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Contextualized Science Teaching and Student Performance: The Case of a Kenyan Girls Science Class*

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This paper is about a case study that investigated the impact of contextualized science teaching and learning on performance of a Form three (Grade 11) class in one of Kenya's girls high schools. The class experienced nine weeks of contextualized science learning. This involved a full day visit to *Jua Kali* where they interacted with artisans. "*Jua Kali*" is a small-scale manufacturing and technology-based service sector where artisans manufacture equipment and other household items that are ubiquitous in everyday Kenyan culture. The visit was followed by organized classroom-based group discussions about what they had learnt and considered most relevant and meaningful. Following this highly engaging student learning discourse, their creativity and innovative abilities in science improved tremendously as reflected in the quality of class presentations and participation in the National Science Congress. Moreover, the school's performance in the Kenya Certificate of Secondary Education (KCSE): a final national exam at the end of Form 4 (Grade 12) improved from a mean of 9.3 in the previous year to 10.4 in the intervention year ($p = 0.022$). This was further attributable to significant improvement in all science subjects: biology, chemistry, physics and mathematics. Besides the critical insights about the *Jua Kali's* richness in scientific phenomena, there is also great potential for contextualized science experience to enhance students' deeper understanding of science.

Keywords: jua kali; contextualize

1. Introduction

1.1 Background

According to contextual learning theory [1, 2] learning occurs only when students process new information or knowledge in ways that make it meaningful in their frame of reference e.g. local context [3]. According to the theory [1], this approach assumes that the mind naturally seeks meaning in a context by searching for relationships that make sense. Thus, students learn better if they can relate the concepts to what they encounter in their day to day life [4]. The local environment is rich in materials and activities where students can learn science concepts without the traditional science laboratories, which are expensive to establish and to run [5]. In Kenya, Education consumes about 40% of Government current budget and this excludes parents and community contribution in terms of fees and infrastructure development [6]. This makes Education not only the most costly service in the nation but also unaffordable to most Kenyans. Under these circumstances, the whole question of benefit from such an investment has to be reviewed. Quality education has socio-economic benefits. In many countries, attempts have been made to get individual recipients of these benefits (students, parents, and the communities) to pay a bigger share of the cost, a situation already prevalent in Kenya [7, 8] High percentage of Kenyans cannot afford to pay for quality education. It has also been noted that gender imbalance is still a problem in Kenya. For example, in Public universities, the number of female students is much lower than that of male students. On the average, the gender ratio is 30:70 in favor of male students—this is per Public University Admission in Kenya (University Admission Board). This situation is replicated in science related disciplines such as Engineering where the ratio is about 20:80. Although the focus of research has been mainly on the differential performance of girls and boys, the high volume of this research has been necessitated by apparent low performance by Kenyan Secondary schools in Science and Maths compared to other subjects especially humanities [9]. A number of reasons have been given for this poor performance, like lack of well-equipped laboratories, attitude and

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lack of qualified teachers among others. There is need to initiate some concerted effort towards not only improving secondary school performance in Science and Maths but also accessibility to tertiary level education related to science and Mathematics disciplines. This study was conducted in a national Girls School that offers all the three science subjects with an aim of providing quality science education to the Kenyan students at a reduced cost by utilizing the local environment, the *Jua Kali* sector. The sector is rich in scientific applications covering almost all the science disciplines. The workshops are spread all over the villages and their products are in use in every Kenyan household.

1.2 General objective

To improve performance in secondary school science in Kenya through contextualized teaching and learning—in the *Jua Kali*.

1.3 Specific objectives

- To determine if using *Jua Kali* activities and products as cheap, sustainable science laboratory can improve science performance in Kenyan secondary schools.
- To determine if students' understanding and interest in science can be improved using *Jua Kali* artisans as learning resources.

2. Presentation

2.1 Literature review

The achievement of universal participation in education depends upon the relevance of education available. Schooling is supposed to help learners develop creatively and emotionally and acquire skills, knowledge, values and attitudes necessary for responsible and productive citizenship. In many countries around the world, the irrelevance of education to the life experience of learners seems to be an enduring problem [10]. Many attempts have been made to adjust educational content so that it becomes relevant to local conditions. In practice, this has often meant the introduction of some "localized" topics, related to the environment. Relatively little emphasis has been placed, however, on the development of education strategies that are based on the immediate context in which the school is located.

