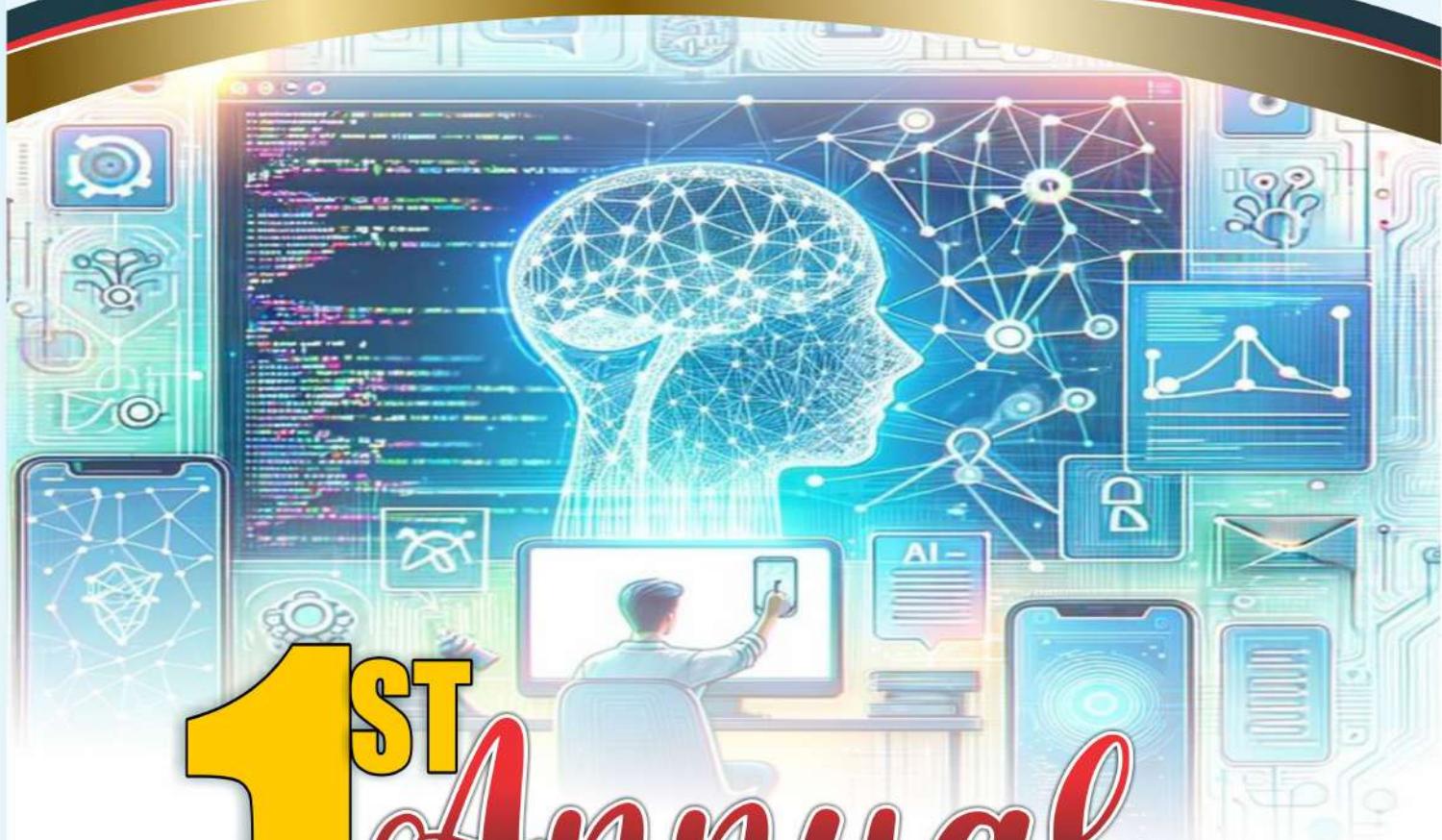




**ASSOCIATION OF SCIENCE EDUCATORS ANAMBRA (ASEA)**

<https://jisepublications.org>

**SCIENCE EDUCATORS AND DIGITAL LITERACY  
IN THE 21ST CENTURY**



**1<sup>ST</sup>**  
*Annual*  
**CONFERENCE**  
**PROCEEDINGS 2025**

**Editor**  
**Prof. Josephine N. Okoli**

# ASSOCIATION OF SCIENCE EDUCATORS ANAMBRA (ASEA)

**THEME: SCIENCE EDUCATORS AND DIGITAL LITERACY IN THE 21<sup>ST</sup>  
CENTURY**

**1<sup>ST</sup> ANNUAL CONFERENCE PROCEEDINGS, 2025**

**10- 12<sup>th</sup> July, 2025**

*Editor*

**Prof. Josephine, N. Okoli**

Printed in Nigeria by:



**Love Isaac Consultancy Services**  
No 1 Etolue Street, Ifite Awka, Anambra State, Nigeria  
+234-803-549-6787, +234-803-757-7391

© ASSOCIATION OF SCIENCE EDUCATORS ANAMBRA (ASEA). All rights reserved

**Published in June, 2025**

**ISBN: 978-978-695-937-5**

## TABLE OF CONTENT

Members of Conference Planning Committee	v
Local Organizing Committee (LOC)	v
Programme of Events	v
Meritorious Awardee of Dr. Samuel Alfayo Boh	vi
Foreword	viii
Preface	ix
<b>Presidential Address</b>	<b>x</b>
Keynote Presentation	1
Lead Paper Presentation	11
<b>Paper 1</b>	<b>26</b>
<b>Digital Literacy Competence as a Predictor of Secondary School Students' Achievement in 21st Century Mathematics Classroom</b>	
<i>Emekastandhope I, Dr. Njoku, Celestine</i>	
<b>Paper 2</b>	<b>35</b>
<b>Effectiveness of Digital Literacy Skills in Personalized Learning of Preservice Mathematics Teachers: Implications for Achievement</b>	
<i>Dr. Ogoke, Chinemeze James, Dr. Otumegwu Tina Uchenna, Achugamunu, Pius C, Uguru Ndubuisi Okon</i>	
<b>Paper 3</b>	<b>44</b>
<b>Staff Level of Awareness on the use of Google Scholar as Learning Resource in Colleges of Education</b>	
<i>Dr. Johnbosco O.C. Okekeokosisi, Kate C. Okoh</i>	
<b>Paper 4</b>	<b>50</b>
<b>Utilizing Digital Literacy Tools as Panacea to Effective Teaching and Learning in Secondary Schools in Orumba South Local Goverment Area</b>	
<i>Anaekwe Grace. U, Okoye Nestor E.</i>	
<b>Paper 5</b>	<b>57</b>
<b>Physical and Health Education and Digital Literacy in The 21<sup>st</sup> Century</b>	
<i>Ahueansebhor Emmanuel, Ayito, Victor Effiom, Urom, Rademene Emmanuel</i>	
<b>Paper 6</b>	<b>67</b>
<b>Exploring the Virtual Learning Environment in the Teaching and Learning of Biology for Enhanced Students' Outcome.</b>	
<i>Dr. Blessing Ifeoma Okafor, Chukwuma C. Ekechukwu</i>	
<b>Paper 7</b>	<b>75</b>
<b>Assessing the Effectiveness of Online Platforms in Education for Teaching and Learning for Sustainable National Development</b>	
<i>Doris N. Akhator, Inaya Adesuwa</i>	
<b>Paper 8</b>	<b>84</b>
<b>Effects of Science Video Instructional Strategy On Students' Academic Achievement in Chemistry Among Secondary Schools in Yenagoa Metropolis, Bayelsa State</b>	
<i>Dr. Moses John Billy</i>	
<b>Paper 9</b>	<b>95</b>
<b>Internet of Things Enabled Smart Environmental Monitoring System Based on the Espressif System 32 Microcontroller</b>	
<i>Udeze Jireh Chukwuma</i>	
<b>Paper 10</b>	<b>107</b>
<b>Digital Literacy and Teachers' Effective Teaching of Mathematics</b>	

