INTEGRATING HANDS-ON ACTIVITIES TO ENHANCE STEM SUBJECTS IN TANZANIA PRIMARY EDUCATION

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Abstract

In recent years, the government of Tanzania has made major plans in the education sector in terms of an increased number of schools, improved infrastructure, and improvements in the education policies and curriculum reviews. Although the latest curriculums require teachers to introduce the use of hands-on activities in their lesson plans, the pass rate for STEM-related subjects is improving but at a very slow pace. Only 7.49% improve was recorded for mathematics while for science pass rate dropped by 3.56% in the year 2017 from the 2016 PSLE results. There is also no defined component to introduce primary school pupils with extra skills such as those mentioned in the 21st-century skills in the whole learning processes and examinations. This paper aimed at exploring the possible ways of integration of hands-on activities to enhance stem subjects in Tanzania primary education by finding out the extent of using hands-on activities in classroom teaching, the presence or absence of learning clubs in primary schools and proposing possible hands-on activities which matches with the STEM subjects’ content and the surrounding environments. Views, challenges, and recommendations were collected from different participants including teachers, parents, pupils, and STEM hubs. Findings showed that the use of hands-on activities is practiced for both government and private schools and also there are different clubs in schools, STEM included. However, these clubs are not as active as they should be and the concept of using hands-on activities has been mistakenly replaced by the use of demonstrations, models, and pictures for teaching and learning purposes. A way forward on the proposed integrations of hands-on activities featured topics has been recommended which are based on science experiments, coding and animation and the use of digital content in learning mathematics subjects. A more needed action from the government is to have regular professional development seminars for the teachers in order to impact more up-to-date knowledge to the pupils.

Keywords: Primary School Education, Tanzania, Science, Technology, Engineering, Mathematics, Hands-on Activities.

1 INTRODUCTION

The Education hierarchy in Tanzania starts from pre and primary level, ordinary secondary school, advanced secondary school, and college/university level. The primary education came into a rapid expansion after the introduction of Universal Primary Education (UPE) in 1974, aiming at equipping every child with the basic primary school education. Since then, there have been major development plans in the education sector in terms of an increased number of schools, improved infrastructure, and improvements in the education policies and curriculum reviews. Some of these plans include; the 2001 Primary Education Development Plan (PEDP) [1], The Revised Education Sector Development Program (ESDP) [2], the Sustainable Development Goals Tanzania Development Vision 2025 (SDGT) [3] and Education and Training Policy Five Year Development Plan (2016–2021) [4]. Among the goals stated in the SDGT 2025 vision is “to ensure inclusive and equitable quality education, to increase access to primary and secondary education and to improve the quality of education for all.”

The primary education sector advanced more with the increase of privately owned schools. Statistics from the National Bureau of Statistics (NBS) and National Examinations Council of Tanzania (NECTA) [5] show that these privately owned primary schools rapidly increased in number from only 426 schools in 2009 to 1,564 in 2018 which is an approximately 267% increase in just 10 years. Currently, data retrieved from NECTA results show that the total number of primary schools owned by both the public and private sectors has reached 17,967 (International schools not included). These schools use curriculums developed and guided by the Ministry of Education, Science, and Technology (MoEST) and Tanzania Institute of Education (TIE), produced in the Swahili language. The private schools are mainly English Medium schools using an English translated version, while most of the public schools use the Swahili language as an official language for teaching.
Despite the increase in the number of schools, regular policy reviews and improvements in curriculums, the education sector goals have not yet been attained at a remarkable pace. The pass rate is still low in accordance with the latest statistics published in the NECTA Primary School Leaving Examination (PSLE) performance data visualizations [6], [7]. For mathematics, only 46.61% and 54.10% passed the PSLE in 2016 and 2017 respectively, while the science pass rate dropped by 3.56% from 2016 and 2017 results. Moreover, still learning content has no enough ability to equip students with extra skills to match with the 21st-century world. Research by [8] analyzed the adopted curriculum for Tanzania primary schools which was basically equipped with theoretical learning content. There was no enough defined hands-on activities or practical integrated with learning. The latest versions of curriculums (for pre and primary education) were published in 2016, and have stated the inclusion of extra activities and the use of Information and Communication Technology (ICT) tools in the process of teaching and learning [9], [10]. It is stated that a teacher needs to use knowledge and creativity in preparing and using proper tools for teaching and learning in accordance with the surrounding environment. However, there is no clear defined way of designing these hands-on activities to be used for all schools. There is also no evidence that shows these teachers have enough skills to design extra activities apart from classroom assigned sessions.

