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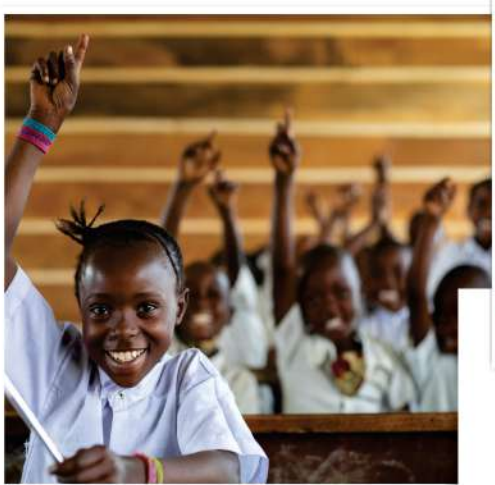
INNOVATIVE STRATEGIES FOR TEACHING VOCATIONAL, SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION: CLASSROOM PRACTICES



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PREFACE

The electronic book (e-book) acknowledges that traditional methods in Vocational, Science, Technology and Mathematics Education: Classroom Practices may not be sufficient to equip students with the necessary skills for a rapidly evolving technological landscape.

Therefore, it advocates for the adoption of Innovative teaching approaches that promote a more dynamic and effective learning experience.

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FOREWORD

This book entitled "**Innovative Strategies for Teaching Vocational, Science, Technology and Mathematics Education: Classroom Practices",** is a book of readings on various innovative classroom pedagogies. It is a welcome literature for Education System and a very important resource book for teachers who are functioning in the disciplines of Vocational Education, Science, Mathematics and Technology education and training. It is a compendium of most of the **active learning strategies** aimed at producing graduates who have been prepared for adaptation to the conditions of the 21st century world of fluidity. The 21st century world accommodates soft skills which the individual can edit from time to time as the conditions of socio-cultural, economic and technological environments change constantly and uncontrollably. A century in which cross-border job openings are important means of employment, a century where attitude is more important than subject-based excellence, a century where collaboration, innovation and creativity are irreducible demands by employers of labour, a century where adaptive skills are critical for entrepreneurship, creation of jobs and wealth.

All categories of teachers at all levels of education would find this resource book interesting and professionally helpful for their teaching practice. Because conditions of the modern world are in perpetual flux, teachers have to re-skill in order to produce adaptive graduates and the era of lecture method is literally over. It is these modern innovative instructional strategies that would enable teachers to produce such graduates who would survive and then succeed in the 21st century global economy.

This book would also be very useful to researchers and innovators in the envisioned pedagogic paradigm shift of this era. I therefore, proudly recommend this book, a compendium on innovative pedagogies to all classes of teachers and researchers on pedagogies and curriculum reforms in the modern era.

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DEDICATION

This book is dedicated to educators in the world

CHAPTER 10

BRAINSTORMING: AN INNOVATIVE TOOL FOR ENHANCING TEACHING AND LEARNING OF BIOLOGY IN SCHOOLS

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Chukwma C. Ekechukwu
Caroline I. Okorie

Abstract
This information age requires teachers to shift the classroom from being teacher-centered to learner-centered. Teachers should initiative novel strategies that will arouse the interest of students to participate, be active and build their own thought during the teaching process. Teachers should ascertain the entry behaviour of students and the necessary modern constructive pedagogical strategies to impart the necessary knowledge. The choice of suitable teaching strategy may be different for each subject, topic and context, and biology is not an exception. Brainstorming strategy for teaching is one of the most appropriate methods to fill the gaps between where the learner is and where he or she is expected to be. This strategy shows higher effectiveness in the academic achievement of students. The researcher tries to explore the concept of brainstorming by presenting comprehensive overview of its meaning, procedure, effectiveness and challenges of this method. Recommendations were made.

Keywords: Brainstorming, Constructivism, teaching strategy.

Introduction

Brainstorming or just 'brainstorm' is the use of brain to develop solutions to problems. It evokes images of exploration, experimental thinking, and wild ideas. The idea is to mine idea "ore" and refine "golden" solutions from it later. Brainstorming is a creativity technique in which a group of people interact to suggest ideas spontaneously in response to a prompt. Brainstorming is an individual or group discussion that encourages students to generate a wide range of potential solutions regarding a specific topic. Brainstorming combines a relaxed, informal approach to problem solving with lateral thinking (AlMutairi, 2015).