2.2 Contextualised leaning

Contextualization of learning occurs when the content of the curriculum, and the methods and materials associated with it, are related directly to the experience and environment of the learner [1, 2]. In many schools in developing countries, most learners have direct experience of activities in their natural environment, either as a result of their own activities, or from observation in their immediate surroundings. *Jua kali* sector and the local environment used as media for contextualising science education can provide avenues through which students can have repeated experiences which help them to master skills. The local environment can be the basis of integrated projects incorporated in the school curriculum, with academic activities chosen for their locally relevant, experimental attributes [3]. Natural resources and activities in the local environment offer unique opportunities for contextualising teaching and learning, because the concepts can be experienced at school, at home and in the wider community. This can lead to a more effective application of what has been learned. There exist several programmes and interventions in different parts of the world that have aimed at using local environment to introduce contextualised learning in both primary and secondary education. One interesting existing example is the REAL Education in Thailand. REAL stands for "Rural Ecology and Agriculture Livelihoods". It is an integrated learning process in which children explore what is happening on local farms, gain an understanding of ecology, and develop critical thinking skills for addressing environmental, health and social problems. REAL is a low-cost approach to integrated learning. The students' field observations serve as a starting point for learning about a wide range of topics, inspiring lessons in science, mathematics, art and language. In addition, the process of getting students out of the classroom and into local fields assist in breaking down barriers between schools and rural communities. Also, this will encourage inter-generational learning and enhance the relevance of the curriculum to the needs of rural people. Just like *jua kali* workshops, the fields surrounding homes and schools provide students with an ideal place for learning about a wide range of issues [11].

2.3 Concept of contextualising teaching and learning using student's environment

Taylor and Mulhall [3] explored three key learning environments for school-going students: the school, the home and the wider community. These three learning environments are often weakly linked and the experiences gained in each are seldom drawn together and integrated in the learning process. The existence of weak linkages between the three learning environments implies that the experiences gained by pupils in school are often perceived to be divorced from life outside school. By maximizing the interfaces between learning environments, learning should become more effective. Contextual learning served as a method of combining different subjects into a coherent whole [12, 13]. The study showed that it is possible to contextualise learning using centralized curricula by teaching in an integrated way where boundaries for subjects are no longer discernible.

2.4 Education in Kenya

Despite numerous attempts to reform education in East Africa, and in particular, Kenya, the question of relevance has always been discussed as part of the reform agenda, but to date careful analysis of the state of education, and especially science education, relevance is like a "mirage" [14–16]. Since attaining independence from Britain in 1963 Kenya has had several major educational reforms, each of which has been preceded by a commission of inquiry including: [6, 17, 18]. All these commission reports have directly or indirectly affected the education system in Kenya, and at best, elicited the unending national debate on the question of relevance in terms of the role of science and technology in national development. Despite the major structural changes in Kenya's education system over the years, [14, 19] with the question of relevance characterizing the rhetoric for change, there has never been much effective shift from *traditional* British-modeled curriculum and pedagogy, especially in science education [15, 16, 20]. Currently, the system is still overly exam-driven, teacher-centered with colonial as well as foreign-leaning science curriculum and pedagogy. This apparent static nature of curriculum and pedagogy is due in part to colonial hangover and influence whereby for a long time foreign experts who had limited knowledge of the local Kenyan context dominated high school curriculum development and implementation [21]. Also, those Kenyans positioned to influence change were often trained abroad, or trained locally by foreign experts, thus they lacked the skills needed to reform curriculum and pedagogy to reflect the local context [21]. In addition, they often borrowed from foreign instructional models not suited for the Kenyan learner, most of who live and grow up in highly ruralized cultures, not privileged by conveniences such as electricity, running water, and motorized transportation. Over time, this has made teachers less receptive to pedagogies that claim to "innovate", but are often entrenched with multiple cultural assumptions about learning and the foreign contexts from which they originated [22]. Instead, Kenyan teachers focus more on getting students to pass exams. The need to make science relevant to the students is regarded as superfluous to examination performance and, at best, perpetuates the traditional culture where science is presented as an encapsulated system that has no relevance to the students in terms of their local contexts and everyday lives [2]. Any attempts to integrate into curriculum visits to local and authentic science learning environments, such as *Jua Kali*, are seen as unnecessary and time consuming distractions. But for most Kenyans, the question of relevance is very important [23] and, despite the local setting's richness in scientific phenomena that can be readily mediated through curriculum, Kenyan science teachers rarely exploit the potential to mediate student learning. Hence, the pedagogical practices of Kenyan teachers remain in a state of inertia despite attempts to reform.