<b>in Public Secondary Schools in Oron Local Government Area of Akwa Ibom State, Nigeria</b>	
<i>Dr. Ekpenyong Effiong Ibok, Dr. Raymond Ogbebe Ogar, Nene Amos Williams</i>	
<b>Paper 11</b>	<b>117</b>
<b>Digital Literacy and Utilization of Educational Technologies among Basic Science Teachers in Anambra State: Implications for Effective Science Teaching</b>	
<i>Prof. Okoli Josephine Nwanneka, Christian-Ike, Nwanneka Oluchukwu</i>	
<b>Paper 12</b>	<b>127</b>
<b>Assessment of Digital Literacy of Computer Teachers in the Utilization of Computer Aided Instruction in Teaching Data Processing in Anambra Schools</b>	
<i>Ibe Perpetual Nwakaego, Engr. Ololo Emmanuel Chimezie, Dr. Eze Irene Febechi, Mokwe Nkiru Celine</i>	
<b>Paper 13</b>	<b>136</b>
<b>Contemporary Economic Realities and the Sustainability of Academic Programmes in Secondary Schools in Okpe Local Government Area, Delta State</b>	
<i>Dr. Perekeme Peresuode, Okoye Grace Nwakaego, Onyeka Patience</i>	
<b>Paper 14</b>	<b>145</b>
<b>Digital Assessment of School Climate and Its Predictive Influence on Chemistry Achievement among Secondary School Students in Imo State</b>	
<i>Akanazu, Grace O., Dr. Akanazu, Eze C.</i>	
<b>Paper 15</b>	<b>154</b>
<b>Effects of Google Classroom on Students' Achievement in National Business Certificate (NBC) Year 11 Accounting Students of State Technical Colleges</b>	
<i>Chika M. Okonkwo</i>	
<b>Paper 16</b>	<b>165</b>
<b>Physical and Health Education and Digital Literacy in The 21<sup>st</sup> Century</b>	
<i>Dr. Ofordum, Maryann Chigozie, Obijekwu, Olivia Ogechukwu</i>	
<b>Paper 17</b>	<b>168</b>
<b>Collaboration Between Science and Physical and Health Educators in Promoting Digital Health Literacy</b>	
<i>Omeje Chigozie Sabina, Ogbonna Marachi Samuel</i>	
<b>Paper 18</b>	<b>177</b>
<b>The Use of Video Analysis in Sports in The 21<sup>st</sup> Century: Advantages and Disadvantages</b>	
<i>Dr. Theresa Nkiru Uzor, Dr. Anthonia Chinyere Uwa</i>	
<b>Paper 19</b>	<b>185</b>
<b>The Influence of Digital Literacy on Students' Scientific Inquiry Skills: Educators' Perspectives in Orumba South Local Government Area, Anambra State</b>	
<i>Okoli Nneka Chigozie, Nwankwo Glory Ure, Agbasi Obioma Lucy</i>	
<b>Paper 20</b>	<b>195</b>
<b>The Impact of Pictures and Videos as Digital Tools in Teaching Physics in the Nigerian Education System</b>	
<i>Atuluku Grace Ikoojo, Okpaneje Onyinye Theresa</i>	
<b>Paper 21</b>	<b>200</b>
<b>Empowering Chemistry Educators with Digital Literacy for 21st Century Classrooms</b>	
<i>Akubue Prince Chidi, Ezeabasili Peter Ikechukwu, Onukwube Sunday Ikechukwu</i>	

## MEMBERS OF CONFERENCE PLANNING COMMITTEE

**Dr. Moses, John Billy (Chairman)**

Science Education Department  
Faculty of Education, Niger Delta University  
Wilberforce Island, Bayelsa State.

**Ahueansebhor Emmanuel**

Human kinetics and Sports Science Department  
Faculty of Science Education,  
University of Calabar,  
Calabar - Nigeria.

**Akanazu, Eze C.**

Department of Chemistry  
Alvan Ikoku Federal University of Education, Owerri,  
Imo State, Nigeria

**Dr. Ofordum Maryann C.**

Physical and Health Education Department  
Federal College of Education (Tech) Umunze,  
Anambra State, Nigeria

**Ass. Prof. Esther B. Enaregha (Sec.)**

Isaac Jasper Boro College of Education Sagbama  
Bayelsa State, Nigeria

**Dr. Njoku Celestine**

Department of Mathematics and Computer  
Science Education, University of Calabar Cross  
River  
State, Nigeria

## LOCAL ORGANIZING COMMITTEE

**Mrs. Amaka Grace (Chairman)**

Physical and Health Education Department  
Federal College of Education (Tech) Umunze,  
Anambra State, Nigeria

**Ogbonna Marachi Samuel (Sec.)**

Physical and Health Education Department  
Federal College of Education (Tech) Umunze,  
Anambra State, Nigeria

**Usan Peter**

Chemistry Department  
Federal Technical College, Awka,  
Anambra State, Nigeria

## PROGRAMME OF EVENTS

- Opening Praying
- Chairman's Opening Remark
- Breaking of Kola nut
- Welcome Address by the acting President of the Association
- Keynote Presentation by Prof. Cecilia O. Ekwueme
- Lead Paper Presentation by Prof. Telima Adolphus
- About the Electronic Book / Unveiling of Book Chapter – E-Book launch
- Item 7
- Meritorious Award
- Paper Presentations

## **MERITORIOUS AWARD**

### **CITATION OF Dr SAMUEL ALFAYO BOH**



It is my pleasure and singular honour to be called upon to read a citation on one of the eminent Doctor that the family of Alfayo has ever produced.

