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Teacher Change: The Effect of Student Learning on Science Teachers' Teaching in Kenya*

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This paper reports on an instrumental case study that employed narrative and teacher change methodological and analytical frameworks to investigate Kenyan science teachers' views of the effect of student learning on their teaching. Interpretation of the teachers' views revealed that they: 1) gained an increased awareness and understanding of their students' science learning abilities that allowed them to take increased responsibility for own learning, 2) developed and accepted new understanding of their teaching roles, and 3) became more critical of how science pedagogy was modeled for them as former high school students and later, continuing practitioners. In the paper we demonstrate how the study's findings validate the emergent literature's support for contextualized science learning and teaching. The study's findings show that students' learning impacted the teachers' pedagogical practices. Therefore, we argue that students' learning and teachers' teaching are not mutually exclusive.

Keywords: teacher change; student learning; contextualized science; pedagogy

1. Introduction

This paper reports on a study that investigated transformations in Kenyan science teachers' teaching as they navigated through, and experienced their students' learning mediated through science curricular reforms. The study was framed in the context of unending debate in Kenya regarding the question of relevance in terms of curriculum and pedagogy, and especially the role of science and technology in national development. Consequently, a number of curricula reforms, particularly in Kenya [1–6] have been undertaken during the last 49 years. But despite all the reforms in education, there has yet to be real change in terms of contextualized (relevant to local settings) curriculum and pedagogy. Moreover, there is extensive research that has provided models and evidence of students' success in contextualized science curricula [7–10]. However, there is a scarcity of studies on the effect of student learning on science teachers' teaching in Kenya. In other words, little is understood about the collateral impact of students' learning on the teachers' teaching in Kenya. Such an understanding is critical to designing pedagogical and curricular models that can better enhance mediation of science teaching through local contexts. Moreover, student learning or performance is a very important motive behind any teacher change. This can in part be discerned from teachers' views about student learning effect on their teaching. Hence, the question: How do Kenyan science teachers perceive the impact of their students' learning in terms of engagement mediated through the implementation of a contextualized science curriculum on their pedagogy, roles and views about their experience with previously modeled science pedagogy?

2. Presentation

2.1 Background and literature

To date careful analysis of the state of education, and especially science education in Kenya, attainment of relevance is like a mirage [11, 12]. Since 1963 Kenya has had several major educational reforms, each of which has been preceded by a commission of inquiry including: [1–6]. 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, with the question of relevance characterizing the rhetoric for change, there has never been much effective shift from traditional western-modeled curriculum and pedagogy, especially in science education. The system is still overly exam-driven, teacher-centred 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 [13]. 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 [13].

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In addition, they often borrowed from foreign instructional models not suited for Kenyan learners. This has made teachers less receptive to innovative pedagogies [14, 15]. Instead, they 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 [14–16]. Any attempts to integrate into curriculum authentic science learning environments, such as Jua Kali[1] (the local manufacturing sector), are seen as unnecessary distractions. But for most Kenyans, the question of relevance is very important as eloquently expressed by [16]: "no Nation can develop in any sense of the term, with a population which has not received a thorough and relevant education" (14, p. i). 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, there is the need for Kenyan teachers to change the way science curriculum and pedagogy is reformed as a means to making science more relevant and meaningful to Kenyan learners. This approach should, with time, lead to a more scientifically oriented and prosperous society.

Student Learning: In this paper, we use student learning to mean student engagement with and motivation about the subject or activities [17, 18]. In the [18] analysis of the 2003 PISA results, it is argued: "motivation and engagement can be regarded as the driving forces for learning" [18, p. 116]. These, as is further argued in the OECD report, can influence whether the students will successfully pursue further educational opportunities. It is this understanding that this paper references when loosely using the term learning. As further noted in the OECD report, motivation is the driving force behind learning, but "extends the picture to students' more general attitudes towards . . . [the subject]" [18, p. 11].

Teacher change: There are many models on how teacher change can be influenced. However, contemporary methods of promoting teacher change come in the form of teacher professional development (PD). According to [19], there are two formats of PD: traditional and job-embedded. Traditional PD format is a top-down model arising from policy mandates where experts hold workshops, seminars, lectures, etc. [19] on what they consider to be effective pedagogy or curriculum reform. On the other hand, Job-embedded PD locates training within the school or local context by utilizing for example, inquiry groups (collaborative in nature) where teachers participate more closely to their own context in shaping curriculum and pedagogy to the service of student learning [19]. Literature on traditional PD format indicates that it is effective in changing teachers' practices when it is longer in duration [20] since teachers need more time [21] and variety of activities [21] to learn more about their practice. On the other hand, studies that advocate job-embedded format advise locating PD within the school for purposes of creating ongoing communities [23] and allowing teachers to do the talking, thinking and learning about their practice and student work [24]. However, the PD activities described in both formats seem to focus on teachers as change agency and disregard student learning as a change agency. Yet student learning or performance has the capacity to influence teacher change. Hence, this is the type of change this study sought to investigate among Kenyan science teachers' views following their experience of student learning in a contextualized science curriculum unit.

