*, *2020*, 1-9.

[24]. Wilson, A. (2020). *The nature of contingency: Quantum physics as modal realism*. Oxford University Press, USA.

[25]. Xerri, D. (2018). The use of interviews and focus groups in teacher research. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *91*(3), 140-146.