People are not chosen for their comfort, they most often to prepare for a life of self sacrifice and even sufferings on behalf of other. And most often their calling is not for privilege but for service. Whichever prism you use in view him, Dr Samuel Alfayo Boh a class teacher of high repute, a man of integrity and fear of God, sacrifices and service for the betterment and advisement of humanity.

May, 18, 1969 marked the beginning of the steadily progressive son of Boh colored mother and the Shongomite father. This account of this childhood and youth in Gombe State shows the prince he had to pay for such a birth. It did not take long before he was revealed as a man of vision and mission as every step he took in both early life and now was clogged with success, and a wide breath of accomplishment.

Dr.Samuel Alfayo Boh spends is early life in Boh with his parent. He attended Boh primary school from 1976 to1984 exposed his qualities as a gifted child enable him to proceed to Government Science Secondary School Kaltungo 1984 to 1987,Teachers College Gombe 1988 to 1990 the exceptional this qualities made way for him to enlist to College of Education Azare 1993 where he bagged National Certificate in Education (NCE) while in Azare, he was elected parliamentary student union 1994 to 1995 session and thereafter in the year 1987, he proceeded to famous University of Maiduguri Borno State and had a Bachelor of Education and passed with flying colours in 2000. Diploma in World Evangelism Mission Training Institute in Borno State in 1999. In 2001, the indefatigable Samuel was drafted in to the National youth service scheme in Tsafe, Zamfara State his service witnessed a continued story of one success after another like the Nehemiah of the Holy Bible. As a man who fully understand what benefits education could bring his way when tapped. Dr Samuel did not hesitate to define where he was headed for in that direction. In 2004, he gain admission to University of Maiduguri, Borno States as an intelligent

student, he graduated in 2008 with Master of Education in Curriculum and Instruction (M.ED). Diploma and Certificate in computer 2009. In the year between 2013 to 2016 he bagged Masters in Guidance and Counseling in Theological Seminary College Kaltungo in Gombe State. Moreover, the influence this celebrated academia exerted on him equipped him to master the techniques of research, the canons of interpretation and reconstruction of academic research, the craft and skills involved and teacher – students relationship in 2010 he proceeded to one of the best University in Nigeria University of Nigeria Nsukka in Enugu State and come out with Doctor of philosophy (Ph.D) in Curriculum and Instruction.

A man with a formidable profile charismatic personality, Dr Samuel is indeed an achieve per excellence he has not only carved a niche for himself, but has also made name and reputation in Nigeria. He has always impacted positively in the lives of everyone he meets. He has also shown high sense of professionalism and dedication to the service of humanity. On several occasion Samuel has interrupted his travels to attend to civilian, accident victims and he has truly saved a lot of lives.

Dr. Samuel Alfayo Boh started his civil service career as a classroom teacher; he had a little starting with the noble teaching profession. In 1996 he took appointment with Boh primary school, Labeke primary school in 1997, Kulishin primary school 1999, Pivotal Teachers Training Programme Lapan in 1999. In 2000 He moved to Government Day Secondary School Boh. In 2000 Tutor Senator T.U. Wada Educational Emancipation Scheme. Presently, lecturer with Federal University Kashere, in the Department of Educational Foundations

Dr. Samuel is a versatile personality of note and a man of many parts. He is fondly referred to as sport, Author and a born teacher of good repute. In his romance with great academics, he has received more than twenty awards, member of many associations, he has presented more than thirty academic papers in both international and national journals, he has published Ninety journals, sixteen book chapters, he has written eight books, presently chairman board of governors Jim Collis Kufai, fellow members of more than seven associations, former permanent commissioner sports commission Gombe State, chairman and secretary of many association, He is happily married to Mrs. Abigail Samuel and blessed with many children.

Having described himself as an enterprising person who has excellence attached to his name, Dr Samuel Alfayo Boh evinces a friendly disposition towards his students. He is a strong advocate of treating students with understanding and affection, Dr. Samuel incontestably mentors, counsels, reprimands, sympathizes and assists his young and old alike. Some of his students describe him as a luminous teacher whose passion for academic scholarship is infectious and whose pedagogical principle skills and friendly disposition are so admirable and endearing that attendance at his lectures is always high and far outstrips most others.

Ladies and gentlemen, Dr. Samuel Alfayo Boh is a small figure on the physical appearance. It is my great honour and privilege to call on this academic repute, erudite, scholar, indefatigable and inspirational mentor, community lover, and motivator ardent love of Shongomite culture and humanist to graciously joint the chairman and other for the formal presentation of this fabulous awards to acknowledge to celebrate his hard word, disciplines, kindness, humanness and commendable role he is playing in the academic careers and character-building

## FOREWORD

It is with profound pride and optimism that I write this foreword to the maiden Book of Conference Proceedings of the Association of Science Educators Anambra State a timely and significant academic documentation that captures the robust engagements, research contributions, and transformative ideas presented at the 1st Annual Conference of the Association, scheduled for July 10, 2025, in Awka, Anambra State, Nigeria.

The conference, with the theme “Science Educators and Digital Literacy in the 21st Century,” could not have come at a more opportune moment. In an age where digital transformation is rapidly redefining education, economy, and society, the role of science educators in equipping learners with not only scientific knowledge but also digital competencies has become more critical than ever. The conference offered a strategic platform for scholars, researchers, policy makers, and practitioners to interrogate, share, and shape new pedagogical paradigms that incorporate digital literacy into the fabric of science education.

In his address of welcome, the Acting President of ASEA, Dr. Johnbosco O.C. Okekeokosisi, delivered a compelling call to action. He set the tone by acknowledging the historical importance of the event and the noble mission of ASEA to champion science education across Anambra State and beyond. His words reflected a clear vision of collective progress, innovation, and institutional synergy. Most notably, Dr. Okekeokosisi emphasized that digital literacy in science education is not merely about embracing technological tools but about empowering both educators and learners to critically engage, create, and transform scientific knowledge for societal advancement.

This compilation of conference proceedings is more than a record of presentations—it is a testimony to the enduring commitment of Nigerian science educators to adapt to global educational trends. With insightful keynote and lead paper presentations by eminent scholars such as Prof. Cecilia O. Ekwueme and Prof. Telima Adolphus, participants were exposed to a breadth of ideas, models, and classroom innovations. These contributions are now immortalized in this volume, accessible to researchers, policymakers, and education stakeholders worldwide. The articles by contributors are of quality standard and intimately related to the conference theme.

The proceedings are also a celebration of collective effort. Dr. Okekeokosisi rightly acknowledged the contributions of past leaders of STAN, the Executive Principal of Igwebuike Grammar School, the Local Organizing Committee, and institutional partners who ensured the success of this pioneering event. Their efforts reflect a shared belief in the transformative power of science education when driven by vision, collaboration, and strategic digital integration.