Science, Technology, Engineering, and Mathematics (STEM) are among the core subjects in the education system. According to [11] & [12], these subjects have been perceived to be the most difficult subjects leading to high failure rates. Some initiatives and projects have been introduced to address the negative perception of STEM by most students. Most of these projects involve the use of ICT tools to develop content and games for learning. Although these projects may have successfully helped students to perform better, the general drawback is that they are not fully incorporated in the curriculums and are piloted in a few primary schools only. STEM subjects can be equipped with a lot of hands-on activities, experiments, and practices to support theory content in a quest for improving the 21st-century skills of students.

This paper aimed at exploring the possible ways of integration of hands-on activities to enhance STEM subjects in Tanzania primary education. Specifically, the study explored the benefits of including hands-on activities for pre and primary school pupils, the presence or absence of learning clubs in primary schools, outlined possible hands-on activities which match with the STEM subjects' content and the surrounding environments.

2 RELATED WORK

2.1 STEM-Related Projects in Tanzania

Over the past few years, there have been many projects developed in the quest of changing the quality and system of education in Tanzania for all levels. These projects are mainly focusing on finding alternative ways to make sure students get up-to-date tools for learning in line with the changing technologies. Among the popular proposed tools are, the use of multimedia enhanced learning, use of games, animations and television programmes. This study focused mainly on STEM-related projects and found projects such as Cheza, Jenga hub, Ubongo Kids and Robotech in Tanzania and a review of other STEM-related researches worldwide. In Cheza project, developed by the Centre for Virtual Learning (CVL), [12] investigated the lack of interest in learning mathematics and why students perceived it as a difficult subject. The project then redesigned and digitized local games into digital format, aiming at improving numeracy skills for children in a fun way. The research done after the project indicated that using digital games is an effective way to stimulate and improve numeracy skills for children. The Ubongo Kids project involved solving math problems and creating animated science experiments. Kids learn in a fun edutainment way through television programs, online videos, audios, and interactive eBooks.

World Vision Tanzania (WVT) is also among the organizations that have worked to improve the education system in Tanzania. In their "spark a child's digital future" programme [13], they aimed at improving teachers pedagogical skills and students learning through the use of digital means. WVT saw the need for doing this project after discovering poor teacher’s trainings, lack of learning materials and lack of trainings in skills needed for the 21st century in sub-Saharan countries. Through their programme, they targeted to reach out to the youth in late grades of primary schools for communities with the greatest needs in Kenya and Tanzania.

Other researches in Tanzania have focused much on a higher level of education, from secondary schools to higher learning institutes. For example, a research project was done for secondary schools
to enhance learning through the use of multimedia developed content [14], [15]. The research based on science and mathematics subjects, showing that lack of interest in these subjects is propagated from primary school level to secondary schools which in turn negatively influences the number of students pursuing STEM-related subjects in higher learning institutions. This theory is also supported by [16] stating that, acquiring knowledge on something from early years of learning provides a good base for advanced years of learning.

However, there are drawbacks of these ways of learning in developing countries like Tanzania. One being that, only the piloted schools and those children who can afford the facilities can access the content. There are limitations of getting proper facilities such as computers, tablets, televisions and other tools for accessing digital content in some areas in the country due to locations and economic conditions. Moreover, in all these projects, learning tools, games, and content were pre-developed by professionals, kids only use the end products for learning purposes. There is little emphasis or mention of the use of hands-on activities.