Brainstorming strategy was introduced by Alex Faickney Osborn, an American advertisement company manager in 1938 as a result of his inconvenience of traditional business meetings to produce ideas without inhibition (Zayton, 2001). Osborne began hosting group-thinking sessions, and discovered that the approach led to a significant boost in the quality and quantity of new ideas. He coined these group meetings "brainstorm" sessions. Classroom Brainstorming is the random generation of ideas based around a topic of subject being taught.

Al-maghrawy (2012) defines brainstorming as a group creativity forum for general ideas. It is a technique that is used under the discussion method which involves oral and pre-writing exercises for helping the learner and for expressing ideas by the teacher. Students should feel safe to contribute during brainstorming sessions and understand that all of their ideas are valuable to the process. It leverages the collective thinking of the group, by engaging with each other, listening and building on other ideas. Brainstorming creates a distinct segment of time when you intentionally turn up the generative part of your brain and turn down the evaluative part.

Hoing (2001) defined it as the multiple thinking that includes the breaking up of old ideas, making new connections, enlarging the limits of knowledge and the onset of wonderful ideas. Brainstorming is a good strategy for generating ideas in the classroom because it helps students get initial thoughts and ideas out of their heads and on to paper. Brainstorming isn't to find the perfect solution to a problem, but to create a bank of thoughts and ideas, used by students as starting points to delve deeper into a subject or devise their own solutions to problems. It is a fun way for students and teachers to explore different methods to discuss any topic to generate innovative ideas.

Biology is the study of living things which has gained popularity among secondary school students as observed in their enrollment during external examinations. According to Okafor & Okoli (2020), the attention given to biology as a subject could be because it is a natural subject which enlightens the students on the day to day living, their environment, plant and animal as well as their health. The importance of biology in the national development has necessitated the inclusion of its study in the curriculum of most nations of the world. They revealed that secondary school students' academic achievement in Nigeria have remained poor. This is evident in their performance at examinations such as the West African Examination Council (WASCCE) and National Examination Council (NECO). Also evidence from the WASCCE chief Examiner's report over the years proves it. From 2007 to 2012, the percentage of students who made credit pass and above was below 40%. From 2013, there has been slight increase in the percentage number of those who passed at credit. However, the rise in percentage does not connote in the performance since the number of students enrolling for the examination has increased drastically. For instance, in 2013, the percentage number of students who made credit pass and above was 51.73% which approximately 852,000 students out of the total population of students that enrolled for the year. In 2014, 56.17% passed at credit level and above, which is approximately 767,000 students out of those that enrolled. One can see from the percentage number of students passing at credit grade and above is still declining. The problem of poor performance could be ameliorated with the strategy of brainstorm.

The basic philosophy of using brainstorming method in education is constructivism. Constructivist methods of teaching are based on constructive learning theories. Constructivism is the theory that says learners construct knowledge rather than just passively take in information; as learning is greater when the learner is actively involved in the learning process. Constructive teaching gives maturity to critical thinking and creates a dynamic and independent learner through experience, reflection and active construction in the mind. It believes that new knowledge construct on the foundation of previous knowledge that is called schema and all new learning is filtered through pre-existing schema, despite the fact that perseverance is required. In such a gradual way, the teacher engages his students through questions and activities, leading them to self-research and self-exploration. The role of the teacher in the teaching and learning process is to facilitate the students as is seen in brainstorming strategy.

Statement of the Problem

In Nigeria, the secondary school biology curriculum is designed to help students investigate natural phenomena, deepen students' understanding and interest in biological sciences and to encourage students' ability to apply scientific knowledge to everyday life in a matter of personal and communal health and agriculture (Nigerian Educational Research and Development Council (NPE, 2013). With reference to the objectives of biology curriculum, it has been revealed by researchers like Okafor and Okoli, (2020) that the interest and achievement of students in Biology and science at large are poor. There is therefore a dire need for attention to be paid to this problem. Hence, the researchers seek to explore the processes of brainstorming as an alternative innovative strategy for teaching in biology classroom.

Purpose of the Study

The purpose of the study was to explore brainstorming as an innovative teaching strategy in teaching biology.