This book also symbolizes the maturity and forward-thinking disposition of ASEA. With its proceedings published online in the Association’s official website ([www.jisepublications.org](http://www.jisepublications.org)), ASEA is setting a benchmark for academic visibility, accessibility, and global relevance. The initiative aligns perfectly with the conference theme—leveraging digital platforms for knowledge dissemination.

As readers engage with the rich content within this publication, it is my hope that they find not only knowledge but also inspiration to further the cause of digital transformation in science education. May this volume serve as a resource, a reference, and a rallying point for continued innovation, research, and excellence in digital literacy, science teaching and learning.

**Prof. Marcellinus C. Anaekwe**  
**manaekwe@noun.edu.ng**  
**National Open University of Nigeria,**  
**Abuja.**

## PREFACE

Digital literacy in the 21st century is crucial for science educators to effectively teach and prepare students for a rapidly evolving scientific and technological world. Science educators must embrace digital tools and resources to enhance their teaching methods and foster students' scientific literacy, critical thinking and problem-solving skills. This includes leveraging online platforms, using educational technologies and digital content to create engaging and meaningful learning experiences.

In this conference proceedings efforts has been made towards promoting the use of digital tools in science education.

**Prof. Josephine N. Okoli**

Science Education Department

Nnamdi Azikiwe University, Awka,

Anambra State, Nigeriascience

**ADDRESS OF THE ACTING PRESIDENT OF ASSOCIATION OF SCIENCE EDUCATORS ANAMBRA (ASEA), DR. JOHN BOSCO O.C. OKEKEOKOSI, AT THE OPENING CEREMONY OF THE 1ST ANNUAL CONFERENCE HELD IN AWKA, ANAMBRA STATE, NIGERIA ON 10<sup>TH</sup> JULY, 2025**

**Theme: “Science Educators and Digital Literacy in the 21st Century”**

Distinguished Guests,

Mother of the Day, and Executive Provost of the Federal College of Education (Technical), Umunze, Prof. Tessy O. Okoli

Past and Immediate Past Chairmen of the Anambra State Chapter of the Science Teachers Association of Nigeria (STAN), Prof. C.V. Nnaka, Dr. Christiana U. Ezenduka Past and Immediate Past Secretary of the Anambra State Chapter of the Science Teachers Association of Nigeria (STAN), Dr. Chinwe B. Njelita, Mr. Kingsley N.C. Ezeokeke

The Executive Principal of Igwebuike Grammar School, Awka, Mrs. Amaka Ifebili

Our Esteemed Keynote and Lead Paper Presenters, Profs: Cecilia O. Ekwueme, Telima Adolphus

Meritorious Awardee, Dr. Samuel Alfayo Boh

Representatives of Educational Institutions, Pharm. Adauzoh C. Joe-Obasi

The Conference Planning Committee

The Local Organizing Committee (LOC),

My Fellow Science Educators,

Ladies and Gentlemen.

It is with deep humility and immense pleasure that I stand before you today as the Acting President of the Association of Science Educators Anambra (ASEA), to welcome you all to this historic gathering — the **1st Annual Conference** of our noble Association, taking place here in the vibrant capital city of Awka, Anambra State.

This moment marks a milestone in the life of our Association and in the educational landscape of our dear state. Today, we have gathered not just to deliberate on academic issues, but to collectively reflect on and shape the role of science educators in a rapidly changing digital world. The presence of each one of you here is a testament to your dedication to the advancement of science education in Nigeria, and in particular, in Anambra State.

Let me begin by extending heartfelt gratitude to our **Mother of the Day**, the erudite and distinguished **Executive Provost of the Federal College of Education (Technical), Umunze**, for honoring our invitation. Your presence is a great source of inspiration, and we are immensely grateful for your unwavering support towards science and technical education in the state. The Host and Board of Directors, Prof. Josephine N. Okoli, Prof. Isaac N. Nwankwo, Prof. M.C. Anaekwe

Chairman of the occasion Ass. Prof. Peter I.I. Ikoku

To the **Past Chairman and Immediate Past Chairman of Anambra State STAN**, we salute you. You laid the foundation for excellence and integrity in science education upon which ASEA continues to build. We are proud to carry forward the torch of progress you lit. Your legacies continue to motivate and guide our mission as science educators.

We also sincerely appreciate the **Executive Principal of Igwebuik Grammar School, Awka**, for the enormous and selfless support towards the successful hosting of this conference. Your generosity and logistical assistance have played a crucial role in bringing this vision to reality. We are proud to host this conference within your institution, and we thank you for embracing the ASEA family.

Special thanks also go to our **Keynote and Lead Paper Presenters**, whose scholarship and insight will surely enrich our understanding of the conference theme: *“Science Educators and Digital Literacy in the 21st Century.”* You are the thought leaders that will help us navigate this complex but exciting intersection between pedagogy and technology.

Meritorious Awardee, **Dr. Samuel Alfayo Boh**, whose contributions to teaching and learning in tertiary institutions lead to the foundation of our members.

The **representatives of educational institutions**, both public and private, we acknowledge your partnership and presence. Your contributions, ideas, and institutional support are essential in sustaining quality science education. Together, we can foster a generation of scientifically literate citizens equipped for the demands of the 21st century.

Let me also specially recognize the tireless efforts of the **Local Organizing Committee (LOC)**. You have worked round the clock, attending to logistics, communications, hospitality, and a host of behind-the-scenes responsibilities. This conference would not be possible without your selfless commitment. I say, “Well done!”

This conference has its theme **“Science Educators and Digital Literacy in the 21<sup>st</sup> Century”**. The theme is very apt considering the fact that we are in the digital age. Thus, the committee on conference looked inward to provide this conference theme for science educators to understand, educate, re-educate, write and deliberate on the effective use of digital tools – technologies in our present time for effective instructional delivery. Participants will be taken through hands-on and minds-on activities in various sessions and they will find the conference package very rewarding. I invite you to pay attention during keynote address to be presented by Prof. Cecilia O. Ekwueme, the Dean Faculty of Science Education, University of Calabar, Cross-River State, Nigeria. Your continuous attention is also needed during the lead paper presentation of Prof. Telima Adolphus of Rivers State University, PortHarcourt, Nigeria.

To all **participants** – educators, researchers, students, policy makers – thank you for making out time to be here. Your presence signifies hope for the future of science education. I urge you to make the most of this gathering by networking, exchanging ideas, and exploring new strategies to embed digital literacy in science classrooms and curricula.

As we delve into this conference theme, let us remember that digital literacy is not just about the use of devices or softwares. It is about empowering both teachers and learners to navigate, create, and critically evaluate digital content. It is about transforming science education into an interactive, engaging, and accessible experience that prepares our students for global competitiveness. We must rise to this responsibility with courage, collaboration and innovation.

