Impact of Performance Assessment on SSII Students' Interest and Academic Achievement in Physics, Chemistry and Biology in Katsina State, Nigeria

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ABSTRACT

The study examined the impact of performance assessment on students' interest and academic achievement in physics, chemistry, and biology in Katsina State, Nigeria. The study included six (6) Government Secondary Schools in Katsina State, with a total of 180 respondents. About 100 students were chosen through simple random sampling. Data was collected using a self-designed questionnaire called Students' Interest and Academic Achievement in Physics, Chemistry, and Biology Questionnaire Test (SIAAPCBQT) with a reliability coefficient of 0.85 Cronbach alpha. Inferential statistics such as T-test and simple regression were used to analyze the data for significant impacts of performance assessment on interest. The results showed that students' interest in science subjects has a noticeably positive impact on their academic achievement. The study recommended providing new science textbooks and modern equipment in schools, as well as maintaining interactive assessment methods to promote students' interest and improve academic achievements.

Keywords: Performance Assessment, Academic Achievement, Physics, Chemistry & Biology

INTRODUCTION

In modern societies, science plays an increasingly central role in our work and everyday lives. Educators, policymakers, and researchers are working to ensure that science subjects such as Physics, Chemistry, and Biology continue to prepare future citizens to be scientifically literate and help societies overcome the new challenges they face (Kahveci, 2015). Academic achievement of students is a fundamental indicator for defining and planning educational interventions at both the national and classroom levels. The process of performance assessment is complex and involves many variables that work together to affect the outcome. However, many researchers tend to analyze each variable separately, which hinders their ability to fully understand the situation (Byrnes and Miller, 2017). Many students find science subjects interesting but challenging (Cohen, 2016). This perception of science subjects affects students' overall attitude towards science and contributes to their underachievement in science subjects among SSII students in Katsina State. The way science subject is taught can be reason for students‘ performance assessment and academic achievements. If a task is void of stimulating or interesting quality and then it is irrelevant, routine or boring, it may lead to academic disengagement in students (Muthalib & Samar, 2018). Impacts of science subject are very important because there is science in everything of human development. An understanding of science by students allows them to deal with some social and biological issues that may deal with at home or the wider society. According to (Baharin, Kamarudin, & Manaf, 2018) a foundation in science subject is considered to be critical for the 21st century students since many of our decisions require an understanding of science. The Science subjects‘ performance assessment results for Katsina and other States were 42.5% respectively in 2015 which were considered to be significantly below Organization for Economic Co-operation and Development (OECD) average (OECD, 2016). Programme for International Student Assessment (PISA) evaluates students‘ability to apply their knowledge to solve world problems. The problem of low achievement is not restricted to Katsina State but includes other States in Nigeria (Awodun, Oni and Aladejana, 2015) as the National Board for Technical Education indicated there has been disturbing number of students graduating with insufficient passes in Science subjects. As a result the students lack knowledge needed to understand and cope with rapid changing environment. In line with Bennett (2018) students‘ attitude towards science subjects is a cause for concern since it is linked to a drop in the number of students selecting pure science at SSII levels in Katsina State which has led to a decline in students pursuing scientific education and scientific careers. The study focus on increasing interest and changing perception, so as to increase students enrollment to science classes and provide teachers with a student-centered approach which would make science interest and relevant to the student so as to improve the students‘ academic achievements. Considering these antecedents, our main objectives are focused on diagnosing the state of learning of scientific competences among Katsina State students at different levels of secondary education. In this study, we aim to explore how high school students identify problems, form hypotheses, draw conclusions, and create experiments. We will investigate the difficulties students face when applying these skills in scientific contexts. This information will help us understand the causes of these difficulties and develop educational initiatives to improve the quality of science education for high school students, with a focus on scientific literacy.

Concepts of Biology, Physics and Chemistry in SSII Students

A lot of biology is complex — Biology, as you well know, is the study of living organisms. The approach taken by biology is guided by and constrained by the fact that the subject is about living organisms. Because of the complexity, the first steps in biology (and in other sciences of the complex) are often about identification, classification, and description of phenomena. Whenever a science considers a complex phenomenon it does this whether it‘s biology, organic chemistry, or plasma physics. In biology, it is important to describe the traits, structure, and behavior of a biological phenomenon before looking toward explanations of how it works. So it was important to do Linnaean classification and morphology before the ideas of evolution could be worked out; and an understanding of the nature of organic chemistry and biological molecules was necessary before the molecular functioning of biological systems could be disentangled. This results in biology having a huge vocabulary and many concepts to teach (Thomas, 2021)

Biology depends on history — by this, we don‘t mean the history of how the science of biology developed, but the history of how organisms developed. All biological organisms are connected through a common, unbroken, history – a chain or web of life-forms that affects how things are today. What has happened over time matters in biology and affects how things are today. This is like geology, and unlike chemistry, physics, or math. (Though when biology gets down to the mechanism of how things actually happen, it is very much like chemistry and physics, and uses math.) The properties of organisms that are currently alive and their relationships to their environments and to each other depend a lot on what happened to their ancestors in the distant past. The history of an organism is written in its genome. Knowledge of evolutionary processes is often an important tool to explain why a particular organism solves a biological problem in a given way.

Biology looks for mechanism — Biology is not just about what is life?, It‘s also about how does it work? At one level, you might look at the organs and parts of either an animal or a cell and figure out what their function is for the organism. Today, using the tools of chemistry and physics (and using math), biology has gone down to the atomic and molecular level, figuring out the biochemistry of genes and proteins. Today, such quantitative measurements can be carried out simultaneously on thousands of genes or proteins in an organism. This has opened a new frontier of science, systems biology, which aims to find mechanisms in these huge datasets and describe how thousands or millions of components work together in a biological system such as a cell, an organism, or a population.

Biology is multi-scaled — an organism can be considered at many scales, for example, the atomic and molecular scale (biochemistry), in terms of the internal structure and functioning of its organs and parts (physiology), and as a part of a much larger system both in space (ecology) and time (evolution). The relation between these scales can be treated by reductionism or emergence going to smaller scales to explain something (reductionism), or seeing new phenomena arise as one goes to a larger scale (emergence).

Biology is integrative– Biological phenomena emerge from and must be consistent with the principles of chemistry, physics, and math. In other words, chemistry and physics constrain how an organism can behave or evolve. Therefore biologists must understand how physics and chemistry manifest themselves in biological organisms and higher-order systems. Increasingly, biologists searching for mechanisms of complex biological behavior are finding it valuable to use mathematical, physical, and chemical models in their research.

Chemistry

Chemistry starts with the idea that all matter is made up of certain fundamental pieces – atoms of about 100 different kinds (elements) – and is about the ways those elements combine to form more complex structures – molecules. But chemistry is not just about building molecules. It‘s about what you can do with that knowledge in our macroscopic world. Chemistry is about how atoms interact to form molecules — understanding the basic principles of how atoms interact and combine is a fundamental starting point for chemistry (Borggaard, 2018).

Chemistry is about developing higher-level principles and heuristics — because there are so many different kinds of molecules possible, chemistry develops higher-level ideas that help you think about how complex reactions take place.

Chemistry frequently crosses scales — connecting the microscopic with the macroscopic, trying to learn about molecular reactions from macroscopic observations and figuring out what is possible macroscopically from the way atoms behave. The connections are indirect, can be subtle, and may involve emergence.

Chemistry often assumes a macroscopic environment — much of what chemistry is about is not just idealized atoms interacting in a vacuum, but is about lots of atoms interacting in an environment, such as a liquid, gas, or crystal. In a water-based environment, the availability of H+ and OH- ions from the dissociation of water molecules in the environment plays an important role, while in a gas-based environment, the balance of partial pressures is critical.

Chemistry often simplifies — in chemistry, one often select the dominant reactions to consider, idealize situations and processes in order to allow an understanding of the most important features. For a chemist, most of what happens in biology is macroscopic – there are lots and lots of atoms involved – even though you might need a microscope to study it. In introductory chemistry you often assume that reactions are taking place at standard temperature and pressure (300 K and 1 atm).