The study specifically sought to;

1. Highlight the steps/processes involved in the use of brainstorm teaching strategy in the classroom.
2. Elicit the benefits the students and the teachers obtain in its use in the teaching and learning engagement.
3. Make reference to the challenges posed in the use of these tools

Forms of Brainstorm

Dorgan & Batdi (2021) highlights the following forms of brainstorming;

Brain-dumping: This is a solo or an individual session of brainstorm. It involves a student writing down all ideas s/he can think of individually. Individual brainstorming is less likely to censor or filter their ideas, allowing them to be as creative as possible.

Brain-writing is a technique where participants write ideas onto cards and then pass their idea cards on to the next person around the group in a circle as participants build on the ideas of others in complete silence.

Brain-walking involves participants getting up from their seats and moving to another spot around the brainstorming table or even to another table altogether. It works best when it is easy to flip or to start from scratch. Brainstorming as a class or in groups can give students confidence as they are inspired by each other's ideas. When working individually or in small groups, it's recommended that you give students a time limit while brainstorming. This encourages students to write down the first things that come to mind and get their thoughts onto paper. This also provides a bit of helpful pressure. 2 to 5 minutes is a good amount of time for a short brainstorm, as students can sometimes lose enthusiasm if they feel like there's too much time to think.

Procedure / Sages to Brainstorming

According to (Nase, A. & Al Mutairi, M. (2015), A-blowy (2006) Al-qarni (2011), brainstorming involves:

Stage 1: Select a leader and a scribe (the teacher may take on one or both of these roles).

Stage 2: introducing the brainstorming rules to direct the students as:

- letting the leader have control
- allowing everyone to contribute
- suspending evaluation of ideas until all ideas are gathered
- assuming that all contributions are valid
- recording each idea, unless it is a repeat
- setting a time limit and stopping when that time is up
- No criticism is allowed during brain storming
- Quality of ideas is important
- Wildness is good, crazy ideas are welcome as they turn out to be the best ones
- There are "NO WRONG" answers
- Try to get as many ideas as possible
- Be prepared to have some simulating ideas for group.

Stage 2: Prepare the Group by setting up a well-lit comfortable meeting environment with tools, resources for the session. Also make a choice between different brainstorming activities for students depending on multiple factors, like class strength, time constraints, difficulty of the topic, and more.

Stage 3: stating the subject or problem or stimulus: A stimulus is a kind of prompt that is used to stimulate ideas in the form of a word or question, an image, song, topic etcetera. The teacher offers a problem and discusses concise introductory but interesting information on its various dimensions for students to ensure understanding. A set of thought-provoking questions be prepared for this stage.

Stage 4: expressing ideas: A person presents his/her idea or it can be written down on paper for subsequent screening. Give people plenty of quiet time at the start of the session to write down as many of their own ideas as they can. The scribe should write down all responses, ideally so that everyone can see them.

Stage five: evaluating ideas: The generated number of ideas are evaluated and the most suitable and important ones selected according to novelty, originality, usefulness as well as logic. Once everyone has shared their ideas, start an open discussion to develop, rank, screen, refine, explore

the ideas, and use them to build or create new ideas including those of the quietest students, and discard repetitions or inappropriate ones. The teacher should stick to one conversation at a time.

From the foregoing, it is obvious that the teacher is pivotal to the effectiveness of utilizing this strategy. According to Ikwumelu & Oyibe (2014) in their study revealed that students increase the opportunity to learn from their mistakes and their peers while still reinforcing basic skills of brainstorming. It gets more attention and active participation of learners if it is used properly. ALshammari (2015) concluded, the results expected from a brainstorming session is a dynamic synergy that expands exponentially in order to increase the creativity of the group. The main feature of brainstorming is its flow of thoughts and ideas that students take away with them. In 2nd World Conference on Education Technology Researches (WCETR) held in 2012, Rizi, Najafipour, Haghani & Dehghan (2013) confirmed the positive effect of brainstorming method on the educational achievement of students in their study on 5th grade students. Brainstorming method of teaching encourages students to think more freely and innovatively than if they were doing a more restricted and routine classroom teaching. Brainstorming helps elementary school students to identify and come up with real questions to include in learning.