2.2 Use of Hands-on Activities in Learning

The use of hands-on activities in STEM featured subjects has been researched by many all over the world. Research by [17] was done to investigate the influence that the hands-on activities can bring to students’ interest in learning. This study, in particular, was done in secondary schools in North Germany using concrete examples of biology practices. The purpose was to find out whether using hands-on activities can lead to students showing a higher interest in the subject than students with no experience in hands-on activities. The findings suggested that many hands-on activities offer a positive influence for students to acquire more interest in the subjects involved. Students are more interested in experimenting and working with tools than reading. Similar studies were conducted to determine the effect of hands-on activities for children knowledge. [18] Mentioned that among the benefits of hands-on activities is to stimulate pupils’ imagination into reality, promote students creativity and social empowerment and thus improving the level of understanding the subjects. It has been generally indicated by [17], [18], [19] that integrating theoretical learning and oral instructions with practical learning can subsequently improve the students’ level of understanding and influence positive perception towards STEM.

3 METHODOLOGY

This study was carried out in Dar es Salaam region which is the most populated region and the business center of Tanzania. The study employed a combined qualitative and quantitative design approach in two different methods. The first method was by organizing pilot STEM camps for pupils aged five (5) to twelve (12) years (which is the basic range of years for pre and primary school pupils) in a period of two weeks. The camps were organized by the Smart Kid Initiative programme under the University of Dar es Salaam ICT incubator (UDICTI) and involved pupils from different pre and primary schools. Thirty (30) children attended the first camp and seventy-two (72) attended the second camp from. These children were given a pre-test on the awareness of STEM subjects and career choices. A post-camp assessment survey on children and their parents was done after the second camp by feedback questionnaires for parents and children and interviewing some parents. The science camp feedbacks questionnaire mainly were used to get views of the camp design, the content used for the camp and recommendations from parents. There were also a set of questions to measure the fun and perceived usefulness of conducting science experiments, coding exercises, and art. A total of 59 pupils and 25 parents responded to the questionnaires.

The second method involved visits to selected schools to determine the presence and activities done in schools’ STEM clubs. Ten teachers from six different schools were selected, six being from public schools and others being from private schools. Data was collected by using teachers’ interviews followed by observations of the activities in the school clubs. The Interviews were conducted for science, ICT and mathematics teachers because these subjects fall under the STEM subjects theme which is the purpose of the study. Interview forms were designed in such a way to collect information about the teaching load, use of hands-on activities in class, activities done in the clubs, challenges faced and how much importance the clubs bring to pupils’ learning process.

Data gathered from pupils and parents surveys were analyzed and presented in tables, graphs, and descriptive presentations. Teachers’ interview responses were compared for similar cases and presented in three approaches; evident on the use of hands-on activities, challenges and recommended approaches to integrate hands-on activities with primary education learning.
4 RESULTS

The main objective of this was to explore possible ways of integration of hands-on activities to enhance STEM subjects in Tanzania primary education. In the results, participation and impact of STEM camp organized by UDICTI to involved students and parents’ perspectives have been discussed. Also, included is an analysis of the current situation in primary school, the presence or absence of learning clubs in primary schools, activities that are done in school clubs and a proposed way forward.

4.1 Smart Kid STEM camps

The Smart kid initiative programme was designed to expose children to STEM subjects in a fun way in order to build their interest in these subjects. Pupils did a number of hands-on activities by using ‘easy to get products’ and waste materials like bottles and cardboards to build science experiments, engineering structures, and robotics. They also learned child-based coding and animations to develop math games, animated stories, and electronic programmed solutions. 72 pupils aged 5 to 12 years old attended the second smart kid STEM camp which is an increase of 140% as compared to 30 attendees of the first camp. Among the attendees, 42.4% were girls and 57.6% were boys as indicated in Fig. 1, 54.2% being between the ages of 8 to 12 years. These pupils came from 32 different schools in Dar es Salaam region. One notable negative aspect of the camp is that pupils came only from private schools. None came from a government school and this may be due to the financial statuses and technological exposure of their parents.