Physics

The goal of physics is to find the fundamental laws and principles that govern all matter — including biological organisms. Those laws and principles can lead to many types of complex and apparently different phenomena. Physics as traditionally taught at the introductory level tends to explicitly introduce four scientific skills that may seem different to what one see in introductory biology and chemistry classes, but these four skills will prove valuable for your career (Kaye and Laby, 2016).

Physicists often spend a lot of time working out the simplest possible example (toy model) that illustrates a principle — even if that example appears not particularly interesting, relevant, or realistic. This lets one understand clearly and completely how the principle works. This understanding then can be woven into more complex situations to produce a better sense of what‘s going on (although the embedding of the simplicity in a realistic, relevant, and complex situation is often omitted in traditional introductory physics classes).

Physicists quantify their view of the real world — although there is a lot of conceptual and qualitative reasoning in physics, physicists tend not to be satisfied until they can quantify what they are talking about. This is because purely qualitative reasoning can sometimes be misleading. While one can come up with an argument that says A happens, if one think carefully, you might also come up with an argument that says something different happens — B. It‘s not until you can figure out that effect B is 1000 times bigger than effect A that you really know how to describe what‘s going on. This is just as true in biology and chemistry as physics, but physicists tend to introduce quantification sooner in the curriculum and more extensively than chemistry, which does it more in introductory classes than biology does.

Physicists think with equations — This is more than just calculating numbers: physicists use equations to both organize their qualitative knowledge about what affects what and how, and to reason with in order to determine how things happen, what matters, and how much. Physicists go back and forth repeatedly between thinking conceptually about a problem and thinking mathematically about a problem, so that each of these ways of thinking sheds light on the other.

Physicists deal with realistic situations by modeling and approximating — this means identifying what matters most in a complex situation and building up a fairly simple model that lets you get a good picture of what‘s happening. This is where the art lies in physics: in figuring out what can be ignored without losing what you want to look at. Einstein got it right when he said: Physics should be as simple as possible, but not simpler. All sciences do this, but because physics is about anything and everything, physicists often assume that they can get away in introductory classes with choosing systems that may seem to be simplified to the point of irrelevance. In this work, we‘ll try to be more explicit in modeling complex examples than in traditional physics classes.

This way of doing science is a bit different from the way biology is often done but elements of this approach and the constraints imposed on biology by the laws of physics are becoming increasingly important both for research biologists and health-care professionals. Bringing these all together to permit coherent and productive thinking is a challenge. In this class we expect and encourage you to bring to bear knowledge you have from your other science classes to try to see how they fit together, support each other, and to learn to identify when a particular disciplinary approach might be most appropriate and useful. While these different scientific disciplines are all ultimately working to the same end: understanding the Universe. They did evolve semi-independently historically. As such, there are *cultural differences* between the sciences just as there are cultural differences between countries (driving on the right or left, for example). These cultural differences are not about right or wrong ways of doing things. They are just different. In fact, these differences in perspective are strength. The different viewpoints between disciplines have often led to many important discoveries throughout history and are still where many of the most exciting advancements are being made. They can, however, be confusing. We have, therefore, worked with biology, chemistry, and mathematics instructors here at government senior secondary schools in Katsina State. These discussions have resulted in some common language used in this study, which might, therefore, be different than in other physics text one may look at. Even so, there are sometimes places where we need to leverage the strength of a different viewpoint. Again, these differences are not right or wrong ways of doing things. They are simply artifacts of the different sciences evolving independently for centuries with influences from different cultures from across the globe.

Statement of the Problem

The new paradigm of science subjects according to Chang and Cheng (2019) is focused on allowing students curiosity and motivation arousal so as to cause them to examine critically, investigate, explore, create and learn. This would improve students ‘interest and academic achievements in science subjects. Best and Khan (2016) assert that current teaching method is failing to hold students' attention during science classes, leading to poor performance and disruptive behavior. Many students enter secondary school with low assessment levels and continue to struggle throughout their six years. There seems to be a lack of interest and motivation among students, possibly due to the teacher-centered delivery method. This method may cause students to dislike science and perceive it as difficult and irrelevant to their lives. The classes being a mixed academic level class may not be always interested and engaged because they are not being stimulated, see science relevant to their situation or challenged at a high cognitive level. The study is designed to examine the impact of performance assessment on SSII students 'interest and academic achievement in Physics, Chemistry, and Biology in Katsina State. This would meet single of the new areas of science education which is to make scholars for a productive lifecycle long science learner within this technology complex world (Chang and Cheng, 2019)

Objective of the study

The study aims to assess the effect of performance assessment on the interest and academic achievement of SSII students in Physics, Chemistry, and Biology in Katsina State, Nigeria, and its impact on educational development. To achieve this, specific objectives have been outlined:

1. To determine the impact of performance assessment of students' interest in science subjects and academic achievement
2. To examine the difference of performance assessment of students' interest in science subjects and academic achievement.
3. To ascertain the significant effect of performance assessment of students' interest in science subjects and academic achievement.

Research Questions

The research questions were formulated to guide the studies are:

1. What the significant impact of Students' interest in science subjects and academic achievement?
2. What is the significant difference of performance assessment of students' interest in science subjects and academic achievement?
3. What are the significant effect of performance assessment of students' interest in science subjects and academic achievement?

Research Hypothesis

1. There is no significant impact of Students' interest in science subjects and academic achievement.
2. There is no significant difference of performance assessment of students' interest in science subjects and academic achievement.
3. There is no significant effect of performance assessment of students' interest in science subjects and academic achievement.

LITERATURE REVIEW

There are many scientific theories underpinned this study but the researchers believed that heuristic, PCK – pedagogical content knowledge and semiotic theories would be very important in making performance assessment of students' interest and academic achievement as a goal in modern globalization. According to Handayani and Marisda (2020) developed STEM-based teaching materials (worksheets) for chemistry subjects. The purpose of STEM education is essential to integrate multidisciplinary science that is used as the key to in-depth understanding, making learning meaningful and effective (Baharin, Kamarudin, & Manaf, 2018). Therefore, in practice, the teacher has an important role as a facilitator to direct students. In its role, the teacher can also design learning activities to raise student enthusiasm for learning. The challenge of STEM

Education arises because there are still problems related to its implementation in learning. STEM education is becoming a necessary but difficult challenge for educators today to collectively provide workable solutions (Lee, Chai, & Hong, 2019). Sarican and Akgunduz (2018) found that educators do not yet have adequate knowledge and experience in implementing learning using the STEM approach. Stanley (2016) explained that there are several ways to understand the actual practice of science through understanding the history and nature of science. It has become a necessity for informal education through trial and error and intuition to produce better scientists more quickly (McComas, 2020). He further categorizes the nature of science into four points: science as a way of thinking, science as a way of investigating, science as a body of knowledge, and science and its interactions with technology and society. The vision of science education shifted from an emphasis on a single-disciplinary perspective to a more multidisciplinary perspective (Johnson, Peters-Burton, & Moore, 2016).

Science learning is an interaction between learning components including educators, students, learning media, and learning tools in the form of teaching and learning activities to achieve the expected goals and competencies. In science learning, communication is established between teachers and students so that activity occurs. Structured learning activities need to be clear and well designed. Bates (2019) explained that quality design is determined by clear learning, carefully structured content, controlled workload, integrated media, assessment of learning outcomes, and also relevant student activities. Problems faced in learning science include inadequate knowledge of engineering, unavailability of quality teaching materials and resources, and limited time considering the problems related to the need to design learning activities with a STEM approach and lack of experience, this research will analyze the literature of articles that discuss learning activities that can be carried out by teachers using this approach.