As we officially declare this conference open, let us do so with a shared sense of purpose and vision. Let us reflect deeply, discuss intelligently and leave this gathering better equipped to build a technologically savvy and scientifically vibrant society.

Ladies and Gentlemen, it may interest us to note that this young growing association has an online Journal, Electronic Book (e-book) and Conference Proceedings. The E-Book and Conference Proceedings were hosted online at the association's website ([jisepublications.org](http://jisepublications.org)) for its visibility. It is obvious that this association has come to stay. To God be the glory.

Once again, I welcome you all to the 1st Annual Conference of the Association of Science Educators Anambra (ASEA). May our deliberations be fruitful, and may the bonds we forge here today grow stronger for the benefit of science education in our state and beyond.

Thank you, and God bless you all.

**Dr. Johnbosco O.C. Okekeokosisi**

Federal College of Education (Tech) Asaba,  
Delta State, Nigeria  
Acting President, ASEA  
10th July, 2025

## PAPER 8

# EFFECTS OF SCIENCE VIDEO INSTRUCTIONAL STRATEGY ON STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY AMONG SECONDARY SCHOOLS IN YENAGOA METROPOLIS, BAYELSA STATE

**Dr. Moses, John Billy**

[mosesjohnbilly@gmail.com](mailto:mosesjohnbilly@gmail.com), [mosesjohnbilly@yahoo.com](mailto:mosesjohnbilly@yahoo.com)

Science Education Department

Faculty of Education, Niger Delta University

Wilberforce Island, Bayelsa State, Nigeria.

### Abstract

*This study explored the "effects of science video instructional strategy on students academic achievement in chemistry." The study adopted the "pre-test and post-test control group quasi-experimental design." Four secondary schools in Yenagoa Metropolis were purposively selected, and the SS1 intact class from each of these schools was used. 111 students participated in the study. Two schools each were randomly assigned to experimental and control groups. Instruments for data collection were two instructional guides and the Chemistry Achievement Test (CAT). The CAT had a reliability of 0.76 using Kuder-Richardson Formula 21 (KR-21). Data was analysed using "mean, standard deviation, and Analysis of Covariance (for the null hypotheses)". The findings of the study showed that students taught using the science videos instruction significantly outperformed those taught with conventional lecture strategies, and gender did not significantly influence students' achievement. It was recommended among others that teachers should make use of science videos to aid chemistry teaching especially when dealing with complex concepts.*

**Keywords:** Science Video Instructional Strategy, Academic Achievement, Modified Lecture Strategy, Gender

### Introduction

Chemistry is one of the most essential fields in the world today. Grancharova (2024) describes it as a central science as it bridges other sciences. It deals with the study of matter, including its composition, structure, properties, and changes (Haynes & Blackie, 2021). It also explores the interactions between different substances and their transformation through reactions.

Chemistry is associated with a wide range of functionalities which has made it quite an important field in various aspects of life. For instance, chemistry is an indispensable element in medicine and healthcare (Rafique, Saddiq, Ashfaq, Akmal, RabiaMehvish, Yousaf, Rahila Yasmeen, Akram & Ullah, 2024). It is necessary for developing items like pharmaceuticals, vaccines and even diagnostic tools. Chemistry is also an important element of agriculture as it is useful in essential activities such as the production of fertilisers and pesticides and the enhancement of crop and animal production. Chemistry is also an essential variable in environmental protection which is a major concern today (Ali & Khan, 2017). Amongst others, chemistry has enabled the development of sustainable materials, and alternative energy sources.

Chemistry has also made significant contributions towards addressing global challenges like climate change (World Economic Forum, 2021). Overall, chemistry and its application is a constituent factor for progress and improvements in quality of life.

Considering just how important the field is, it is thus essential to have individuals who are adequately knowledgeable in this domain. As such, there is a need to ensure a good achievement rate in the subject among students. However, this is not necessarily being achieved. Anaso (2024) states that "despite the central and important role that chemistry plays in the lives of the individual and the nation as a whole, poor academic achievement of students in chemistry at secondary level still persist" (p. 162).

At the core of students' achievement in chemistry is the way chemistry is being taught. Typically, in classrooms, chemistry institution is carried out through variations of the lecture method, which is one of the most commonly used instructional strategies in history (Akor, Subari, Jambari, Noordin & Onyilo, 2019). A major characteristic of the lecture method is its one-way flow of information from teacher to students (Tufail & Mahmood, 2020). In adopting this strategy, teachers present learning content or information to a class of students of varying sizes, who are expected to listen to the teachers. The lecture method is typically accompanied by note giving and taking as well as activities like brief questions and answer sessions.

The lecture method is not without its advantages, and it is those advantages that have facilitated its unparalleled use in formal learning institutions. Prominent among these advantages is its functionality in effectively delivering large amounts of learning content to students at the same time (Rahman, 2020). It has also been associated with ease of planning and application. However, in several learning contexts, particularly in learning science fields like chemistry, these advantages are not enough to compensate for the limitations of the lecture method.

A prominent limitation recognized as impeding the effectiveness of the traditional lecture method is its lack of support for active learning (Zakrajsek, 2018). However, in recent years, teachers have taken steps to ensure more student engagement in the learning process, leading to modified versions of the lecture method. However, the lecture method is still inherently flawed as it places too much emphasis on the teachers doing the bulk of the work when it comes to students learning. Addae and Quan-Baffour (2018) state that in the lecture method, teachers are often required to take the role of repository of knowledge, responsible for transmitting such knowledge to the students with little student involvement.

The lecture method is also ineffective for engaging students in the learning process, leading to reduced interest and attention and hence impeding learning outcomes. Mansir, Tumin and Purnomo, (2020) assert this stating that a major disadvantage of the lecture method is that it tends to facilitate disengagement and boredom.

At the root of the deficiencies of the lecture method is how it doesn't align or is based on how people actually learn. For instance, research has demonstrated that for meaningful learning to occur, students need to take an active role in learning by constructing new learning to prior knowledge (Darling-Hammond, Flook, Cook-Harvey, Barron & Osher, 2020; Kostiainen, Ukskoski, Ruohotie-Lyhty, Kauppinen, Kainulainen, & Mäkinen, 2018; Lombardi Shipley, Astronomy Team, Biology Team, Chemistry Team, Engineering Team, Geography Team, Geoscience Team, & Physics Team, 2021). In the lecture strategy, little opportunities are typically

provided to achieve this. The lecture method is also ineffective in accommodating different learning styles and preferences.

Based on these limitations, there is a need to explore other approaches through which subjects like chemistry can be taught. A common recommendation in this context is the integration of technology into the instructional process. This integration involves using digital tools and resources to enhance the teaching and learning process. It is often termed as e-learning, and the technology used is referred to as educational technologies.