![Figure 1. STEM camp participants gender and age groups](image)

4.2 Activities in Smart Kid STEM camps

The activities were divided into two categories according to age groups, 5 to 7 (lower) age group and 8 to 12 (upper) age group. Some of the involved lower age group activities and the upper age group are indicated in Table 1. For each activity children were given oral instructions on how to build, assisted in building them and discussed the lessons learned from the activities.

<table>
<thead>
<tr>
<th></th>
<th>Activities for Lower age group (5 to 7 years)</th>
<th>Activities for Upper Age Group (8 to 12 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Electricity Conductivity by Aluminium foil</td>
<td>Working Principle of Lungs</td>
</tr>
<tr>
<td>Two</td>
<td>Working Principle of a fan</td>
<td>Demonstration of Series and Parallel Circuits</td>
</tr>
<tr>
<td>Three</td>
<td>Volcanic eruptions</td>
<td>Working principle of a vacuum cleaner</td>
</tr>
<tr>
<td>Four</td>
<td>Balloon and Rubber band powered cars</td>
<td>Demonstration of Different Liquids’ Densities</td>
</tr>
<tr>
<td>Five</td>
<td>Building stable structures, bridges</td>
<td>Lemon Batteries</td>
</tr>
<tr>
<td>Six</td>
<td>Balloon inflation by chemical reaction</td>
<td>Building Robots using cardboards</td>
</tr>
<tr>
<td>Seven</td>
<td>Balloon water fountain</td>
<td>A Smart House with automatic filling tank and self-lighting circuit</td>
</tr>
<tr>
<td>Eight</td>
<td>Coding and animation using scratch</td>
<td>Coding and animation using scratch</td>
</tr>
</tbody>
</table>
Pupils were asked about the level of enjoyment for each specific activities and the average responses indicated that they had “a lot of fun”, which was also supported by their parents.

4.3 Initial Impact of Smart Kid STEM Camp

23 out of 30 pupils that participated in the first camp returned for the second camp which is equivalent to 76.7%. In this second camp, demand was so high for parents kept calling in to secure places for their children. In the post-camp survey pupils were asked to give their view about the camp on three categories by using a five-level Likert scale as indicated in the x-axis of the graph in Fig. 2. These pupils had to be guided through the survey in order to understand the questions and give their honest opinions. The overall calculated mean was \( M=4.37 \) which indicates a ‘high’ level of perception. This was also collaborated by parents responses as they indicated on how much their kids are having fun explaining the daily activities and are eager to practice more even when they were at home.

“One son has given me a list of materials that I should buy for him to practice at home. Can you share the contents and topics with the availability of the learning tools?”

![Figure 2. Pupils view about Smart Kid STEM camp](image)

Even though there were many positives feedback about the camp, some showed negative responses particularly on two aspects, time allocated and space. Comments from parents revealed that the time allocated for the camp was very limited compared to the scheduled number of activities and space was not enough for the kids. Some of the quoted responses from parents;

“You need to do this camp for at least one month and a lot more frequently so as to have a true impact. Increase time duration for the camp and allocate more time for activities so that all the kids can participate fully”

4.4 The Situation in Tanzania Primary Schools

The private and government schools share the same curriculum content but of different languages, Swahili for government and English for private schools. It was observed that the teacher-student ratio is 1:43 as per government requirements, supported also in a report by UNICEF [20]. This means that a number of teachers are assigned to schools depending on the number of students and not the number of subjects. Consequently, one teacher is assigned up to five different subjects, from different grades leading to having multiple sessions per week, every session taking forty minutes long. The summary of findings for teachers assigned sessions in elaborated in Table 2.
Table 2: Sample assigned load of primary school teachers