Heuristics are general guidelines or rules of thumb. In science subjects, heuristics are usually discussed with respect to problem solving or investigative techniques that can be used to improve performance or assist a student to arrive at a defensible explanation. These heuristics provide direction for how to solve problem and can include using a fair test, trial and error, or following a certain pattern of argumentation (Johnson, Peters-Burton, & Moore, 2016). This study first consolidates a set of important heuristic strategies for constructing scientific models from three books; including studies in the history of genetics and electromagnetism, and an expert think-aloud study in the field of mechanics. As a branch of science, the general Pedagogical Content Knowledge (PCK) refers to the knowledge of concepts and strategies specific to the teaching of science. Besides Chemistry, there are other branches of science such as Biology and physics, therefore there is domain specific PCK for Biology, Chemistry and Physics respectively. Knowledge about how to transform subject matter content into ideas, words and activities that children can understand. Roberts 'Conception of Curriculum Emphases: A curriculum emphasis (Roberts, 2016) communicates a message as to why it is important to learn science. It is usually implicit, requires time and repetition if is to take, goes in and out of fashion, and is politically and economically driven. Roberts recognizes seven different curriculum emphases: personal explanations (how science explains the world for individuals), correct explanations (the products and findings/ideas/laws/theories of science), scientific skill development (the physical and conceptual processes of science), everyday applications (usefulness of science in helping us cope with everyday life), science technology and society (limits of science and technology in coping with the practical affairs of society) and solid foundations (today's science learning as a foundation for tomorrow's science learning). Science: Science involves gathering evidence and constructing explanations of the natural world. Science is concerned with answering the question why, and scientific inquiry is the investigative approach connected with science.

Semiotics is the study of signs and sign systems and how people interpret these signs and systems. In science subjects, semioticians could study the physical structure of the classroom, the structure of the lesson, how time is used and the interactions between the teacher and students to discuss the messages contain in these phenomena (Thomas, 2021). For example, the way in which a science teacher organizes a class discussion contains subtle messages about what the teacher believes about how children construct meaning in science classes. Another example could involve the arrangement of seating in the classroom (e.g., in rows or in groups) and how this arrangement can reflect the teacher‘s belief about how children learn and the nature of appropriate classroom interactions. Skills are the cognitive, procedural and manipulative tools children use during scientific inquiry, technological problem solving and STS decision making. Common scientific inquiry skills include asking questions, researching information, planning simple investigations (observing, classifying, inferring, formulating hypotheses, predicting, designing fair tests), employing equipment and tools to gather data (measuring, observing), recording data and using the data to construct reasonable explanations (formulating models, defining operationally, communicating). In line with Torlakson, (2015) common technological problem-solving skills include identifying a problem, designing a solution or product (drawing ongoing designs, considering constraints, troubleshooting), implementing a proposed solution (choosing materials, using appropriate techniques), evaluating the completed design or device and communicating with others. Common STS decision-making skills include understanding the issue, organizing information, identifying alternatives, analyzing and synthesizing information, deciding on a course of action, taking action, evaluating actions and decision making.

Social constructivist theory is focused on the social rather than individual nature of learning. Social constructivism is now used by many science education researchers to interpret interactions within science classrooms. Social constructivism about science is a doctrine that involves the following claims: (a) scientific concepts are not innate. (b) Scientific concepts have been brought into existence by human beings. (c) Scientific theories involve scientific concepts, rather than being blank slates, students bring their own unique experiences and personal beliefs to the science classroom, and some of these intuitively held ideas differ from the ideas accepted by the scientific community. Türk, Kalaycı, & Yamak, (2018) STS (Science/Technology/Society): An instructional approach STS that considers the many complex interactions among science, technology and society (and environment). For example, an STS view recognizes that:

• new scientific discoveries can inform current and new technology (e.g., the laser and research on light) • new technology can assist scientific inquiry and the generation of new scientific discoveries (e.g., the electron microscope) • society influences the kinds of scientific questions that are asked (e.g., questions about stem cell research) and the kinds of technologies that are built (e.g., technology that allows us to harvest stem cells) • technology that is created (e.g., the automobile) and scientific ideas that are constructed(e.g., the science behind organ transplants) influence the direction of society. Subject Matter Knowledge: Knowledge about content how it is organized and the general and specific concepts that comprise that content.

Technology involves practical activity focused on the manufactured world. Technology arises from human wants and needs and is concerned with answering the question how? Design is a key feature of technological problem solving. A term commonly used to describe technology topics in the Alberta Elementary Science Programme is design technology. This term helps to distinguish this work from information technology. Rapid technological developments have its impact on education. It can be said that the practice of teaching science has been more traditional than any other curriculum area, but technological developments have affected science education also. There are some issues and problems in science education. The technological developments could help science teachers to overcome these problems. In science education, teachers and students have a chance to use a variety of valuable resources offered by information technology. The forthcoming information technology tools can be listed as the Internet, simulations, hypermedia, and software/video resources.

In Clement (2018), analyzed think aloud case studies of experts solving explanation problems in mechanics. The work describes difficulties, breakthroughs, conceptual change, and the creative construction of new theories. They focus largely on qualitative modeling, viewed as essential for providing a firm foundation for later quantitative models. Together they describe dozens of scientific reasoning strategies that were used across three different fields of science. Consolidating them will also enable asking the question of whether the strategies are used in random order or are organized in some way. For instance, they have to attend to their students who are unique, varied and unpredictable individuals (Cohen, 2016), then they have to respond to the

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environmental distractions, diagnosing students‘ learning difficulties and spotting their misconceptions, monitoring their progress and making necessary adjustment, plus many other routine or non-routine works and duties (Can & Boz, 2015). In Ancient Greece, more than 300 years BC, Aristotle set the path for Western science by reasoning from the particular to the universal. After a period of derailment during the middle ages, science as we know it today got back on track in the 17th century, when there was a scientific revolution. The scientific revolution is a shorthand way of saying that sudden developments in mathematics, physics, astronomy, chemistry, and human biology caused large-scale change in the way that Western individuals viewed the world, both its natural and social aspects (Stanley, 2016). The scientific revolution began in Europe near the end of the period called the Renaissance and continued throughout the 18th century, which was a time of intellectual expansion retrospectively called The Enlightenment. When people in the present day express concern that research activities might not be empirical enough or, contrastingly, that the explanations they supply are unreasonable, they are participating in 18th-century debates which are the foundation of modern science. According to Efklides (2017), the crucial difference between a traditional perspective of Science and Technology (and society) versus a constructivist perspective of science and technology is the interconnectedness of the domains. Chang & Cheng, (2019) observed a clear distinction between political and scientific categories, they are intertwined and other constructivists teach that understanding and regulation of scientific information is a social activity. They also state that social shaping of technology and technical building of society is two sides of the same coin. Social constructivists believe that science, technology and society are intertwined.

Education around the world has evolved from teacher-centered learning to student-centered learning, teaching students to take responsibility for their learning and become more independent. Many teachers still use traditional practices, such as direct lecturing and strict reliance on textbooks as the only reference, without making the learning relevant to real-life scenarios. According to Yore (2015), this approach does not emphasize the development of critical thinking skills and important scientific concepts. On the other hand, Cobb, McClain, de Silva Lamberg and Dean (2017) state that: Design experiments have both a pragmatic bent and a theoretical orientation developing domain-specific theories by systematically studying those forms of learning and the means of supporting them. The goals of practical work are to enhance students' understanding, improve their problem-solving skills, and grasp the essence of science by emulating the practices of scientists. While solving a scientific problem, students should act like a scientist and follow scientific processes. In Hodson's study (2021), it was found that practical work in teaching science can motivate students, stimulate their interest, and enhance their scientific knowledge. Tsakeni's research (2018) focused on access to practical work for physical sciences learners in South African high schools. The study revealed that the absence of practical examinations led to underestimating practical work and marginalized learners. It was also noted that limited access to practical work raised social justice concerns. Dillon (2018) pointed out several reasons for incorporating practical work in scientific education, such as encouraging accurate observations, applying theories to real-life situations, and promoting logical and reasoning skills. Additionally, Bryson, Millar, Joseph & Mobolurin (2015) argue that practical work helps improve students' scientific knowledge and academic achievement.