2.5 Role of secondary school education and science subjects in Kenyan education system

In the 8-4-4 (8 years of primary, 4 years of secondary and 4 years of bachelors) system of education currently used in Kenya, secondary school education acts as a preparatory phase for all tertiary courses and programs, be it at polytechnic, university or other middle level colleges. The certificate obtained at the end of form 4 is perhaps the most important document a student in Kenya needs to access a good profession. Mathematics and science based subjects (chemistry, physics, and biology) form the core subjects in secondary education. This is evident from the subject requirements for enrolment into various courses at tertiary level. For example, at the university level, more than 60% of the courses require at least a pass in science and mathematics [24, 25]. As a result, most students opt to study and aim to pass well in science and mathematics. This is to broaden the range of professional disciplines they can fit into. In Kenya, good performance in science and mathematics at the national examinations level—Kenya Certificate of Secondary Education (KCSE) is commonly registered by schools with well-equipped science laboratories. No wonder it is most parents' dream to take their children to National schools with the belief that these schools are better at preparing students for university entrance at the end of secondary school phase. Therefore, the value of using experiments and other strategies to teach or learn science cannot be underestimated.

2.6 Science and mathematics in Kenyan secondary schools

The Government of Kenya recognizes the importance of science and maths in the realization of its vision 2030; to become a globally competitive and prosperous country by 2030. This is reflected in amount of resources both human and otherwise that are channeled towards enhancing the teaching and learning of science and maths at all levels of education system [8]. However, this high input does not seem to be reflected in the performance [9].

Analysis of KCSE result every year show poor performance in science and maths as compared to other subjects like history [25]. This trend was noted [17] and recommendations were made that more facilities be provided for science and maths teaching. Following this, a number of intervention strategies have been put in place to ensure that the teaching/learning of science and maths is as effective as possible. Apart from providing science teachers, the Government has institutionalized Service Education and Training, (INSET) for science and maths teachers under the Strengthening of Mathematics and Science in Secondary Education (SMASSE) Programme [26]. Schools on the other hand are charged with providing, learning resources/facilities through Board Of Governors (BOGs) and Parents Teachers Associations (PTAs). A number of organizations also offer laboratory equipment to support science education [17]. In spite of all these initiatives, KCSE performance in the sciences and maths is still poor [9]. This study aimed to explore *Jua Kali* sector as a cheap, sustainable, easily accessible secondary school science teaching resource to improve performance in the sciences and mathematics.

2.7 Procedure

This was an exploratory study involving contextualized science learning (the intervention) in one secondary school and comparing the outcome with a second school of the same level. The study procedures were as follows:

A. The intervention was introduced to three science teachers (physics, chemistry and biology) in a select Form 3 science class in one urban girl's high school. Upon acceptance, the teachers and the researchers visited a local *Jua Kali* site, surveyed it and identified varieties of products and production activities that could be linked to school science curriculum or could be understood in terms of school science as well as attract students' curiosity and attention to understand the embedded science. In collaboration with *Jua Kali* artisans the teachers and researchers divided the site into ten production stations to ensure that the students engaged in science learning through interaction with variety of products and production activities and the artisans.
B. Later in a workshop format the science teachers and researchers identified topics from the Form 3 science curriculum and *Jua Kali* products and production activities and developed guiding questions that enabled the students to engage in discussion with Jua Kali artisans and their peers at the site and back in the classroom with the purpose of trying to understand science through or embedded in *Jua Kali* products and production activities.
C. After the workshop, the teachers, equipped with the general framework for implementing the integrated science unit, organized introduction sessions with the Form 3 class that was aimed at sensitizing or cueing the students to/on the potential role local contexts could play in enhancing science understanding, our role as researchers and the aim of the study.
D. One day after the teachers cued the class of the potential benefits of *Jua Kali* as a site to engage in science learning, the students, teachers and researchers visited a local *Jua Kali* site where the students used the guiding questions to interact with Jua Kali artisans as they sought important information on the products and production activities for about three hours.
E. The visit was followed by a one-hour in-class activity that required students to reflect on the science embedded in at least one *Jua Kali* product and production activity they had experienced during the visit and make a 10-minute group presentation on a product and production activity that evoked most science knowledge and using science knowledge to suggest possible modifications to improve the product and production activity. The same students sat for their final National Examination one year after exposure to *jua kali* activities.