Benefits of Brainstorming

Teamwork: Brainstorming gives students a chance to contribute comfortably to a collective activity and collaborate easily. This process inspires creativity, as there is no pressure to generate perfect ideas, as long as you're generating something. It creates confidence in students to understand their value as part of the process by including their ideas or even connecting them to other suggestions, thus providing a safe ground for introverted students. By collaborating on different brainstorming activities, educators get a pool of ideas from every student, which helps them to quickly analyze each student on similar grounds. The students also by expressing ideas and listening to what others say adjust their previous knowledge or understanding, accommodate new information, and increase their levels of awareness and language abilities. This teaches acceptance and respect for individual differences.

Brainstorming teaching strategy according to Khan, Ashraf and Azad (2021) helps students to learn and construct knowledge. The teacher facilitates the teaching process while students feel a sense of responsibility and become independent learner. Students get ample opportunity to express their ideas, concepts, thought and knowledge which develops creativity, critical thinking, collaboration, communication and problem solving skills. They use the skills learned in the classroom in the external world observations and experiences. It helps students to become better learners and it is a fun activity which students enjoy well.

Although there has been some dispute about the effectiveness of brainstorming (Furnham, 2000; Al-Samarraie & Hurmuzan, 2018; Johnson & D'Lauro, 2018), it remains a widely used technique in a variety of contexts, including the tertiary classroom.

Challenges encountered using Brainstorming

Initially, some students may be reluctant to speak out in a group setting, as poorly facilitated face-to-face brainstorms do stifle creativity. Osborn (2018) opined that because only one participant may give an idea at any one time, other participants might forget the idea they were going to contribute or not share it because they see it as no longer important or relevant. Exchanging ideas in a group may reduce the number of domains that a group explores for additional ideas. Members may also conform their ideas to those of other members, decreasing the novelty or variety of ideas, even though the overall number of ideas might not decrease (Kohn & Smith, 2011). Henningsen & Henningsen (2013) emphasized personality characteristics as extroverts have been shown to outperform introverts, generating more unique and diverse ideas than introverts when additional methods were used to stimulate idea generation, such as completing a small related task before brainstorming, or being given a list of the classic rules of brainstorming.

Sometimes human brains run out of ideas, either the students cannot come up with good ideas or figuring out the right answers or solutions to the class activities.

With verbal brainstorming, the number of ideas which can be expressed at once is limited with longer time resulting in many participants forgetting or becoming confused while others shout out ideas. This is especially so for those who are shy or introverted or who may be at a disadvantage due to being less senior or unfamiliar with the specializations being discussed.

Methods to improving Brainstorming Sessions

- Avoid face-to-face groups as it can increase production blocking, evaluation apprehension, social matching and social loafing.
- Brainstorming rules should be followed, and violations lead to mediocre ideas.
- Encourage members to pay attention to others' ideas.
- Include both individual and group approaches such as brain-writing. This is where members write their ideas on a piece of paper and then pass it along to others who add their own ideas.
- Allow silence during group discussions so that members have time to think things through and complete the task.
- Members should stay focused and persist at the task even when productivity is low.
- A skilled discussion leader can motivate members, correct mistakes, and provide a clear standard of work. They can also be used to keep track of all the ideas and make sure that these ideas are available to everyone.
- A help from technology using a brainstorming app in the class called EDrawMind is a helpful program for education. It's an all-in-one tool with mind mapping, concept mapping, brainstorming, note-taking, and more integration.

Conclusion

In today's advanced, academically driven world, innovative strategies are vital. Brainstorming activities for students promote a healthy environment for all including students, teachers, administrators and researchers. It helps students to learn by their own observations and desired opportunity to express their ideas, thought and knowledge which develops creativity, critical thinking, collaboration, communication and problem-solving skills.

Suggestions for Improvement

1. Workshops, seminars and training should be organized for teachers on how to use brainstorming in their classroom teaching.
2. Teachers should be encouraged to use this strategy in teaching different disciplines of knowledge as it significantly improves the academic achievement of the students.
3. Students should also be encouraged to develop positive attitude and mindset towards its application in the classroom by the teacher for effective learning.

References

Al-blowy, Q. (2006). *The effectiveness of using brainstorming strategy in developing creative thinking in Islamic Education among Third secondary students in Tabouk City*. Master Thesis. Mut'a University, Krak. Jordan.

Al-maghawry, A. (2012). Effectiveness of Using the Brainstorming Technique to Learn Some Basic Skills and Collection of Knowledge for Beginners in Volleyball. *World Journal of Sport Sciences,* 6 (4); 361-366.