Effectiveness of Practical Work in Chemistry, Physics and Biology

It is widely argued that practical work is essential for teaching and learning in scientific studies, and that good quality practical work helps develop students' understanding of scientific processes and concepts. However, it is still under investigation whether this affects the attainment scores of the students. In a study conducted over eight weeks on a group of 40 5th-grade students from two different classes, it was shown that students who were instructed through inquiry-based learning achieved higher scores than the ones who were instructed through traditional methods (Abdi, 2016). Several studies examining the role of practical work on student attainment investigated many aspects of the quality of the practical work, such as the design of the task given in terms of encouraging students to make links between theoretical and practical aspects. In a study of 25 science lessons involving practical work in English secondary schools, the results showed that practical work kept students focused on tasks and doing hands-on work, but was less effective in helping students make a connection between concepts and application in the lab and reflect on their collected data (Abrahams & Millar, 2018). The study found that people who design these activities for science lessons do not sufficiently consider linking concepts to observables. Millar (2016) proposes stimulating students' minds before starting practical work by providing them with background information on what they are investigating. Also, task design should direct students' efforts to make links between the two domains of knowledge. Consequently, science teachers should be trained based on the most recent research studies to amend their practices and put forth more time and effort to reflect on linking scientific concepts with the natural world (Jokiranta, 2015). It's important to note that feedback from teachers of laboratory work is a vital source of information about its value. In previous studies, teachers mentioned that laboratory work is vital for studying sciences, but they faced issues such as lack of materials needed for experiments, insufficient information and techniques for experimenting, lack of information about glassware and chemicals, safety rules, and steps to follow to avoid accidents during experiments, and what to do in case of an accident (Aydogdu, 2015).

Cons of Practical Work in Chemistry, Physics and Biology

Sotiriou, Bybee, and Bogner (2017) argue that traditional lab work focuses exclusively on scientific terminology, limiting students to observing experiments without fostering creativity or cognitive skills. Merely following instructions from a lab manual without real-world connections renders the methods ineffective. Madhuri, Kantamreddi, and Prakash Goteti (2017) highlight that cookbook-style labs fail to help students translate scientific outcomes into meaningful learning. Some teachers cast doubt on the effectiveness of practical work in teaching scientific knowledge. Hodson (2019) contends that practical work in many schools is poorly planned and counterproductive, contributing little to students' science learning. Similarly, Woolnough (2018) and Millar (2016) express skepticism regarding the effectiveness of practical work in enhancing learning. Solomon (2019) provides an example where a medical student struggled to understand an X-ray picture without practical exposure, emphasizing the intertwined nature of practical and theoretical learning in the scientific field.

Relevance of Practical Work in Chemistry, Physics and Biology

The fields of chemistry and biology are important areas of science that study the structure, composition, properties, and interactions of matter. Understanding these subjects can help us comprehend the world around us. However, they are often considered challenging due to the extensive information about materials and their properties, which may discourage students from pursuing these subjects. To grasp the properties of materials and the changes that occur when they interact, extensive practical applications and experiments are essential in studying these two challenging subjects (Singer, Hilton & Schweingruber, 2016). Although laboratory work is a fundamental component of chemistry and biology, some researchers argue that traditional laboratory activities may fail to engage students in discussions and promote effective understanding of chemistry. They also argue that traditional laboratory work only involves small groups of students and that students' discussions during laboratory work mainly focus on procedures and equipment rather than deeper understanding of the experiments. In group work for experimental activities in chemistry and biology, the quality of interaction among group members can significantly influence the level of understanding of the experiments and the expected outcomes. Each student should have the opportunity to apply their learning to future tasks during group work experiments to enhance their learning (Russell & Weaver, 2018). According to Piaget (2017), practical work is crucial for understanding sciences, as it provides support for students' learning and links real objects and observable facts to abstract ideas.

Methods of Teaching, Learning, and Assessment

The teaching of science curriculum in UAE high schools employs various methods of teaching, learning, and assessment. According to Edgar Dale's Cone of Experience (Dale, 2015), individuals retain and remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they see and hear. The

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most effective learning methods involve direct, purposeful experiences, such as hands-on or field experiences (Anderson, 2019). It's important to involve students in the process when choosing an instructional method to maximize their information retention. To keep the class energy elevated, in-class activities and projects are mainly done in small groups. Specific techniques and ideas are offered through demonstrations and hands-on experiences to reinforce the core skills of the assigned projects. Furthermore, group members are encouraged to articulate and represent what they know and can do through the process of demonstrating and explaining, aiming to help reinforce lesson concepts and encourage students to take ownership of the learning. This approach will help students make connections to the lessons learned in the classroom. The study seeks to contribute to the teaching and learning process of science subjects such as chemistry and biology by emphasizing students' engagement as an essential aspect of the teaching and learning process. Practical work is essential for the development of students' knowledge and skills by tying practical and theoretical learning together. Overall, the adoption of practical work is useful for teachers in local UAE schools as it engages students in learning process and enhances the science curriculum (Anderson, 2019). Many schools could also enhance their science curriculum through the provision of practical work along with the provision of theoretical knowledge using traditional teaching methods.

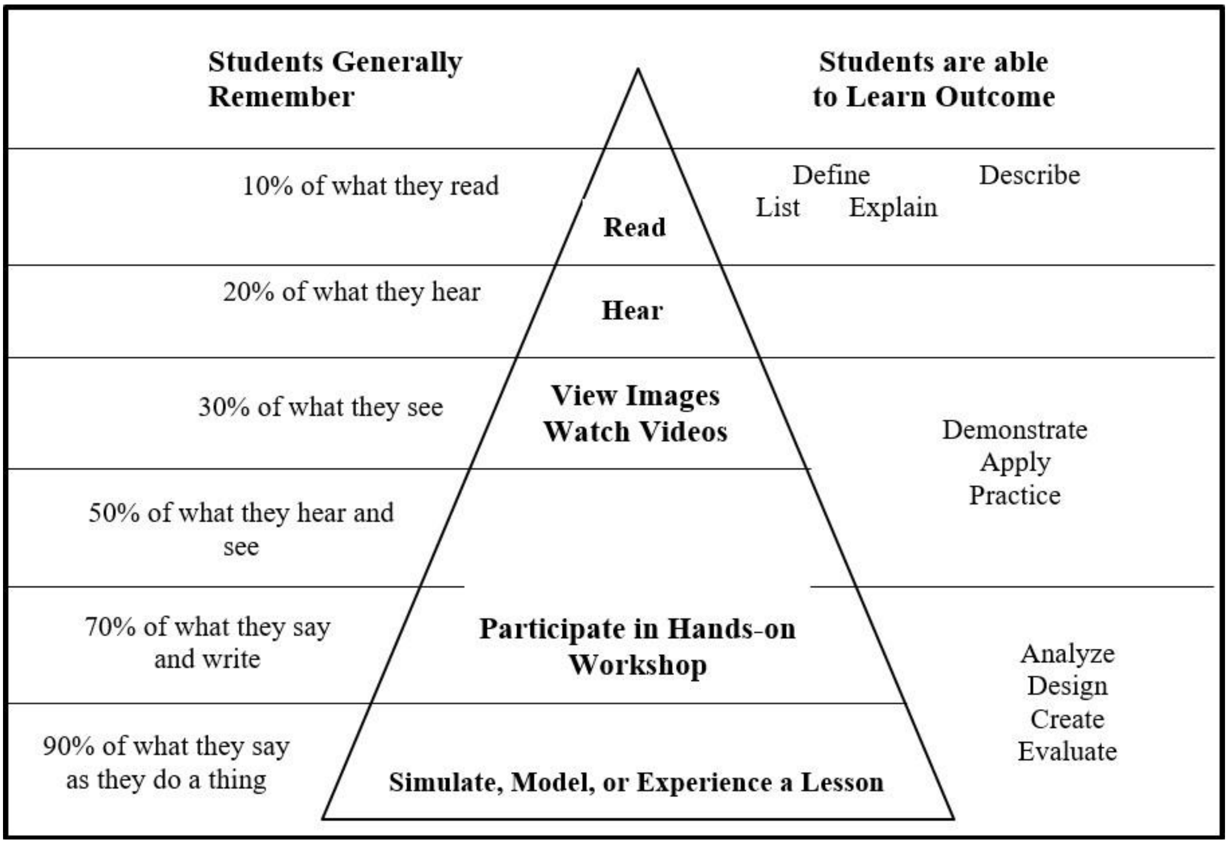

Figure 1. Edgar Dale Cone of Experience (Dale, 2015)

Significance of the Study

The impact of performance assessment on SSII students ‘interest and academic achievement in Physics, Chemistry and Biology in Katsina State cannot be overemphasized because some students believed that the subjects are difficult to pass with different assumptions. Chemistry and physics are branches of science that both study matter. The difference between the two lies in their scope and approach. Chemists and physicists are trained differently, and they have different professional roles, even when working in a team. The division between chemistry and physics becomes diffuse at the interface of the two branches, notably in fields such as physical. These subjects open doors to students and job opportunities, allow them to pursue a career in a dynamic field, and provide them with knowledge and skills to live a successful life. It also allows students to connect with peers, contribute to society, and develop a sense of self-worth. The research study is of great importance to parents, teachers, students and policy makers by understanding the diversity of Physics, Chemistry and Biology in teaching senior secondary school students in Katsina State.