<table>
<thead>
<tr>
<th>Teachers' ID</th>
<th>Type of School</th>
<th>Number of Assigned Subjects</th>
<th>Number of Session per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher1</td>
<td>Government</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Teacher2</td>
<td>Private</td>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>Teacher3</td>
<td>Private</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Teacher4</td>
<td>Government</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>Teacher5</td>
<td>Government</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Teacher6</td>
<td>Government</td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>Teacher7</td>
<td>Government</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Teacher8</td>
<td>Private</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Teacher9</td>
<td>Private</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Teacher10</td>
<td>Government</td>
<td>5</td>
<td>24</td>
</tr>
</tbody>
</table>

Conclusively, solely from the gathered statistics, the government school teachers are assigned more types of subjects and although teachers from private schools may have been assigned fewer subjects, they have a bigger number of sessions per week.

4.5 Use of Hands-on activities in schools

It is stated in the curriculum and teaching aid that hands-on activities should be used for every subject as a method to emphasize the theoretical classroom learning [10]. All the interviewed teachers indicated that they use activities in their assigned subjects. However, from their responses, it was observed that teachers use demonstrations and pictures instead of actual involving pupils in hands-on activities. Also, they use a few practical examples depending on the topic and availability of materials. Science topics like Plants and living things, sensory organs and environment were mentioned to be easy to demonstrate. Other topics that require more time and cost for materials are usually not included.

The impact of overloading teachers with many sessions per week may have also led to less use of hands-on activities and concentration on a particular subject. Some of the teachers explained this by saying how difficult it is to do activities within the scheduled time.

“When I finish one class, I go directly to another class and I don’t have time to rest. Sometimes I think of the next class while I am in the current class, so it is difficult for me to concentrate”

“There is no proper guide for doing these hands-on activities so it is difficult to come up with activities for every course that you have been assigned”

This statement is supported by the averagely calculated number of class hours and the free time of each teacher. The standard total number of sessions per day is 8 in accordance with the primary teaching guide. From Table 3, the mean number of sessions per week (25) indicates that one teacher is assigned 5 sessions a day, meaning that more time is spent teaching and less time for preparations of multiple subjects.

Table 3: Mean values of teachers’ assigned load.

<table>
<thead>
<tr>
<th>Index</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Assigned Subjects</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Number of Session per Week</td>
<td>21</td>
<td>30</td>
<td>25.00</td>
</tr>
</tbody>
</table>

4.6 Presence of STEM clubs in Schools

One of the key items to investigate in primary schools was the presence or absence of STEM clubs. Although the curriculum and teaching aid require a teacher to use hands-on activities for every
subject, there is no clear statement about the initiation of clubs in schools whether academic or sports clubs. However, there are frequent government inspections in schools and among the key inspected items is the evidence of presence and activities done in school clubs. The purpose of the inspections is to rank school performances and make a follow-up on per government requirements. All of the visited schools had a number of clubs; mathematics, science, and ICT being the common clubs that fall under STEM. The major observed difference comes with the activeness and involved activities in those clubs for each school. Some schools have clubs just for the sake of fulfilling the inspection requirements and some use clubs as a discussion meeting to solve difficult or extra questions from classroom taught subjects. Overall, there is no proper guidance for teachers to run these clubs and this leads to having different unplanned activities as per teachers’ skills and choices. The time allocated for the club activities is about 60 to 80 minutes, once a week, depending on each individual school.

4.6.1 Selection of Students

Each school had a different style of selecting pupils to join the STEM clubs. Some of the commonly mentioned methods were; by observing pupils interests in particular subjects, by giving them the freedom of choosing what they like, and by using exams results to balance the good, moderate and poor performing pupils in clubs. Others involve only higher grader students in the clubs, particularly grade six and seven. However, when further discussions were made, it was evident that each particular method had a negative aspect. Giving freedom for pupils to select what club to join may result in having more students in one interesting club than others. Students tend to choose ICT, sports and other outdoor clubs than mathematics and science clubs. Similarly, the use of exam results doesn't consider pupils interests which may lead to pupil's loss of concentration in activities. The proposed method was to have both academic and sports clubs separately so that students can join more different clubs.