The use of technology for educational activities holds several benefits and advantages. One of such benefits is that it allows the presentation of information in innovative and diverse ways (Haleem, Javaid, Qadri & Suman, 2022). For instance, with the aid of technology information can be presented through multimedia, virtual simulations, and even gamified activities. Technology also comes equipped with tools and features that are supportive of a more interactive and inclusive classroom.

Technological tools can also be used to foster personalised learning. This is achievable through tools like adaptive learning platforms and analytics (Kem, 2022). These tools are capable of analysing students' performances and using that information to provide personalised content based on the needs of the individuals, as well as their strengths and weaknesses. With these digital tools, students can receive better access to additional support if needed, while advanced learners can be challenged with more complex materials or levels. Furthermore, one major benefit of technology in education is that it grants access to a vast and unparalleled repository of learning materials and resources across diverse formats (Kalyani, 2024).

Technology is also notable for its communication tools and features, such that it could enhance collaboration and communication in the learning process (Ratheeswari, 2018). For instance, tools like cloud-based platforms, video conferencing software, and collaborative apps enable students to work together on projects, share ideas, and provide feedback in real-time, regardless of their physical location.

A notable approach to integrating technology into the learning process is the use of multimedia to carry out or support the learning process. The use of multimedia like science videos has over time emerged as a pivotal strategy when using technology in the learning process.

Science videos are particularly useful when teaching abstract concepts, which is a characterising feature of several domains in the sciences. Science videos are functional as traditional methods like textbooks and lectures may not be enough to convey abstract and complex concepts and intricate processes. Science videos can be used to offer students a visual and auditory representation of scientific principles, rather than just learning theoretically (Shao, Tang & Zhang, 2024).

The visual learning achievable through science videos can help enhance the students' understanding and comprehension of concepts (Alabi, 2024). Avado Learning (2021) states that a significant portion of the population are visual learners and are thus likely to learn better when information is visually presented to them. Science videos excel in this regard as they can make use of various content types like animations, real-world footage, diagrams, and simulations (among others) to illustrate concepts like chemical reactions.

The use of science videos can also foster engagement and interest (French, Ravn, Balcaite, & Moore, 2023). These increased interest and engagement are likely to translate to better academic outcomes. Science videos are also notable for their accessibility and flexibility. These videos can be sent to students and they can watch at their own pace, and even pause to take notes or replay as much as needed to grasp the concept.

The use of science videos also supports the incorporation of real-world contexts or applications into the learning process. In line with this, Muhtarova (2023) states that "authentic video materials bridge the gap between classroom instruction and real-world context". For instance, the videos can include real-world examples of the concepts or processes being explained.

Thus, this study explores how using science videos to support teaching in the classroom can affect students' achievement in chemistry. The study also explores the moderating effects of gender.

### **Statement of the Problem**

Chemistry is an important field of study in our world and is rooted in global advancements as well as the expansion of knowledge about the world. As such, ensuring a good achievement rate in this field is quite essential, particularly at the secondary level of education which directly determines the pathway for further studies and thus, students' professional future. However, the traditional mode of instruction in chemistry just like other subjects is often lecture-based, which is limited in ensuring meaningful learning and understanding, particularly when dealing with abstract and complex concepts.

The use of technology in the instructional process is a common recommendation to address this issue, as advancements in technology have brought about several innovations in the instructional process. Multimedia resources like science videos are relevant in this context, as they could prove valuable in communicating intricate scientific concepts and complex processes in chemistry. However, the functionalities of science videos are still not adequately explored or leveraged in Nigeria (specifically in Bayelsa state).

Thus, considering the potential of science videos in enhancing learning outcomes, this study seeks to explore how science video-based instructional strategy can affect students' achievement in chemistry.

### **Purpose of the Study**

This study investigated the effects of science videos instructional strategy on students' academic achievement in chemistry among secondary schools in Yenagoa Metropolis, Bayelsa State. Specifically, the study;

1. investigated the chemistry mean achievement scores of students taught through the science video instructional strategy and those taught through the modified lecture method.
2. assessed the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught through the modified lecture method.

## **Research Questions**

The following research questions guided the study;

1. What are the chemistry mean achievement scores of students taught through the science video instructional strategy and those taught through the modified lecture method?
2. What are the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught through the modified lecture method?

## **Hypotheses**

1. There is no significant difference in the chemistry mean achievement scores of students taught through the science video instructional strategy and those taught through the modified lecture method.
2. There is no significant difference in the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught through the modified lecture method.

## **Methodology**

The study adopted the "pretest, posttest quasi-experimental research design." The study involved two groups of students designated as the experimental and control group. The experimental group received classroom instruction through science videos, while the control group received classroom instruction through modified lecture method.

The population of the study consisted of all SS1 students in public secondary schools in Yenagoa, Bayelsa state. Four schools were selected through purposive sampling techniques. The sampling was based on the following criteria: "the school must be a public secondary school, and the school must have experienced chemistry teachers willing to be involved. Two schools each were randomly assigned into control and experimental groups.

The instrument for data collection included "Instructional Guide for Science Videos Strategy (IGSVS), Instructional Guide for Modified Lecture Method (IGMLM), and Chemistry Achievement Test (CAT)". The IGSVS and IGMLM were used to teach the experiments and control groups respectively. The CAT was used to measure students' achievement in chemistry. The Instruments were validated using expert review. The reliability of the CAT was established using Kuder Richardson Formula 21 (KR-21) after being administered to 30 students outside the research population. This yielded a reliability coefficient of 0.76.

Data collection commenced after seeking permission from school head teachers. The first week of data collection was spent training chemistry teachers in each school to serve as research assistants, particularly in the use of the instructional guides. At the end of the first week, the CAT was administered to the students as pretest. The next two weeks were used for classroom instruction in chemistry through the instructional guides. The final week of data collection was used to re-administer the CAT as posttest. Data was analysed using mean and standard deviation for the research questions, while Analysis of Covariance was used for the null hypotheses.

## Results

**Research Question 1:** What is the chemistry mean achievement scores of students taught through the science video instructional strategy and those taught through the modified lecture method.

**Table 1: Summary of Mean and Standard Deviation of Pre-test and Post-test Scores Showing the Effects of Instructional Strategies on Students' Achievement in Chemistry**

Instructional Strategies	N	Pre-test Scores		Post-test Scores		Mean Gain
		Mean	STD	Mean	STD	
Science Videos	58	42.07	4.56	76.17	6.99	34.1
Lecture Method	53	47.17	4.98	54.72	7.36	7.55
Total	111	41.64	4.77	65.93	12.92	24.29

Table 1 shows that the posttest mean score of students taught through the science videos instructional strategy ( $M = 76.17$ ,  $SD = 6.99$ ) is greater than those taught through the modified lecture method ( $M = 54.72$ ,  $SD = 7.36$ ). The table further shows that the mean gain score of students taught through the science videos instructional strategy (34.1) was greater than that of students taught using the modified lecture method (7.55). Consequently, ANCOVA was used to determine the Significance of the observed difference.