Scope and Limitation of the Study

The research covered the impact of performance assessment on SSII students 'interest and academic achievements in Physics, Chemistry and Biology in Katsina State. The scope is limited to impact of performance assessment on students 'interest and academic achievement in teaching senior secondary students. This cannot be effectively discussed without considering the demographic factors of the educational zones in Katsina State. The study is limited to Government Senior Secondary Students within the three (3) Senatorial Zones in Katsina State.

METHODOLOGY

The research method deals with impact of performance assessment on SSII students 'interest and academic achievements in Physics, Chemistry and Biology in Katsina State, Nigeria. Two schools were randomly selected from each of the three (3) senatorial zones in Katsina State. A total of six (6) schools in the State and in each school, thirty (30) students will be randomly selected through simple random technique (15 boys and 15 girls). The total population of students stand at (180) for the research as indicated in the table below. The students were given academic achievement test to determine the level of students 'interest in science subjects 'questionnaire (Physics, Chemistry and Biology). The researchers adopted descriptive survey because it is approaches that provide relevant and accurate information which involve clearly define problems and objectives. The descriptive survey design assisted the research in recording, analyzing and interpreting the existing conditions of impact of performance assessment on students' interest in science subjects and academic achievements. The data collected from the responses are coded and analyzed to answer the research questions using the inferential statistics of simple linear regression for significant impact and reliability while frequency and percentage were used as the descriptive statistics to uphold or reject the hypotheses advanced for the study at 0.05% level of significance. Statistical Package for Social Science (SPSS, Version 23) was used in analyzing the data generated from the respondents through questionnaire and testing of the hypotheses.

Table 1: Distribution of Government Secondary Schools in the three (3) Senatorial Zones and Selected Students with their Sample Size in Katsina State

ZONE A	**No. of Students selected**	**Male**	**Female**	**Total**	**Sample Size**
Govt. Science Secondary School Batagarawa	30	15	15	30	16.6
Govt. Day Secondary School, Kankia	30	15	15	30	16.6
ZONE B.					
Federal Govt. College Daura	30	15	15	30	16.6
Govt. Technical College, Mashi	30	15	15	30	16.6
ZONE C.					
Govt. College, Funtua	30	15	15	30	16.6
Govt. Day Secondary School, Kafur	30	15	15	30	16.6
Total No. of Schools =	**180**	**90**	**90**	**180**	**99.6 ≈ 100**

Total Summary:

No. of LGAs = 6

No. of Senatorial Zones = 3

No of Schools Selected = 6

No. of Students selected = 180

Sample Size $= \frac{Total\ number\ of\ student\ randomly\ selected\ in\ each\ school}{Total\ number\ of\ all\ the\ six\ selected\ schools} \times 100 = \frac{30}{180} \times 100 = 16.6$

Total sample size = 16.6 × 6 = 99.6 ≈ 100

The impact of performance assessment on students‘ interest and academic achievements in Physics, Chemistry and Biology in Katsina State was evaluated using simple random and purposive sampling technique of thirty (30) respondents to which structured questionnaire was administered.

Research Instruments

The instruments used for data collection in this research study include the following:

The students ‘interest and academic achievement in Physics, Chemistry and Biology Questionnaire Test (SIAAPCBQT)

The self-designed questionnaires on the impact of performance assessment on students‘ interest and academic achievements in Physics, Chemistry and Biology for senior secondary school students was developed after an intensive review on the concept. The inventory forms the foundation based for generating items used in the instrument for the research study. The initial draft of the instrument had responses as Yes or No. After the trial test, the responses were changed to the present Modified Likert Attitudinal Scales. The questionnaires for the students comprise section (A) that elicit demographic information of the students while section (B) contains ten (10) questions each in Physics, Chemistry and Biology. The questionnaires were disturbed to respondents with the help of research assistants to ensure coverage in distribution and collection. The test instrument was scored with Likert scale of four responses on the bases of Strongly Agree (SD=4), Agree (A=3), Disagree (D=2) and Strongly Disagree (SD=1) It is a four point modified likert attitudinal scales format ranging from 1-4 point.

Validity of the Instrument

The questionnaire was given to professionals, test constructors, some lecturers in Federal College of Education, Katsina and Federal University Dutse-ma for thorough scrutiny, clarity, precision, observation and corrections in order to minimize errors in interpretation. After making series of corrections, the content of the instrument was ascertained valid and found to be capable for measuring the impact of performance assessment on students ‘interest and academic achievements in Physics, Chemistry and Biology for senior secondary school students in Katsina State.

Reliability of the Instrument

The researchers pre-tested thirty (30) questionnaires at an internal of two (2) weeks at some selected secondary schools in Kaita Local Government Area and Bindawa Local Government Area in Katsina State which are different from the schools used for the research study. A test re-tests method for determining test reliability was employed to compare and determine consistency and it yields a high reliability index which was considered appropriate in this research study.

Method of Data Collection

The researchers travelled to the three (3) senatorial zones viz: Katsina, Funtua and Daura zones in the State to administer the instruments to the respondents by direct delivery. The researchers employed the services of some teachers and a research assistant from the schools to help in the process of administering the instruments. There are three different questionnaires (i.e. Physics, Chemistry and Biology) to measure the impact of performance assessment on SSII Students ‘interest and academic achievement. The questionnaires were distributed to the respondents with the help of research assistant to ensure coverage in distribution and collection. Each respondent was given a copy of the questionnaire for completion under the guidance of the researcher and his assistant who helped the respondents to fill them and return back immediately.

Method of Data Analysis

The data collected from the responses will be coded and analyzed to answer the research questions using the inferential statistics of t-test for significant difference and simple linear regression for significant impact and reliability while frequency and percentage were used as the descriptive statistics to uphold or reject the hypotheses advanced for the study at 0.05 level of significance. The analysis of the date generated from the respondents through questionnaire and testing of the hypotheses was done.

Data Analysis and Results

The data collected were sorted, organized and presented for data analysis. The bio-data of the respondents were presented in table 1 below.

Table 1: Bio-data of the respondents

SN	Items	Category	Number	Percentage (%)
1	Age of students	13-15 years	49	27.2
		16-18 years	79	43.9
		19 years	52	28.9
		Total	180	100.0
2	Gender of students	Male	96	53.3
		Female	84	46.7
		Total	180	100.0
3	Class	SS I	80	44.4
		SS II	100	55.6
		Total	180	100.0

The results in table 1 showed that the age distribution shows that the majority of respondents are between 16-18 years old, with a significant number also in the 13-15 year age group. Only a smaller proportion is 19 years. The gender distribution indicates that slightly more males (53.3%) than females (46.7%) are represented in the sample. The class distribution shows that the majority of respondents are in SS II (55.6%), with a smaller proportion in SS I (44.4%).

Research Questions and Hypotheses

Research Question 1: What is the significant impact of students' interest in science subjects on academic achievement?

