Greener Journal of Educational Research
Vol. 14(1), pp. 123-131, 2024
ISSN: 2276-7789

https://gjournals.org/GJER
DOI: https://doi.org/10.15580/gjer.2024.1.111424169

Design and Testing of Brush Robot as Innovation in Improving STEM Instructional Out-Come in Pre-Service Teachers in Plateau State.

DUGURYIL, Zipporah Pewat (PhD); KATNIYON, Henry David (PhD); LONGMUT, Dakup Ibrahim [U1]

Tetfund Centre of Excellence for Innovative Teaching and Learning, Federal College of Education Pankshin, Plateau State, Nigeria.

ARTICLE INFO

Article No.: *111424169*
Type: *Research*
Full Text: *PDF, PHP, HTML, EPUB, MP3*
DOI: *10.15580/gjer.2024.1.111424169*

Accepted: *14/11/2024*
Published: *16/11/2024*

****Corresponding Author***
Dr. Katniyon Henry David
E-mail: *katniyonhenry@gmail.com*

Keywords: *Robot Design, Testing, Brush Robots, Pre –service Teachers*

ABSTRACT

In this study, an experimental research design was used to design and test brush robots with pre-service teachers in Federal College of Education Pankshin Plateau state. This intends to solve the problem of innovation deficit in classroom instruction. The population for the study consisted of all NCE one students in the department of early childhood offering the course Science Technology Engineering and Mathematics STEM in the 2023/2024 session. A Sample of 30 Pre service NCE teachers participated in the research. A robot brush was constructed using low cost kits in the robot design stages. The instruments used consisted of Robot Parts test and the Solve-It tasks (design and functionality test) with Cronbach alpha reliability of 0.81. Treatment lasted for 6 weeks. Data was collected and analysed using descriptive and inferential statistics. Results indicated that pre-service teachers have poor knowledge of robot parts such as DC motors. This implies that pre-service teachers are novice to robot part and use Also, participants were very competent in robot design process activities and robot base cutting. Participants also showed average competence in Robot stage cutting, construction of rollers and fixing of robot parts. They however showed only fair competence in coupling of robots parts. Findings indicate that the teachers designed robots have high educational value. The robots are averagely complete in form, ease of use motion and durability. The designs however have low compliance to safety. It was recommended amongst other that Teacher training colleges should organised in-service training to improve teacher competent in handling engineering and technology parts and programming of STEM robots.

INTRODUCTION

Science, Technology, Engineering, Mathematics (STEM) education has become a major focus in efforts to prepare students to face the demands of a modern world that is increasingly dependent on skills in the fields of technology and science (National Research Council, 2011). In the midst of dynamic changes in educational curricula, innovative and effective learning approaches are important to facilitate in-depth understanding of STEM concepts and sharpen students' critical thinking skills (Bybee, 2010).

The use of robotics in STEM education is a learning tool that is attracting increasing attention because robotics provides a practical approach that allows students to apply theoretical concepts in real-world situations. By including robotics in the curriculum (M. I. Sholeh, 2023a), schools can provide learning experiences that are more interesting and oriented towards practical applications, as discussed in the research of Andreu et al. (2019). Students can learn about the basic principles of science and technology while designing, programming, and operating robots directly (Khanlari & Mansourkiaie, 2015). Shively & Farris's (2021) article reviews the use of robotics in education and the opportunities it offers to enrich STEM learning. Chapter Knezek et al. (2013) discussed the impact of using robotics in STEM education and how this technology can impact learning and teaching in the context of science, technology, engineering, and mathematics (Sholeh, 2023). Although not directly related to STEM education, the study of Šabanović et al. (2013) highlight how interactions with robots can influence user learning and experience, which is relevant in the context of the use of robotics in education.

The use of robotics not only helps students understand STEM concepts in more depth, but also helps them develop critical thinking, creativity, and problem-solving skills (Liu et al., 2019; Klopfenstein & Sadri, 2018). When students interact with robots, they are faced with challenges that require critical thinking and the ability to find solutions (Chen et al., 2020). Apart from that, the use of robotics can also increase students' interest in STEM fields of science which are often considered complicated or difficult to understand (Nyein et al., 2019). Although interest in the use of robotics in STEM education is growing, further research is still needed to fully understand its impact on student achievement (VanLehn & Jones, 2017).