3. Discussions

3.1 Analysis and findings

Data analysis is an attempt to summarize the data that have been collected in a dependable, accurate, reliable and correct manner [27]. One year later, the students having reached their final year, sat for KCSE. KCSE results for that year were collected and analyzed for any significant improvement in students' performance as per the recorded mean grades in the sciences and school's overall mean. The table below (Table 1) shows the analysis of KCSE results of 4 streams with 40 students each from the National girl's school in Kenya who experienced the contextualized science unit. Student mean grade in chemistry, physics, biology, mathematics, English (a language) and Geography—a

Table 1. Effect of Jua Kali Learning Experience on Performance

Mean ± SD			
Before	**After**	**t-value**	**P-value**
8.3 ± 0.6	9.7 ±0.7	3.078	0.022

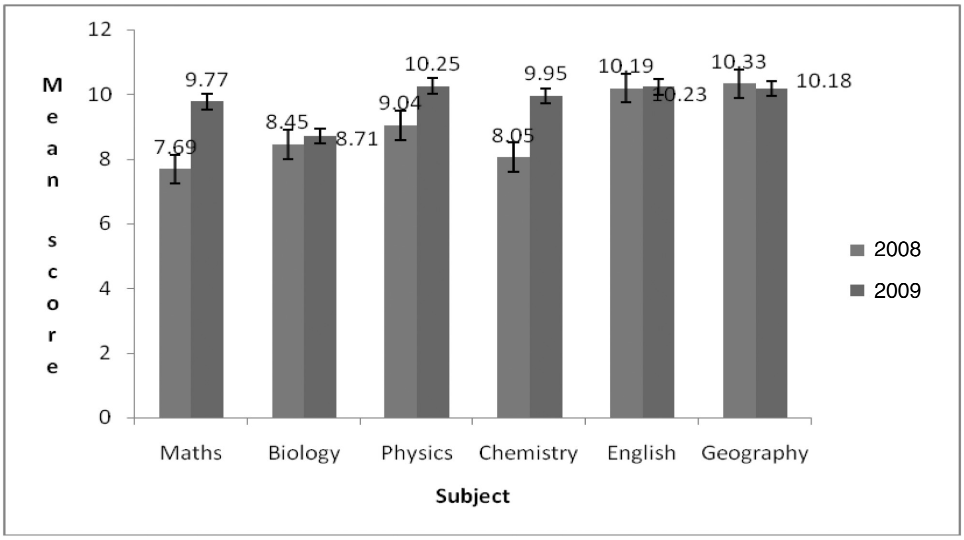

Fig. 1. Mean scores before and after *Jua Kali* exposure by subject in Mountain School.

humanity) were subjected to statistical analysis to determine if there was any significant improvement in performance as compared to the previous year, candidates of which did not experience the contextualized science learning experience. The results are shown in Fig. 1.

There was a significant improvement in mean performance in the science subjects from before to after *Jua Kali* learning experience (8.3 vs. 9.7, p = 0.022). In the above output the mean difference between before and after the *Jua Kali* learning experience in biology, English and geography is not significant but the rest are significant. We speculate that the activities in *Jua kali* are more attuned to physics, chemistry, and mathematics. Although the sector has great geography and biology related phenomena and concepts, it requires careful teasing out of the syllabi to engage in constructive biology and geography discourses. These can better be appreciated whenever environment is discussed. However, environment is emphasized but it is not a subject. Given the exam culture and syllabus driven teaching, there is a high possibility the teacher could not refocus their teaching as it would not be appreciated by the students and to some extent their parents.

Figure 2 compares the mean performance for six subjects in a comparative girl's school that did not experience *Jua Kali* exposure but sat the same exams with the intervention group. The average mean difference between the two years was very small and insignificant. For example, in maths and biology the mean difference was 0.1937 and 0.2811 respectively.