Table 2: Impact of students’ interest in science subjects on academic achievement

Interest	Number	Mean	Std.Dev	Mean Difference
Low	114	13.02	7.366	16.043
High	66	29.06	4.406	

The table 2 analyzes the impact of students' interest in science subjects on their academic achievement by comparing the performance of students with low interest to those with high interest. Students with low interest in science subjects have a mean academic achievement score of 13.02 while Students with high interest in science subjects have a significantly higher mean academic achievement score of 29.06. The standard deviation for students with low interest (7.366) is higher than for those with high interest (4.406). This indicates that academic achievement scores among students with low interest are more spread out and variable compared to those with high interest. The mean difference between the two groups is 16.043. This substantial difference suggests a significant impact of students' interest in science subjects on their academic achievement.

H01: Students' interest in science has no significant impact on academic achievement.

Table 3: Regression Analysis results of impact of students' interest in science subjects of academic achievement

Items	R2	F-value	Df	p-value	Alpha	Decision
Students' interest vs academic achievement	0.593	259.005	179	0.000	0.05	Reject H01

The table 3 presents the results of a regression analysis examining the impact of students' interest in science subjects on their academic achievement. The R-squared value of 0.593 suggests that approximately 59.3% of the variation in academic achievement can be explained by students' interest in science subjects. This is a substantial proportion, indicating a strong predictive power of interest on achievement. The F-value of 259.005 is significant at the 0.05 level, as indicated by the p-value of 0.000. This means that the null hypothesis (H01) that students' interest in science has no significant impact on academic achievement is rejected. This conclusion is supported by the decision to reject H01.

Research Question 2: What is the significant difference in performance assessment between students with different levels of interest in science subjects?

Table 4: Difference in performance assessment between students with different levels of interest in science subjects

Interest	Number	Mean	Std. Dev	Mean Difference
Low	114	1.38	0.555	1.153
High	66	2.53	0.503	

The table 4 compares the performance assessment scores between students with low interest and high interest in science subjects. Students with low interest in science subjects have a mean performance assessment score of 1.38 while Students with high interest in science subjects have a significantly higher mean performance assessment score of 2.53. The standard deviation for students with low interest (0.555) is slightly higher than for those with high interest (0.503). This indicates that scores among students with low interest are slightly more variable compared to those with high interest. The mean difference between the two groups is 1.153. This substantial difference suggests a significant disparity in performance assessment scores based on the level of interest in science subjects.

H02: There is no significant difference in performance assessment scores between different levels of interest.

Table 5: t-test results of difference in performance assessment scores between different levels of interest

Interest	N	Mean	Std.dev	t-cal	Df	P-value	Alpha	Decision
Low	114	1.38	0.555	13.898	178	0.000	0.05	Reject H02
High	66	2.53	0.503					

Table 5 presents the t-test results to examine the hypothesis (H02) that there is no significant difference in performance assessment scores between different levels of interest in science subjects. The t-calculated value is 13.898 at degree of freedom 178, which measures the difference between the two groups relative to the variation in their scores. The p-value is 0.000, which is significantly less than the alpha level of 0.05. This indicates that the difference in mean scores between the two groups is statistically significant. Given that the p-value is less than the alpha level (0.05), the null hypothesis (H02) is rejected. This means that there is a significant difference in performance assessment scores between students with different levels of interest in science subjects.

Research Question 3: What are the significant effects of performance assessment on students' interest and academic achievement?

Table 6: Effects of performance assessment on students' interest and academic achievement

Items	Categories	N	Mean	Std. Dev	Std Error
Academic achievement	Low	75	9.17	5.249	0.606
	Moderate	66	22.38	4.529	0.558
	High	39	31.72	3.546	0.568
Interest	Low	75	1.00	0.000	0.000
	Moderate	66	1.47	0.503	0.062
	High	39	1.90	0.307	0.049

The table 6 examines the effects of performance assessment on students' interest and academic achievement. Students with low academic achievement have a mean score of 9.17, Students with moderate academic achievement have a mean score of 22.38 and Students with high academic achievement have a mean score of 31.72. The mean scores increase significantly from low to high categories, indicating a strong positive relationship between performance assessment and academic achievement. Students with low interest have a mean score of 1.00, Students with moderate interest have a mean score of 1.47 and Students with high interest have a mean score of 1.90. The mean interest scores increase from low to high categories, indicating a positive effect of performance assessment on students' interest. Higher levels of performance assessment are associated with higher mean scores in both academic achievement and interest, with reduced variability among higher-performing groups.

H03: There is no significant effect of performance assessment on students' interest and academic achievement.

Table 7: Regression Analysis results of effect of performance assessment on students' interest and academic achievement

Items	R2	F-value	Df	p-value	Alpha	Decision
Effect of performance assessment on interest and performance	0.784	320.998	179	0.014	0.05	Reject H03

Table 7 presents the results of a regression analysis to test the hypothesis (H03) that there are no significant effects of performance assessment on students' interest and academic achievement. The R-squared value of 0.784 suggests that approximately 78.4% of the variation in students' interest and academic achievement can be explained by performance assessment. This is a substantial proportion, indicating a strong predictive power of performance assessment on both variables. The F-value of 320.998 is significant at the 0.05 level, as indicated by the p-value of 0.014. This means that the null hypothesis (H03) that there is no significant effect of performance assessment on students' interest and academic achievement can be rejected. This conclusion is supported by the decision to reject H03.

FINDINGS AND DISCUSSION OF THE RESULTS

The summaries of findings of the study are:

1. Students‘ interest in science subjects has significant impact on their academic achievement where High-interest students performed better than low-interest students.

2. There is a significant difference in performance assessment scores between students with different levels of interest in science subjects where the Performance assessment scores were significantly higher for students with high interest in science subjects compared with low-interest students.

3. Performance assessment significantly affects both students' interest and academic achievement affirming the significant impact of performance assessment on both interest and academic achievement.

The study examines the impact of performance assessment on the interest and academic achievement of SSII students in physics, chemistry, and biology in Katsina State, Nigeria. The research aims to investigate the relationship between performance assessment and students' interest and academic performance in these subjects. The first finding of data analysis clearly indicates that students with a high interest in science subjects perform significantly better academically than those with low interest. The mean academic achievement score for highly interested students is more than double that of students with low interest. Students‘ interest in science subjects has a significant impact on their academic achievement, with high-interest students performing better than low-interest students.

This analysis strongly supports the conclusion that students' interest in science subjects has a significant positive impact on their academic achievement. These findings align with previous research that has consistently by Alhadabi and Li (2020), and Alhadabi (2020) who shown that interest in science subjects is a strong predictor of academic performance. Students who are more interested in science tend to perform better academically compared to those with lower interest levels. High-interest students are more motivated, leading to greater engagement with learning materials and activities, resulting in better academic performance. Interest enhances cognitive processing, allowing students to understand and retain information more effectively. Students interested in science are likely to have higher self-efficacy, which contributes to persistence and effort in challenging tasks.

The second finding from data analysis shows a clear and significant difference in performance assessment scores between students with different levels of interest in science subjects. This analysis highlights the importance of fostering interest in science to improve academic performance and assessment outcomes. The t-test analysis confirms that there is a significant difference in performance assessment scores between students with low and high interest in science subjects affirming that students' interest in science subjects has a significant impact on their performance assessment scores. This implies that students with high interest in science tend to perform better academically compared to those with low interest. High-interest students are more likely to engage thoroughly with performance assessments, using them as opportunities to demonstrate their knowledge and skills. Students with higher interest typically adopt more effective study habits and are more proactive in seeking help and resources. Success in assessments can reinforce interest, creating a positive feedback loop where interest and achievement mutually enhance each other.

This finding is in line with studies by Hulleman and Harackiewicz, (2019) who have found that science interest among high school students is a strong predictor of enrolling in science related courses and occupations. Also, the study by Hazari, Potvin, Cribbs, Godwin, Scott, & Klotz, (2017) found that students who had higher science interest and studied in classrooms where their classmates shared the same high interest scored statistically higher STEM career intentions than other groups of students with a lower science interest.

The third finding indicated that performance assessments are effective in enhancing students' interest in science subjects and improving their academic achievement. Performance assessment significantly affects both students' interest and academic achievement, affirming the significant impact of performance assessment on both variables. Performance assessments provide feedback that can enhance student motivation and interest in science by showing them areas of strength and improvement. Well-designed assessments help students develop critical thinking and problem-solving skills, which can increase their interest and confidence in the subject. Performance assessments often involve applying knowledge in practical scenarios, which can make learning more engaging and relevant, thereby boosting both interest and achievement.