Al-Mutairi, A.N.M. (2015). The Effect of Using Brainstorming Strategy in Developing Creative Problem Solving Skills among male Students in Kuwait: A Field Study on Saud Al-Kharji School in Kuwait City. *Journal of Education and Practice,* 6 (3); 136-146

Al-qarni, F. (2011). *Measuring the effectiveness of using brainstorming strategy in developing creative thinking in science among third intermediate students in Qurayyat city.* Unpublished Master thesis. Al-balqa Applied University. Salt. Jordan.

Al-Samarraie, H. & Hurmuzan, S. (2018). A review of brainstorming techniques in higher education. *Thinking Skills and Creativity*, 27, 78 – 91. https://doi.org/10.1016/j.tsc.2017.12.002.

AL-shammari, M. K. (2015) Effective Brainstorming in Teaching Social Studies for Elementary School in Saudi Arabia, *Journal of Education & Social Policy*, 2(3); 70-75.

Dogan, Y. & Batdi, V. (2021). Revisiting brainstorming within an educational context: A meta-thematic analysis. *Journal of Learning for Development*, 8(3); 541 - 556.

Furnham, A. (2000). The brainstorming myth. *Business Strategy Review*, 11(4); 21-28.

Henningsen, D. D. & Henningsen, M. M. (2013). Generating Ideas about the Uses of Brainstorming: Reconsidering the Losses and Gains of Brainstorming Groups Relative to Nominal Groups. *Southern Communication Journal*. 78 (1); 42-55.

Ikwumelu, B., & Oyibe, Y. (2014). The Comparative Effects of Simulation Games and Brainstorming Instructional Strategies on Junior Secondary School Students' Achievement in Social Studies in Nigeria. *African Research Review,* 5(3). doi:10.4314/afrrev.v5i3.67342.

Johnson, B. R. & D'Lauro, C. J. (2018). After brainstorming, groups select an early generated idea as their best idea. *Small Group Research*, 49(2); 177 – 194.

Khan, A.F., Ashraf, S. & Azad, M. (2021). Brainstorming as a Promising Tool for Teaching Languages. *Journal of Emerging Technologies and Innovative Research (Jetir*), 8 (8); 420 – 423.

Kohn, N. & Smith, S.M. (2011). Collaborative fixation: Effects of others' ideas on brainstorming. *Applied Cognitive Psychology*. 25(3); 359 – 371.

Naser, A. & AlMutairi, M. (2015). The Effect of Using Brainstorming Strategy in Developing Creative Problem Solving Skills among male Students in Kuwait: A Field Study on Saud Al-Kharji School in Kuwait City. *Journal of Education and practice,* 16 (3); 138 -143.

National Policy on Education (2013). (sixth). NERDC.

Okafro, B.I. & Okoli, J.N. (2020). Predicting Secondary School Students' Interest in Biology Using Emotional Intelligence, Self-Efficacy and Self-Esteem. *International Journal of Innovative Research and Advanced Studies (IJIRAS)* 7(3); 41-50.

Okafro, B.I. & Okoli, J.N. (2020). Emotional Intelligence, Self-Efficacy and Self-Esteem as Predictors of Secondary School Students' Academic Achievement in Biology Anambra State. *IOSR Journal of Humanities and Social Science (IOSR-JHSS)* 25(3); 51-57.

Osborn, A. F. (2018). *Applied imagination; principles and procedures of creative thinking.* Scribner. OCLC6 41122686- via Open WorldCat.

Osborn, A.F. (1963) Applied imagination*: Principles and procedures of creative problem solving*. New York: Charles Scribner's Sons.

Ritter, S. M. & Mostert, N. M. (2018). How to facilitate a brainstorming session: The effect of idea generation techniques and of group brainstorm after individual brainstorm. *Creative industries Journal*, 11(3); 263 – 277.

Seeber, I., de Vreede, G.-J., Maier, R. & Weber, B. (2017). Beyond brainstorming: Exploring convergence in teams. *Journal of Management Information Systems*, 34(4); 939 – 969.

Rizi, C. E., Najafipour, M. C. , Haghani, F.D. & Shahla D.(2013), The effect of the using the brainstorming method on the academic achievement of students in grade five in Tehran elementary schools. *Procedia - Social and Behavioral Sciences,* 83, 230 – 233