**Research Question 2:** "What is the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught with the modified lecture method?"

**Table 2: Summary of Mean and Standard Deviation of Pre-test and Post-test Scores Showing the Effects of Instructional Strategies on Male and Female Students' Achievement in Chemistry**

Instructional Strategies	Gender	N	Pre-test Scores		Post-test Scores		Mean Gain
			Mean	STD	Mean	STD	
Science Videos Strategy	Male	28	41.57	4.30	74.86	7.97	33.29
	Female	30	42.53	4.81	77.40	5.80	34.87
	Total	58	42.07	4.56	76.17	6.99	34.1
Modified Lecture Method	Male	27	40.89	5.78	54.30	7.42	13.41
	Female	26	41.46	4.10	55.15	7.42	13.69
	Total	53	47.17	4.98	54.72	7.36	7.55
Total	Male	55	41.24	5.04	64.76	12.88	23.52
	Female	56	42.04	4.49	67.07	12.97	25.03
	Total	111	41.64	4.77	65.93	12.92	24.29

In Table 2 shows that for students taught through the science videos instructional strategy, the posttest score of female students ( $M = 77.40$ ,  $SD = 5.80$ ) was greater than that of male students ( $M = 74.86$ ,  $SD = 7.97$ ). For students taught through the modified lecture method, the posttest mean score of female students ( $M = 55.15$ ,  $SD = 7.42$ ) was also greater than that of male students ( $M = 54.30$ ,  $SD = 7.42$ ). Thus, the total mean posttest score of female students ( $M = 67.07$ ,  $SD = 12.97$ ) was greater than that of male students ( $M = 64.76$ ,  $SD = 12.88$ ). The table further shows that female students had a greater mean gain score (25.03) than male students 23.52. Consequently, ANCOVA was used to determine the significance of the observed differences.

**H01:** "There is no significant difference in the chemistry mean achievement scores of students taught through the science video instructional strategy and those taught with the lecture method."

**Table 3: One-way Analysis of Covariance of the Post-test Chemistry Achievement Scores of Students taught through the Science Videos Strategy and those taught with the Modified Lecture Method**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12750.797 <sup>a</sup>	2	6375.399	122.940	.000	.695
Intercept	6284.168	1	6284.168	121.181	.000	.529
Pretest	2.404	1	2.404	.046	.830	.000
Instructional Strategies	12667.134	1	12667.134	244.267	.000*	.693
Error	5600.626	108	51.858			
Total	500812.000	111				
Corrected Total	18351.423	110				

<sup>a</sup>. R Squared = .695 (Adjusted R Squared = .689), \*Sig at p < 0.05."

The result in Table 3 shows that there is a significant main effect of instructional strategy on students' mean achievement scores,  $F(1, 108) = 244.267$ ,  $p < 0.05$ , partial eta squared = .693. This gives an effect size of 69.3%. Thus, the null hypothesis which states that "there is no significant difference in the chemistry mean achievement scores of students taught through the science video instructional strategy and those taught with the lecture method" is rejected.

**H02:** "There is no significant difference in the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught with the lecture method".

**Table 4: Two-way Analysis of Covariance of the Post-test Biology Achievement Scores of Male and Female Students taught through the Science Videos Strategy and those taught through the Lecture Strategy.**

Source	Type III		Mean Square	F	Sig.	Partial Eta Squared
	Sum of Squares	Df				
Corrected Model	12857.550 <sup>a</sup>	4	3214.388	62.019	.000	.701
Intercept	6373.142	1	6373.142	122.965	.000	.537
Pretest	5.769	1	5.769	.111	.739	.001
Instructional Strategies	12618.257	1	12618.257	243.459	.000	.697
Gender	82.980	1	82.980	1.601	.209	.015
Instructional Strategies *	20.083	1	20.083	.387	.535*	.004
Gender						
Error	5493.873	106	51.829			
Total	500812.000	111				
Corrected Total	18351.423	110				

"a. R Squared = .701 (Adjusted R Squared = .689), \*Sig at p < 0.05."

The result in Table 4 shows that there is no significant interaction effect of gender and instructional strategies on students' mean achievement in chemistry,  $F (1, 106) = .387$ ,  $p > 0.05$ , partial eta squared = .004. This gives an effect size of 0.4%. Thus, the null hypothesis which states that "there is no significant difference in the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught with the lecture method" is accepted.

## Discussion

The finding of this study showed that "students taught using the science video instructional strategy had a significantly better mean achievement score in chemistry than those taught using the lecture method." The findings also showed that "there is no significant difference in the chemistry mean achievement scores of male and female students taught through the science video instructional strategy and those taught with the lecture method."

This finding agrees with that of Swe and Aung (2016) who investigated the "impact of activity-based learning, including video materials, on science teaching at the middle school level" and reported that students exposed to video-assisted learning performed significantly better in science subjects. The findings are also in line with that of Ramadani and Guspatni (2025) who explored the "use of electronic media on learning chemical bonding" and reported that there exists several media (including science videos) that can be effectively used to improve students' conceptual grasp and motivation.

The finding of the study also agrees with that of Manabete and Ughili (2025) who explored the "effects of video clips on basic science achievement of junior secondary school students" and reported that video-based instruction enhances learning outcomes compared to traditional methods. Ozkan, Bilgin, and Uğraş (2025) also agree with these findings. The study examined the

effects of "Computer-assisted instruction with virtual reality on students' achievement in science courses". Short animated videos were displayed in the virtual reality headsets that are relevant to the concept being learned. The findings of the study showed that science video-aided instruction significantly enhanced students' achievement, and gender did not significantly influence the achievement of students.

## Conclusion

Science educators have continued to seek for innovative methods and strategies for the effective teaching and learning of science which chemistry is a part. This is to ensure that, the achievement level of the students improves. Science video instructional strategy was found in this study to be one of such effective strategies that could be used to improve the achievement of the students in chemistry. Therefore, it was concluded that the use of science videos is effective for the teaching of chemistry concepts. The study also found that gender does not affect students' achievement in relation to the science video instructional strategy.

## Recommendations

Base on the findings of the study, the following recommendations were made;

1. Educators should adopt digital resources like science videos for teaching chemistry.
2. Educational authorities and curriculum developers should take steps towards integrating the use of innovative digital tools like science videos into the science curriculum.
3. Teachers should be provided with appropriate training and resources to enable them to incorporate technological resources like science videos into their classroom instructions.
4. Educational institutions and authorities should develop high-quality repositories of quality science videos.