This finding align with previous researches conducted by Stets Brenner, Burke, & Serpe, (2017) that has consistently shown that performance assessment can have a positive impact on both academic achievement and interest levels. By providing students with opportunities to demonstrate their skills and knowledge through performance tasks, educators can foster a deeper engagement with the subject matter and improve overall academic performance of students and it is in good agreement with the study conducted by Williams, Brule, Kelley, & Skinner, (2018) where academic achievement and level of interest of students were affected by performance assessment in the subjects.

CONCLUSION

The study finds a significant positive impact of performance assessment on both students' interest and academic achievement in physics, chemistry, and biology. The results indicate that students who are more interested in these subjects tend to perform better academically, and that performance assessment can enhance both interest and academic performance. The findings support the idea that performance assessment can be an effective tool in improving students' engagement and achievement in science subjects. Students ‘interest in science significantly boosts their academic performance, primarily by enhancing motivation, engagement, and cognitive processing. Interest in science subjects leads to higher performance assessment scores, likely due to increased engagement, better study habits, and a reinforcing cycle of interest and achievement. Performance assessments play a crucial role in influencing both students' interest in science and their academic achievement by providing valuable feedback, developing essential skills, and making learning relevant and engaging.

RECOMMENDATIONS

The following recommendations were drawn from the study:

1. Educators should incorporate strategies that spark and sustain student interest in science, such as hands-on experiments, real-world applications, and opportunities for student choice in topics.
2. Teachers should design performance assessments that are engaging and relevant to students ‘interests, providing varied and meaningful contexts for demonstrating knowledge and skills.
3. Educators should use performance assessments not just for grading, but as tools for learning and engagement, ensuring they are well-designed to enhance both interest and academic outcomes. Incorporating diverse and interactive assessment methods can help maintain student interest and promote higher achievement.

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REFERENCES

1. Abdi, A. (2016). The Effect of Inquiry-based Learning Method on Students‘ Academic Achievement in Science Course. Universal Journal of Educational Research, [Online] 2(1), 37-41. Available from: https://doi.org/10.13189/ujer.2014.020104 (Accessed: 15 March 2019).
2. Abrahams, I., & Millar, R. (2018). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. International Journal of Science Education, 30(14), 1945-1969. https://doi.org/10.1080/09500690701749305
3. Acar,Ö., Türkmen, L., and Bilgin, A. (2015). Examination of gender differences on cognitive and motivational factors that influence 8th graders‘ science achievement in turkey. *Eur. J. Math. Sci. Technol. Educ.* 11, 1027–1040. doi: 10.12973/eurasia.2015.137
4. Alhadabi, A. (2020). Individual and contextual effects on science identity among American 9th grade students (HSLS: 09): hierarchical linear modeling, in *American Educational Research Association Annual Meeting* (San Francisco, CA).
5. Alhadabi, A., and Li, J. (2020). Trajectories of academic achievement in high schools: growth mixture model. *J. Educ. Issues* 6, 140–165. doi: 10.5296/jei.v6i1.16775
6. Anderson, H.M (2019). Dale‘s Cone of Experience [Online]. Available from: http://www.queensu.ca/teachingandlearning/modules/active/documents/Dales_Cone_of_Experience_summary. https://doi.org/10.11113/jt.v63.2013
7. Awodun, A. O., Oni, S. A., and Aladejana, A. L. (2015). Students‘ variables as predictor of secondary school students‘ performance in physics. *Int. J. Sci. Res.* 4, 541–545.
8. Aydogdu, C. (2015). Science and technology teachers‘ views about the causes of laboratory accidents. International Journal of Progressive Education, 11(3), 106-120.
9. Baharin, N., Kamarudin, N., & Manaf, U. K. A. (2018). Integrating STEM Education Approach in Enhancing Higher Order Thinking Skills. International Journal of Academic Research in Business and Social Sciences, 8(7), 810–821. https://doi.org/10.6007/ijarbss/v8-i7/4421
10. Bates, A. (2019). Teaching in Digital Age. 2nd Edition. Tony Bates Associates.
11. Bennett, J. (2018). The development and use of an instrument to assess students‘ attitude to the study of chemistry. *Int. J. Sci. Educ.* 23, 833–845. doi: 10.1080/09500690010006554
12. Best, J. W & Khan, J.V. (2016) Research in Education (10th Ed) New Delhi: Pearson Education Inc.
13. Borggaard, O.K. (2018) Soil Chemistry in a Pedagogical Context, 16th Ed. DSR Press, Copenhagen
14. Bryson, K.M.N., Millar, H., Joseph, A. & Mobolurin, A. (2015). Using formal MS/OR modeling to support disaster recovery planning. European Journal of Operational Research, 141(3), 679-688. https://doi.org/10.1016/S0377-2217(01)00275-2
15. Byrnes, J. P., and Miller, D. C. (2017). The relative importance of predictors of math and science achievement: an opportunity–propensity analysis. *Contemp. Educ. Psychol.* 32, 599–629. doi: 10.1016/j.cedpsych.2006.09.0
16. Can, H. B., and Boz, Y. (2015). A cross-age study on high school students attitudes toward chemistry. *Int. J. New Trends Educ. Implic.* 3, 82–89.
17. Chang, C.-Y., and Cheng, W.-Y. (2019). Science achievement and students‘ self-confidence and interest in science: a taiwanese representative sample study. *Int. J. Sci. Educ.* 30, 1183–1200. doi: 10.1080/09500690701435384
18. Chu, H.-E. (2021). Editorial: STEAM education in the Asia Pacific Region. Asia-Pacific Science Education, 7(1), 1–5. https://doi.org/10.1163/23641177-bja10026
19. Clement, J. (2018). *Creative Model Construction in Scientists and Students: The Role of Imagery, Analogy, and Mental Simulation.* Dordrecht: Springer. doi: 10.1007/978-1-4020-6712-9
20. Cobb, P., McClain, K., de Silva Lamberg, T., & Dean, C. (2017). Situating teachers‘ instructional practices in the institutional setting of the school and district. Educational Researcher. 32(6), 13-24. https://doi.org/10.3102/0013189X032006013
21. Cohen, J. (2016). *Statistical Power Analysis for the Behavioral Sciences.* Hillsdale, NJ: L. Erlbaum Associates.
22. Cohen, J., Cohen, P., West, S. G., and Aiken, L. S. (2016). *Applied Multiple Regression/correlation Analysis for the Behavioral Sciences.* 3rd Edn. Mahwah, NJ: Lawrence Erlbaum Associates.