The bristlebot typically is a project designed to construct robots that can handle activities such as sweeping, smoothing, scrubbing, or painting. Participants learn engineering design skills such as cutting, geometry, gumming, add-on designs and other related skills.With increasingly advanced technology and changes in the world of education, it is important to understand how the use of robotics can influence the learning process and students' academic achievement (Liu et al., 2019). Through this research, it is hoped that it can be identified to what extent the use of robotics influences students' understanding of STEM concepts, as well as how this impacts their learning achievement. By understanding more deeply the impact of using robotics in STEM learning, it is hoped that it can provide valuable insights for teachers, students and other educational stakeholders. It is hoped that the results of this research can become the basis for developing more effective and innovative learning strategies in Schools, as well as contributing to scientific literature in the field of STEM education. Few research in Nigeria Katniyon et al (2023) focused on theoretical knowledge only and has not addressed the issue of design and testing of brush robots. In this context, this research aims to bridge the existing knowledge gap and provide a better understanding of the potential for using robotics in improving student achievement in primary schools in Pankshin. Therefore, this research aims to conduct a more detailed investigation regarding the design and testing of Brush Robot in improving STEM learning outcome in Pre-schools in Pankshin. The brush robot is a robot that employs elastic elements, referred to as brushes, to convert the energy of a vibration source into directed locomotion. The subset of the brushbots on which we focus our study is that of planar robots moving on a smooth surface

Theoretical Framework

Two theories guiding this research are **constructivism and constructionism**. Constructionism as an educational theory is student-centered and emphasizes discovery learning, where students are encouraged to work with tangible objects in the real world and use what they already know to gain more knowledge. **Constructivism** Theory states that knowledge constructed by connecting new experience to existing ideas. Experiences gained each week was based on a three-stage learning progression model, (Fig 1) namely: copy, tinker, and create. In the first stage (approximately 30 min), students copied robot design examples from learning material for practice purposes. Subsequent stages participants modified those examples by adding more components, and in the final stage which saw the creation of brush robot.

Figure 1 . Three-stage learning progression model.

The implication of these theories to the study is that the design of educational robots and curriculum using tangible technology to create new knowledge on design and testing of a robot. Participants were availed hands on opportunities for hands on engagement in research.

Purpose of the Study

The purpose of this research is to Explore the design and testing of an off - screen Educational Robotics curriculum among early Childhood STEM teachers in Plateau State. Specifically it intends to:

1. Find out if pre - service teachers' are able to identify brush robots components?
2. Assess if participants are able to demonstrate competence in brush robots design skills
3. Assess if teachers designed brush robots are effective when exposed to functionality test?

Research Questions

The following research questions will guide the study:

1. To what extent are participants able to demonstrate competence in brush robots design skills?
2. To what extent are pre - service teachers' able to identify brush robots components?
3. To what extent are the designed brush robots functional when exposed to functionality test?

METHODS AND MATERIALS

The research design is experimental design which intended to design and test educational robotics (ER) curriculum for pre-service teachers. The population will consist of NCE one students in the department of early childhood offering the course Science Technology Engineering and Mathematics STEM (ECE 124) in the 2023/2024 session. A Sample of 30 Pre service NCE teachers were selected. The school was selected as a research site in order to see how the robotics curriculum would unfold in a typical Nigerian public school, outside of a research lab setting. The course and level was selected to empirically observe how the new component STEM in the NCCE minimum standards for early childhood will be implemented by would be teachers. Also, it will provide an opportunity for pre- service teachers to be proficient in teaching 21st century engineering and technology aspects of STEM compared to peers in UK, Crete and USA. The study lasted for 4-week with each week having an activity. Data was collected from the participants using two assessments instruments: the Robot Parts test (which will assess robotics knowledge) and secondly the Solve-Its tasks (which will assess design process). Robotics knowledge Test will assess pre-service teachers' knowledge of the use of educational robotics. The activities lasted for 6 weeks. Data was analysed using percentages, mean and Standard Deviation. The materials used are:

Method Used in design and testing

Use of Sawing

The saw was used to trim the brush handle to the required shape.