## References

Addae, D., & Quan-Baffour, K. (2018). The pedagogical value of the lecture method: The case of a non-formal education programme in Ghana. *Africa Education Review*, 15(1), 123-137. <https://doi.org/10.1080/18146627.2016.1256748>

Akor, T. S., Subari, K. B., Jambari, H. B., Noordin, M. K. B., & Onyilo, I. R. (2019). Engineering and related programs' teaching methods in Nigeria. *International Journal of Recent Technology and Engineering*, 8(2), 1279-1282. [http://eprints.utm.my/88766/1/TerungwaStephenAkor2019\\_EngineeringandRelatedProgramsTeaching.pdf](http://eprints.utm.my/88766/1/TerungwaStephenAkor2019_EngineeringandRelatedProgramsTeaching.pdf)

Alabi, M. (2024). *Visual learning: The power of visual aids and multimedia*. <https://www.researchgate.net/profile/Moses-Alabi/publication/385662029>

Ali, H., & Khan, E. (2017). Environmental chemistry in the twenty-first century. *Environmental Chemistry Letters*, 15(2), 329-346. <https://doi.org/10.1007/s10311-016-0601-3>

Anaso, J. N. (2024). Effect of cooperative learning, expository, and inquiry-based strategies on chemistry students' academic achievement in senior secondary schools in Zamfara State, Nigeria. *International Journal of Vocational Studies and Library Science*, 5(1). <https://journals.benchmarkjournals.com/index.php/ijovalis/article/download/79/73>

Avado Learning. (2021, July 1). *What are the 7 different learning styles and do they work?* Avado Learning Blog. <https://www.avadolearning.com/blog/the-7-different-learning-styles-and-what-they-mean/>

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 24(2), 97-140. <https://doi.org/10.1080/10888691.2018.1537791>

French, S., Ravn, S., Balcaite, E., & Moore, E. (2023). Understanding students' views on the efficacy of video technology to promote engagement in higher education. *Pacific Journal of Technology Enhanced Learning*, 5(2), 1-14. <https://ojs.aut.ac.nz/pjtel/article/view/172>

Grancharova, D. (2024). The role of STEM lab experiments in building science literacy in chemistry education. *International Journal of Multidisciplinary Research in Arts, Science and Technology*, 2(8), 42-50. <https://doi.org/10.61778/ijmrast.v2i8.76>

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275-285. <https://doi.org/10.1016/j.susoc.2022.03.002>

Haynes, D. A., & Blackie, M. A. L. (2021). The building blocks of matter. *HTS Teologiese Studies/Theological Studies*, 77(3). <https://www.ajol.info/index.php/hts/article/view/232752>

Kalyani, L. K. (2024). The role of technology in education: Enhancing learning outcomes and 21st-century skills. *International Journal of Scientific Research in Modern Science and Technology*, 3(4), 5-10. <https://ijsrmst.com/index.php/ijsrmst/article/view/199>

Kem, D. (2022). Personalised and adaptive learning: Emerging learning platforms in the era of digital and smart learning. *International Journal of Social Science and Human Research*, 5(2), 385-391. <https://www.researchgate.net/profile/Lukman-Prakoso/publication/359005289>

Kostiainen, E., Ukskoski, T., Ruohotie-Lyhty, M., Kauppinen, M., Kainulainen, J., & Mäkinen, T. (2018). Meaningful learning in teacher education. *Teaching and Teacher Education*, 71, 66-77. <https://doi.org/10.1016/j.tate.2017.12.009>

Lombardi, D., Shipley, T. F., Astronomy Team, Biology Team, Chemistry Team, Engineering Team, Geography Team, Geoscience Team, & Physics Team. (2021). The curious construct of active learning. *Psychological Science in the Public Interest*, 22(1), 8-43. <https://doi.org/10.1177/1529100620973974>

Mansir, F., Tumin, T., & Purnomo, H. (2020). Role-playing learning method in the subject of AqidahAkhlak at Madrasa. *Nazhruna: Jurnal Pendidikan Islam*, 3(2), 191-201. <https://doi.org/10.31538/nzh.v3i2.675>

Muhtarova, N. T. K. (2023). The effective use of authentic video materials in the teaching process. *Science and Innovation*, 2(Special Issue 14), 582-587. <https://cyberleninka.ru/article/n/the-effective-use-of-authentic-video-materials-in-the-teaching-process>

Özkan, Y., Bilgin, E. A., & Uğraş, G. (2025). Computer-assisted instruction with virtual reality: Exploring its impact on science learning and gender differences. *Journal of Pedagogical Research*, Advance online publication. <https://doi.org/10.33902/JPR.202529271>

Rafique, A., Saddiqा, A., Ashfaq, A., Akmal, H., RabiaMehvish, Yousaf, S., Rahila Yasmeen, Akram, A., & Ullah, M. K. (2024). A Comprehensive Review on Chemistry Uses in Medicine and Medical Technology. *Scholars International Journal of Chemistry and Material Sciences*, 7(02), 12–16. <https://doi.org/10.36348/sijcms.2024.v07i02.001>

Rahman, S. (2020). Improving the power of lecture method in higher education. In *Teaching, learning and new technologies in higher education* (pp. 135-147). Springer. [https://doi.org/10.1007/978-981-15-4847-5\\_10](https://doi.org/10.1007/978-981-15-4847-5_10)

Ratheeswari, K. (2018). Information communication technology in education. *Journal of Applied and Advanced Research*, 3(1), 45-47. <https://core.ac.uk/download/pdf/386340189.pdf>

Shao, F., Tang, L., & Zhang, H. (2024). Video watching and hands-on experiments to learn science: What can each uniquely contribute? *Disciplinary and Interdisciplinary Science Education Research*, 6, 17. <https://doi.org/10.1186/s43031-024-00103-x>

Swe, M. K., & Aung, H. W. (2016). An investigation into the impact of activity-based learning on science teaching at the middle school level. *Yangon University of Education Research Journal*, 6(1), 91-106. <https://meral.edu.mm/record/10047/files/An%20Investigation%20into%20the%20Impact%20of%20Activity-Based%20Learning%20on%20Science%20Teaching%20at%20the%20Middle%20School%20Level.pdf>

Tufail, I., & Mahmood, M. K. (2020). Teaching methods preferred by school science teachers and students in their classrooms. *PUPIL: International Journal of Teaching, Education and Learning*, 4(2), 332-347. <https://www.researchgate.net/profile/Imran-Tufail/publication/344640006>

World Economic Forum. (2021, December 6). *How chemistry is part of the solution to climate change – and not just part of the problem*. World Economic Forum. <https://www.weforum.org/stories/2021/12/green-chemistry-manufacturing-climate-change/>

Zakrajsek, T. (2018). Reframing the lecture versus active learning debate: Suggestions for a new way forward. *Education in the Health Professions*, 1(1), 1-3. [https://journals.lww.com/ehpf/fulltext/2018/01010/reframing\\_the\\_lecture\\_versus\\_active\\_learning.1.aspx](https://journals.lww.com/ehpf/fulltext/2018/01010/reframing_the_lecture_versus_active_learning.1.aspx)