23. Dale, E. (2015). Audiovisual Methods in Teaching. New York: Dryden Press.
24. Deary, I. J., Strand, S., Smith, P., and Fernandes, C. (2007). Intelligence and educational achievement. *Intelligence* 35, 13–21. doi: 10.1016/j.intell.2006.02.001
25. Dillon, J. (2018). A review of the research on practical work in school science [Online]. Available from: http://www.score-education.org/media/3671/review_of_research.pdf (Accessed: 28th Spril 2019).
26. Efklides, A. (2017). Interactions of metacognition with motivation and affect in self-regulated learning: the masrl model. *Educ. Psychol.* 46, 6–25. doi: 10.1080/00461520.2011.538645
27. Efklides, A. (2017). The role of metacognitive experiences in the learning process. *Psicothema* 21, 76–82.
28. Habord, M. & Sims, S. (2020) Zebra Stripes: A Review Zoology Research International, 131 PP. 108973
29. Handayani, Y., & Marisda, D. (2020) Model pembelajaran discovery learning berbasis hypercontent pada konsep suhu dan kalor. Karst: Jurnal Pendidikan Fisika Dan Terapannya, 1(1), 32–37.
30. Hazari, Z., Potvin, G., Cribbs, J., Godwin, A., Scott, T., and Klotz, L. (2017). Interest in STEM is contagious for students in biology, chemistry, and physics classes. *Sci. Adv.* 3:e1700046. doi: 10.1126/sciadv.1700046
31. Hegarty, M. (2014). Spatial thinking in undergraduate science education. *Spat. Cogn. Comput.* 14, 142–167. doi: 10.1080/13875868.2014.889696
32. Hinneh, J.T. (2017). Attitude towards Practical Work and Students‘ Achievement in Biology: A Case of a Private Senior Secondary School in Gaborone, Botswana. IOSR Journal of Mathematics (IOSR-JM), 13(4),06-11.
33. Hodson, D. (2019). Practical work in science: time for a reappraisal. Studies in Science Education, 19(1), 175-84. https://doi.org/10.1080/03057269108559998
34. Hodson, D. (2021). A critical look at practical work in school science. School Science Review, 70(256), 33-40.
35. Hulleman, C., and Harackiewicz, J. (2019). Promoting interest and performance in high school science classes. *Science* 326, 1410–1412. doi: 10.1126/science.1177067
36. Johnson, C. C., Peters-Burton, E. E., & Moore, T. J. (2016). STEM road map: A framework for integrated stem education. NY: Routledge.
37. Jokiranta, K. (2015). The Effectiveness of Practical work in Science Education. Bachelor‘s Thesis. Available from: https://jyx.jyu.fi/dspace/bitstream/handle/123456789/42979/URN:NBN:fi:jyu-201402181251.pdf ?sequence=1 (Accessed: 20 March 2019).
38. Kahveci, A. (2015). Assessing high school students‘ attitudes toward chemistry with a shortened semantic differential. *Chem. Educ. Res. Pract.* 16, 283–292. doi: 10.1039/C4RP00186A
39. Kan, A., and Akbaş, A. (2016). Affective factors that influence chemistry achievement (attitude and self-efficacy) and the power of these factors to predict chemistry achievement-I. *J. Turk. Sci. Educ.* 3, 76–85.
40. Kaye, G.W.C, & Laby, T.H. (2016) Tables of Physical and Chemical Constants, 16th Ed, Longman
41. Lee, M. H., Chai, C. S., & Hong, H. Y. (2019). STEM education in Asia Pacific: Challenges and development. Asia-Pacific Education Researcher, 28(1), 2–5. https://doi.org/10.1007/s40299-018-0424-z
42. Linn, M.C., Davis, E.A., & Bell, P. (eds.) (2004). Internet environments for science education. Mahwah, NJ: Lawrence Erlbaum Associates.
43. Longobardi, C., Prino, L. E., Marengo, D., and Settanni, M. (2016). Student-teacher relationships as a protective factor for school adjustment during the transition from middle to high school. *Front. Psychol.* 7:1988. doi: 10.3389/fpsyg.2016.01988
44. Madhuri, G.V., Kantamreddi, V.S.S.N., & Prakash Goteti, L.N.S. (2017). Promoting higher order thinking skills using inquiry-based learning. European Journal of Engineering Education, 37(2), 117-123. https://doi.org/10.1080/03043797.2012.661701
45. McComas, W. F. (2020). Nature of science in science instruction. Springer Nature Switzerland AG.
46. McKnight, K., Yarbro, J., Graybeal, L., & Graybeal, J. (2016). United Arab Emirates: What makes an effective teacher? [Online]. Available from:

https://www.pearson.com/content/dam/corporate/global/pearson-dot-com/files/innovation/globalsurvey/reports/RINVN11137_UAE_report_f_crops_091116.pdf (Accessed: 27th April 2019).

47. Millar, R. (2016). The role of practical work in the teaching and learning of science [Online]. Available from:https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_073330.pdf (Accessed: 27th March 2019).
48. Muthalib H. H, & Samar, N. (2018). Retooling Science Teaching on Stability on Topic For STEM Education: Malaysian Case Study. Journal of Engineering Science and Technology, 13(10), 3116–3128
49. Okam, C.C., & Zakari, I.I. (2017) Impact of Laboratory-Based Teaching Strategy on Students‘ Attitudes and Mastery of Chemistry in Katsina Metropolis, Katsina State, Nigeria. International Journal of Innovative Research and Development, 6(1), 112.
50. Piaget, J. (2017). The construction of reality in the child. UK: Routledge & Kegan Paul. https://doi.org/10.4324/9781315009650
51. Price, P., Jhangiani, R., & Chiang, I.A. (2015). Research methods in psychology (2nd ed.). Washington D.C: Saylor.org
52. Roberts, A. (2016). Practical Work in Primary School [Online]. Available from: http://www.score-education.org/downloads/practical_work/primary.pdf (Accessed: 27th April 2019).
53. Russell, C.B., & Weaver, G.C. (2018). A comparative study of traditional, inquiry-based, and research-based laboratory curricula: impacts on understanding of the nature of science. Chemistry Education Research and Practice, 12(1),. 57-67. https://doi.org/10.1039/C1RP90008K
54. Sarican, G., & Akgunduz, D. (2018). The impact of integrated STEM education on academic achievement, reflective thinking skills towards problem solving and permanence in learning in science education. Cypriot Journal of Educational Sciences, 13(1), 94–107. https://doi.org/10.18844/cjes.v13i1.3322
55. Schwichow, M., Zimmerman, C., Croker, S., & Härtig, H. (2016). What students learn from hands-on activities? Journal of Research in Science Teaching. Advance online publication. https://doi.org/10.1002/tea.21320
56. Singer, S.R., Hilton, M.L., & Schweingruber, H.A. (2016). America‘s Lab Report: Investigations in High School Science. Washington, DC: The National Academies Press.
57. Solomon, J. (2019). Envisionment in practical work. Helping pupils to imagine concepts while carrying out experiments. In J. Leach and A. Paulsen (eds.). Practical work in science education: Recent research studies, 60-74. The Netherlands: Roskilde University Press/ Kluwer.
58. Sotiriou, S., Bybee, R.W., & Bogner, F.X. (2017). PATHWAYS–A Case of Large-Scale Implementation of Evidence-Based Practice in Scientific Inquiry-Based Science Education. International Journal of Higher Education, 6(2), 8-19. https://doi.org/10.5430/ijhe.v6n2p8
59. Stanley, M. (2016). Why should physicists study history? Physics Today, 69(7), 38–44. https://doi.org/10.1063/PT.3.3235
60. Stets, J., Brenner, P., Burke, P., and Serpe, R. (2017). The science identity and entering a science occupation. *Soc. Sci. Res.* 64, 1–14. doi: 10.1016/j.ssresearch.2016.10.016
61. Sunal, C.S., Smith, C., Sunal, D.W., & Britt, J. (1998). Using the Internet to create meaningful instruction. The Social Studies, 89(1), 13-17. https://doi.org/10.1080/00377999809599816
62. Thomas, T. F (2021) Current Microbiology Research in UK. A Review Microbiology Frontiers, 2(4) PP. 407-416
63. Tobin, K. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. School science and Mathematics, 90(5), 403-418. https://doi.org/10.1111/j.1949-8594.1990.tb17229
64. Torlakson, T. (2015). Innovate: A blueprint for science, technology, engineering, and mathematics in California Public Education California: State Superintendent of Public Instruction.
65. Tsakeni, M. (2018). Inquiry-Based Practical Work in Physical Sciences: Equitable Access and Social Justice Issues. Issues in Educational Research, 28(1), 187-201.

66. Türk, N., Kalaycı, N., & Yamak, H. (2018). New trends in higher education in the globalizing world: STEM in teacher education. Universal Journal of Educational Research, 6(6), 1286–1304. https://doi.org/10.13189/ujer.2018.060620
67. Williams, D., Brule, H., Kelley, S., and Skinner, E. (2018). Science in the Learning Gardens (SciLG): a study of students‘ motivation, achievement, and science identity in low-income middle schools. *Int. J. STEM Educ.* 5, 1–14. doi: 10.1186/s40594-018-0104-9
68. Woolnough, B.E. (2018). Effective Science Teaching. Developing Science and Technology Education. Bristol: Open University Press.
69. Yore, L.D. (2015). What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform. Electronic Journal of Science Education, 5(4), 1-7.