Gluing

Glue is used to gum the materials to the top of the brush in order to maintain firmness.

Connecting of components

Cables and connector are used for connecting battery to D.C. motor firmly.

Finishing

Nigerian National flag is used to give the brush robot an attractive finishing and appearance.

Safety Precautions Undertaken.

- Wearing of nose masks to avoid plastic dusts and chemical inhaling from glue
- Using of hand gloves to avoid hand sticking to glue
- Wearing of goggle glass to protect your eyes during sawing the plastic.
- Wearing of protective shoes to avoid injury during the practical such as canvas.

Procedure and Presentation of Finished Work

Procedure

The following are the procedures for designing and testing of brush robot

- Put the brush on the table first
- Cut the hand of brush
- Make sure you measure the hand before cutting
- Use Mr. bone glue to hold the materials
- Add D.C Motor 12V battery on the brush
- Test and see whether it will move
- Then add battery connector on the battery to connect the battery and the D.C Motor
- Add 9V battery to the brush top to see how it move
- Connected the witch to see how it work; and if it work we then connect it to the brush to on it/of it.
- Add glue to gum both the battery, 9V battery D.C Motor switch and battery connector on the brush and it move smoothly and vibrate to work faster. That make the robot perfect.
- Add on: Nigerian National Flag to beautify the robot to make it attractive for pupils; and it's at the back of the robots.

Step 1: Cutting/Sawing

Fig 2: Cutting/Sawing brush

It's recommended to use saw for trimming the brush handle in order to create a medium for placing the DC motor, 9V battery and switch.

Step 2: Connecting the 12V DC Motor

After trimming the brush handle, the DC motor is placed on the medium created well fixed with on a glue with wire connection to the battery for the purpose of rotation or vibration.

Step 3: Fixing of Parts

Fig 3: Fixing of Robots Parts

The parts such as the DC Motor, battery, battery connector and wire are brought altogether and fixed one after the other for proper working of the bush robot. Terminals of the battery are tightly fixed to avoid slippage likewise with all the parts.

Step 4: Vibration testing

Fig 4: Vibration testing

After the components are fixed, the battery apart is used for testing the movement. There it was observed that wrongly fixing the battery terminal leads to brush robot jumping rather than vibrating; which was later removed and the battery terminals fixed appropriately to the DC Motor before working properly.

Step 5: Rear view of finished model

Fig 5: Rear view of finished model

Step 6: Side view of finished model

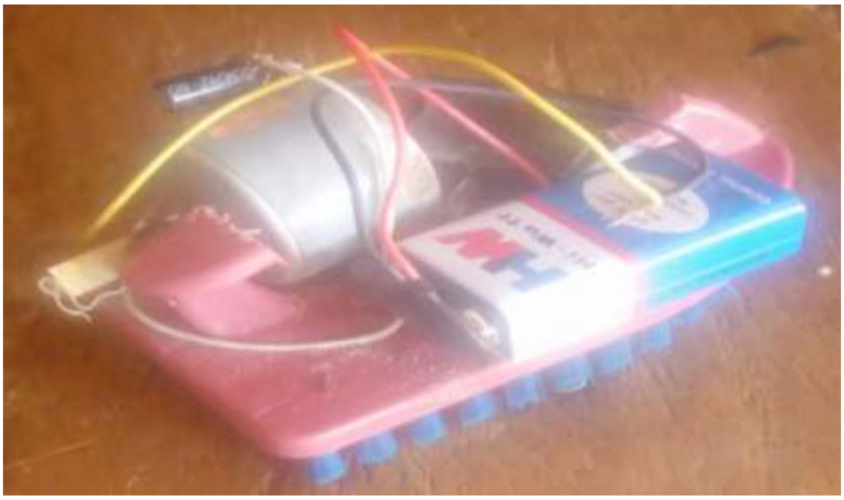

Fig 6: Side view of finished model

After testing with the battery apart, showing proper vibration not jumping. The battery is then fixed firmly and the final functionality test done with proper vibration ascertained.