4.6.2 Involved Activities

When asked about the regular involved activities, there were different responses for each of the three identified subjects that fall under STEM. For mathematics, the main activities are such as; solving difficult questions, math games, and mathematics principles. For science, there was a wider range of activities focusing on discussions, use of pictures, models for learning and simple science experiments. And lastly, for the ICT club, the main activities are learning how to use computers, hardware parts, and basic Intel learning. There is no school that teaches simple coding and animations for kids like how it was done in the STEM camps. Teachers argued that they couldn’t initiate those activities if they have no skills and it is not part of the curriculum content.

4.7 Benefits and Challenges of STEM clubs

Participants were asked about what they thought to be the key benefits of STEM clubs and their responses were similar to reviewed literature in [17] and [19]. Some of the mentioned benefits include;

- “It helps the pupils to widely understand the lesson more than normal class time”
- “Teaching by using hands-on activities is one of the learning advancements which can help a beginner to understand easily than other methods”
- “Children are more open, free and curious during the club sessions than classroom sessions”
- “It strengthens children memories, creates interests on the subjects and is a platform to ask many questions than in classrooms”

All schools agreed that there are many challenges in running their STEM clubs in Tanzania primary schools. The most common challenges were grouped in three different categories; challenges in terms of facilities, in terms of content and guidance and in terms of teachers creativity skills. There is a lack of proper facilities, especially for science and ICT subjects. It was noted that primary schools don't have science laboratories so activities are done in classrooms or outdoors. There were science kits distributed to schools but some are lost or damaged and not in use anymore. Moreover, those science kits contained models and card pictures that are only used for demonstrations and cannot be termed as satisfying the need to do hands-on activities. The subject with the most challenges is ICT and computer studies. Schools have none or very few facilities including computers, projectors, and software which have been acquired from participating in different non-governmental organizations'
projects. There is no budget or funds to buy computers for each government school as well as for some private schools.

5 CONCLUSIONS

The involved participants; teachers, parents, pupils, and other stakeholders gave their comments and recommendations on the way forward and methods of integrating hands-on activities in primary schools leaning. Taking into account all the recommendations, we came up with a proposed way and a general conclusion.

5.1 The Proposed way of Integrating Hands-on Activities

The use of hands-on activities needs to be redefined and understood by all involved in the education system, and should not be confused with the use of demonstrations. From the teachers’ views, stem hubs views and other stakeholders these are some proposed ways of how hands-on activities can be integrated into primary school learning in Tanzania.

1. Involve teachers and STEM hubs in identifying topics and their corresponding activities and practices.
2. Develop teachers guides and reference books for all grades to include; topics, affordable materials, methods and lessons behind each activity.
3. Conduct regular seminars and training of trainers for in-service and pre-service teachers.
4. Initiate and monitor active clubs in schools for all grades. Involve pupils in activities, competitions, and exhibitions to encourage them to actively participate more.
5. Develop a sustainability plan to develop internal funds if needed.

5.2 Conclusion

According to the literature and findings of this study, there have been major developments in changing the ways of learning in Tanzania, but no more effort is needed for primary education. The demand for pupils to be involved in hands-on activities has been found to be high as pupils enjoy and understand the learning process much easier. Parents and teachers also believe this to be a good way for ease of acquiring knowledge and understanding. As Tanzania moves towards industrialization, children from an early age should be equipped with problem-solving mind-sets by putting more efforts into the STEM subjects. It is clear that this method is beneficial for preparing the next generation (children) in taking the development of the county to the next level. Programmes such as the Smart kid initiative, the Jenga hub, Robotech and others of such kind should be supported by the government and other development organizations.

ACKNOWLEDGEMENTS

We wish to send our gratitude to teachers, parents, and pupils who participated in the interviews and survey for their contributions to accomplish this study. We also acknowledge Feza school management, Jenga hub, the Smart kid initiative team and others who participated in the dialog conference to share their opinions in the matters of children and youth innovations.

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