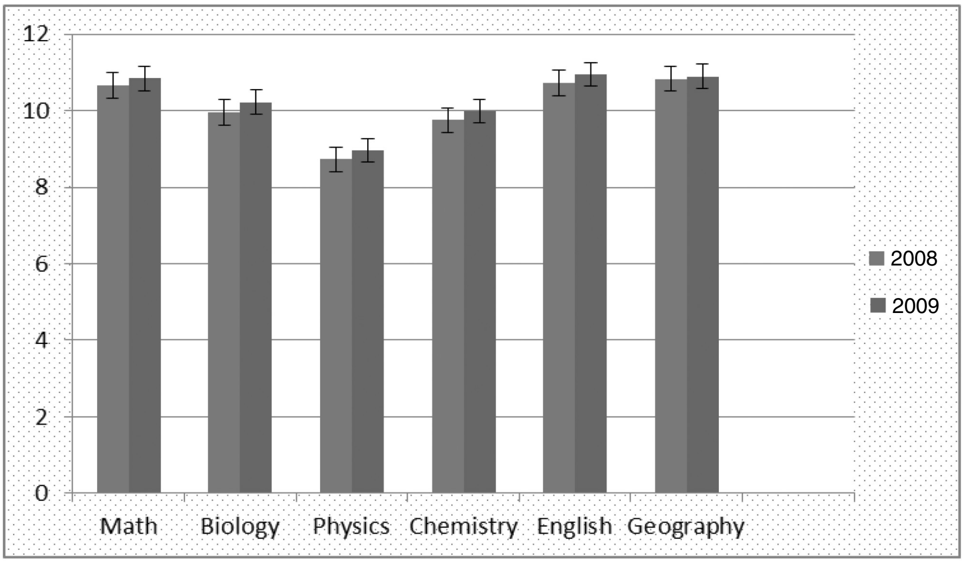

Fig. 2. Mean score in a non-intervention Valley School.

Table 2. Analysis of Variance (ANOVA)

	Sum of Squares	d.f	Mean Square	F	Sig.
Between Groups	61.560	3	20.520	13.060	0.000
Within Groups	29.852	19	1.571		
Total	91.412	22			

Analysis of variance indicated that there was a significant difference in mean performance within the schools between the years (2008 and 2009).

Post hoc analysis indicated that the mean difference existed in Mountain School between the years 2008 and 2009 ($p < 0.001$). However, there was no difference in mean score in Valley School between the years 2008 and 2009 ($p = 0.404$).

4. Conclusions

These results are important in the attempt to bridge the divide between classroom knowledge and local settings with the strong potential to assist students to develop relevant modes of learning science. Relevance in science is a question that students in Kenya and elsewhere confront all the time. Most local schools in Kenya cannot afford well-equipped science laboratories. This could be the reason for not only poor performance but also low enrolment in science subject in Kenyan secondary schools. *Jua Kali* workshops are found almost in every market place in Kenya. The artisans are locals capable of passing information to students using very understandable local codes which the teacher can easily help the students to translate into the school science language. After all they would have had the experience of the phenomena and concepts and understood them in cultural ways. In other words, the students will in this case have a narrower border to cross into science than would have been the case in a strictly contrived school laboratory experiments. Therefore, results from this research could offer solution to the poor performance in secondary schools especially to those in rural schools who already have fear for science and maths and who may be opting out of physics especially because of being in a school with no established science laboratory. Products from *Jua Kali* include cooking stoves, farm tools, brooders, sandals and paraffin lamps. These items are found in villages and therefore familiar to students given that they have used them in one way or another. Improved performance in science has demonstrated that students understand science better when they see its relevance and meaningfulness in community contexts and that learning in traditional science laboratories can be supplemented with local environments which are cheaper, richer in scientific knowledge, and are sustainable.

Endnote

"*Jua Kali*" refers to small-scale manufacturing and Technology-based industry where artisans manufacture equipment and other household items such as rakes, hoes, metal boxes, kerosene lamps, chicken brooders, local sandals and charcoal stoves which are ubiquitous in everyday Kenyan culture while also providing related services to other small scale producers [28].

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