DISCUSSION OF FINDINGS

Findings and Discussion

Findings from the study is presented based on the research questions as follows:

Research Question one:

To what extent are pre - service teachers' able to identify robots components?

Table: 1 Percentage of Component Identification by Participants

S/N	Components	Robot parts Identification			
		Low	Percentage	High	Percentage
1	Brush	5	8.34	25	91.66
2	DC motor	10	18.34	20	81.66
3	Battery	0	100	30	0.00
4	Jumper wires	10	75	20	25
5	Small Switch	4	6.67	26	93.33
6	Glue	20	83.33	10	16.67
7	Costume add on	4	93.33	26	6.67

Source : Pre-testing exercise 2024

From data on table 1 and figure 50% of our participants did greatly in identification, 10% had never seen some of the components and a 55% has ever use the components in this project exercise. The fact that they have now seen, used it in this project exercise is an evidence that whatever they have seen, handle could be excellently use to achieve other projects of like manners less stressfully, also as they conceived an idea they can execute such without much issue. This implies that pre-service teachers are novice to robot part and use. This is agreement with findings of Cirfat et al (2022) and Katniyon et al (2023) who found teachers to possess poor digital skills including robot parts. This position is worrisome, if the educational and societal benefits of robots design and use is to be effective in Nigeria and globally, then teachers must be availed opportunities to interact with and design robots parts which will positively influence their classroom practices in STEM teaching and learning.

Research Question Two:

To what extent are participants able to demonstrate competence in robots design skills?

Table 2: Mean Brush Robot Design Skills competence exhibited by participants

	Robots design skills being assessed	N	X	SD	Decision
1	Robots design process activities	30	3.6	0.80	VC
2	Robot base cutting	30	3.1	0.92	VC
3	Robots stage cutting	30	3.0	0.84	C
4	Construction of robots rollers	30	2.8	0.64	C
5	Coupling of robots parts	30	2.7	0.82	FC
6	Fixing of robots parts	30	3.2	0.66	C

Source: Pre-test exercise 2024
KEY: VC Very Competent, C =Competent, FC= fairly competent, NC Not competent

Data on Table 2 shows the performance of participants had a very high competence in design process activities mean of 3.6, SD 0.80. While coupling of robots parts had the lowest competence mean of 2.7 SD 0.82. This implies that participants were effective in 90% of the task assigned to them. Data on Table 2 shows that participants were very competent in robot design process activities and robot base cutting. The also showed competence in Robot stage cutting, construction of rollers and fixing of robot parts. They however showed only fair competence in coupling of robots parts. This in consonant with findings of Katniyon et al (2023) who discovered that teachers exposed to robots design training pick up interest and improved with practice. If Nigeria must be part of the 4 and 5th industrial revolution globally, then its teacher's must be deliberately exposed to 21st century pedagogical methodologies such as robot designs to impart these skills on the children they teach especially at the foundational school levels. Early design skills are capable of laying adequate foundation for future careers in STEM areas.

Research Question Three

To what extent are the designed robots functional when exposed to functionality test?

Table 3: Mean functionality test exhibited by designed robots

	Robots design skills being Assessed	N	Functionality			Decision
			Low	Average	High	
1	Completeness of form	30		X		Functional
2	Age appropriate	30			X	Functional
3	Ease of use	30		X		Functional
4	Motion and functioning	30		X		Functional
5	Compliance with safety	30	X			Needs improvement
6	Durability	30		X		Functional
7	Educational value	30			X	Functional

Source: Pre-test exercise 2024

Data on table 3 indicate that the designed robots have high educational value and are age appropriate. The robots are averagely complete in form, ease of use motion and durability. The designs however have low compliance to safety. This implies an average functionality test for the design off screen robots.

Functionality test of any engineering equipment is very important if it must not be an excise in futility. Interest and attitude towards a design process increases if there is a functional display of the usability of the product from participants (Eguchi, 2016; Katniyon et al 2023). In a classroom setting the teacher's confidence to improve the technology and engineering component of STEM engagements is enhanced in areas of age appropriateness ease of use safety compliance and educational values amongst others. Ultimately enhancing learner's creativity, critical thing and problem solving skills.

The research was an engineering design process undertaken to access participants' skills in designing a bristlebot. Results from this study indicated that the brush robot vibrated when the switch was turned on. This indicates effective functionality for the created brush robots. This findings is in-line with the findings according to an article written by Ben Finio, (2024) titled 'how to build a brushbot' who states that: when you turn the motor on, it makes the robot vibrate and move across the table, the robot design functionality test is excellent. This happens because you attached an off-center weight (the cork) to the motor's spinning shaft. If you removed the cork, the robot would not vibrate at all. This is the same concept used to make video game controllers, electric toothbrushes, and cell phones vibrate; they have little spinning motors with weights inside. Your robot probably did not move in a straight line. In fact, it probably buzzed all over the place, and crashed into things! This is because your brushbot's movement is random. There is no computer "brain" telling the robot how to steer. More-advanced robots rely on computer programs to help them avoid crashing into things.

The brush robot components are inexpensive and the brush robot can be customised/beautify into different forms just like National flag is added to it. This is similar to the findings of Vanstone, (2022) in his article titled 'How to build a brushbot' which states that brushbots are super simple mini robots that only need a few bits of inexpensive kit to create. All the materials can be reused in other robotics projects too. They are easy to build and can be customised in many different ways!

Summary of Findings

The robot design experiment by the participants shows that the brush robot vibrated and moved across the table. This happens because you attached an off-center weight (the cork) to the motor's spinning shaft. If you removed the cork, the robot would not vibrate at all. This is the same concept used to make video game controllers, electric toothbrushes, and cell phones vibrate; they have little spinning motors with weights inside.

1. Pre - service teachers' were able to identify some brush robots components
2. Participants were able to demonstrate competence in brush robots design skills
3. Designed brush robots are effective when exposed to functionality test.

CONCLUSION

Having achieved the purpose of the project though there was delay in the execution of the project due to disagreement on issues relating to the design and testing with diverse views. However, the aim of the project was achieved; the design and testing of the bristle robot with every group member participating from beginning to the end having a proper understanding.

Recommendation

Considering the positive impact of the project on the pupils and the Department of Early Childhood Care and Education, entirely, the following recommendation should be taken into consideration;

1. The pupils should perform practical involve in the practice to acquire knowledge and skill in any project given.
2. The school should provide some materials and tools that will be used during the practical and project execution. For examples; tabular circular saw, DC Motor, battery, battery connector and the brush machine; which will be used by pupils to enable a smooth and easy work and also to help the pupils know how to use some equipment involve in design and testing.

Acknowledgement*:*

The authors of this research article wish to acknowledge the support of Tertiary Education Trust Fund, IBR Federal College of Education, Pankshin Nigeria who fully funded this research.

REFERENCES

Azah, N., sholeh, M. I., & Supratno, H. (2024). The influence of the principal's leadership style, administrative support, and professional development on teacher performance At Mtsn 17 Jombang. *Journal of Research Administration,* 6(1).

Alimisis, D. Educational robotics: Open questions and new challenges. *Themes Sci. Technol. Educ.* **2013**, *6*, 63–71.

Bybee, R. W. (2010). Advancing STEM Education: A 2020 vision. *Technology and Engineering Teacher*, 70(1), 30–35.

Chen, G., Zhang, X., & Jin, Y. (2020*). Research on the application of educational robotics in STEM education*. In 2020 15th International Conference on Computer Science & Education (ICCSE) (pp. 261- 265). IEEE.

Finio, B. (2024). STEM-activities/brushbot Retrieved from https://www.sciencebuddies.org/stem-activities/brushbot 1st September, 2024.

Guenat, S.; Purnell, P.; Davies, Z.G.; Nawrath, M.; Stringer, L.C.; Babu, G.R.; Balasubramanian, M.; Ballantyne, E.E.F.; Bylappa, B.K.; Chen, B.; et al. Meeting sustainable development goals via robotics and autonomous systems. *Nat. Commun.* **2022**, *13*, 3559.

Katniyon, H. D. Duguryil, Z. P. & Ladan, N. (2023). The future of science teaching: Pre-primary teachers' knowledge of educational robotics in STEM learning in Plateau state. *International Journal of Research and Innovation in Social Sciences,*VII (V), DOI

Khanlari, A., & Mansourkiaie, F. (2015). Using robotics for STEM education in primary/elementary schools: Teachers' perceptions. 2015 10th International Conference on Computer Science & Education (ICCSE), 3–7. https://doi.org/10.1109/ICCSE.2015.7250208

Knezek, G., Christensen, R., Tyler-Wood, T., & Periathiruvadi, S. (2013). Impact of robotics and geospatial technologies on science, technology, engineering, and mathematics (stem) learning and teaching. In Handbook of Research on Educational Communications and Technology (pp. 735-745). Springer.

Liu, Y., Navarrete, C., Brophy, S., & Pagnucco, M. (2019). The impact of robotics education on creativity and problem solving skills. In 2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 261-269). IEEE.

National Research Council. (2011). Successful K-12 STEM *education: identifying effective approaches in science, technology, engineering, and mathematics.* National Academies Press

Nyein, AK, Khaing, KT, & Soe, TK (2019). A review on educational robotics in stem education. In 2019 International Conference on Advanced Information Technologies (ICAIT) (pp. 142-147). IEEE.

Papadopoulos, I.; Lazzarino, R.; Miah, S.; Weaver, T.; Thomas, B.; Koulouglioti, C. A systematic review of the literature regarding socially assistive robots in pre-tertiary education. *Comput. Educ.* **2020**, *155*, 103924.

Papert, S.; Solomon, C. (1971). *Twenty things to do with a computer*; Constructing Modern Knowledge Press: Cambridge, MA, USA, 1971.

Papert, S. *Mindstorms (1980). Children, computers and powerful ideas*; Basic Books: New York, NY, USA, 1980

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. Basic Books.

Piaget, J. (1950). The Psychology of Intelligence. Routledge.

Šabanović, S., Bennett, C. C., Chang, W. L., & Huber, L. (2013). PARO robot affects diverse interaction modalities in group sensory therapy for older adults with dementia. In Proceedings of the 8th ACM/IEEE International Conference on Human-Robot Interaction (pp. 385-392).

Sachs, J.D.; Schmidt-Traub, G.; Mazzucato, M.; Messner, D.; Nakicenovic, N.; Rockström, J. Six transformations to achieve the Sustainable Development Goals. *Nat. Sustain.* **2019**, *2*, 805–814.

Sadovnikova, K., & Chounta, I. A. (2020). Robotics in STEM education: A review of current practices. In Proceedings of the 13th International Conference on Computer Supported Education (CSEDU 2020) - Volume 1 (pp. 243-250). SciTePress.

Shively, K. R., & Farris, A. V. (2021). Robotics in education: A review of uses and opportunities. The Mathematics Educator, 31(2), 9-28.

Sholeh, muh I. (2023). Use of big data in education management: Building data powered decision making. *Promis*, 4(2), 347–371. https://doi.org/10.58410/promis.v4i2.735

Uluer, P. Akalın, N.; Köse, H. (2015).A new robotic platform for sign language tutoring. *Int. J. Soc. Robot.* **2015**, *7*, 571–585.

VanLehn, K., & Jones, R. M. (2017). Supporting learning from exploratory learning environments with intelligent tutoring capabilities. *In International Conference on Artificial Intelligence in Education* (pp. 600-603). Springer, Cham.

Vanstone, E. (2022). How to build a brushbot. https://www.science-sparks.com/how-to-build-a-brushbot/.

Cite this Article: Duguryil, ZP; Katniyon, HD; Longmut, DI (2024). Design and Testing of Brush Robot as Innovation in Improving STEM Instructional Out-Come in Pre-Service Teachers in Plateau State. *Greener Journal of Educational Research*, 14(1): 123-131, https://doi.org/10.15580/gjer.2024.1.111424169.