2.2 Objectives

The paper's objective is to report the analysis of a study about the influence of student learning on teachers' 1) pedagogy, 2) teaching roles, and 3) assessment of previously modeled science pedagogy as perceived by select Kenyan teachers who implemented a contextualized science unit in a Form 3 (Grade 11) science class in Kenya. Moreover, the analysis is aimed at providing critical understanding of how students' learning in terms of engagement with contextualized science curricular activities affects their teachers' pedagogy, teaching roles, and views about their previously modeled science pedagogy. It is the view in this paper that understanding the effect of students' science learning in terms of engagement with local contexts is critical to addressing the issue of relevance in science discourses and might be a step towards teachers' sensitivity to retaining and motivating students who are always seeking relevance in science curricula. This can be seen as a gateway into deeper understandings that can assist formal education to better connect with local industry in Kenya and elsewhere.

2.3 Theoretical framework

The study employed a blend of two teacher change models: traditional, which is a top-down professional development model grounded in policy demands and job-embedded model that is localized to specific needs within teaching contexts [19]. A traditional model is about experts holding workshops, seminars, lectures, etc. [19] on what they consider to be effective pedagogy or curriculum reform. On the other hand, job-embedded model

locates teacher learning or professional development within the school or local context. Here, teachers participate more closely to their own context in shaping curriculum and pedagogy to the service of student learning [19]. Although these two formats can help teachers gain new knowledge (change), there is no unity on the kind of directive to be in place for teacher learning and change to take place [25]. Literature on the traditional model indicates that it is effective in bringing about teacher change when: 1) it is longer in duration [20] since teachers need more time [21] and 2) there is variety of activities [22] to learn more about their practice. On the other hand, Job-embedded is catalytic to 1) creating ongoing communities [23] and allowing teachers to do the talking, thinking and learning about their practice and student work [24]. Moreover, [26] sees this teacher learning and for that matter teacher change to include feelings and values embedded in knowing how to do things such as organizing student learning experiences.

A blended framework allows teachers to engage in the experience for a longer time with expert guidance from researchers while interpreting and implementing policy consistent with the prevailing local conditions (contextual). However, these two models do not explicitly identify student learning as a change agency. Yet student learning is a very important motive behind any teacher change. According to [27] social context is critical to a teacher's sense of purpose as a teacher [27]. Individuals as agency to change a context is possible in ways they act to affect their immediate settings [3] by using culturally, socially and historically developed resources. The two theoretical perspectives were important in interpreting and understanding the study's results. We sought teachers' views of how student learning had affected the way they taught immediately after and one year after a 9-week contextualized science unit experience. Traditional model of professional development (PD) applied in this case in that, the research team organized the initial workshop where the teachers developed a 9-week science unit and the fact that the teachers were allowed to continue contextualizing subsequent science units they taught, where possible, accounted for the need to engage in this type of teaching for at least one year. Job imbedded PD model was clearly the basis of investigating the effect of student learning on the teachers' teaching.

2.4 Methodology

The interpretive [28, 29] case study [30, 31] employed narrative methodology [32, 31] to investigate Kenyan science teachers' stories of the effect of student learning on their pedagogy, roles and views about their experience with previously modeled science pedagogy. A narrative, according to [33], is "a story that tells a sequence of events that [are] significant for the narrator or his/her audience" (31, p. 4). Stories about how the teachers' pedagogy, roles and views about their experience with previously modeled science pedagogy were affected by their students' learning were prompted in a narrative interview format. Since the study was about understanding the science teachers' perceived transformation in their teaching practice, a descriptive, interpretive approach was appropriate [29].

2.5 Context of the study

The study involved three Form 3 science teachers from one multiethnic urban girl's high school that ranks as one of the top schools in Kenya. Typically, the top high schools in Kenya are highly exam centred and teaching strategies that contextualize learning experiences are not valued. Thus, offering a contextualized science unit in such a school was for us excellent fodder for understanding the effect of this way of student learning on the science teachers' pedagogy, roles and views about their experience with previously modeled science pedagogy. Moreover, focusing on one of the top performing schools was critical as such a school in Kenya is typically known to influence greatly curricular activities in many provincial and district schools due its excellent performance record on national exams.

2.6 Procedures

The study was implemented as follows

1. Initially the study was introduced to three science (biology, chemistry and biology) teachers in a select Form 3 science class in one urban girl's high school.
2. 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 during the impending 3-hour class visit, the students engaged in science learning through interaction with variety of products and production activities and the artisans.
3. 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. During the workshop the teachers were allowed the flexibility of developing science lessons that capitalized on the richness of Jua Kali as a context for making science learning more engaging and relevant. Thus, the teachers agreed to develop and implement science lessons that constituted a 9-week unit—contextualized science unit. Noteworthy, is that the learning activities integrated classroom and Jua Kali experiences by demanding on the students to use, engage or understand science knowledge holistically as opposed to compartmentalizing it into physics, biology or chemistry. Further, the three teachers agreed to co-teach the science unit to the Form 3 class to ensure a coherent integration as well as subject content that met curricular requirements for each science area (physics, chemistry and biology). In other words, since they each were specialized in different science subjects, there was a realization that co-teaching was the best way to ensure that their three curricular areas were sufficiently addressed. Also, the contextualized science unit had to be in accord with the guiding questions and in harmony with the Kenyan national curriculum. The unit was implemented in a series of lessons that involved a visit to a Jua Kali site.

4. 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.
5. 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. The students worked in groups and were shadowed by their teachers and the research team during the 3-hour visit as they interacted with Jua Kali artisans, products and production activities in each station.
6. 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.
7. This was then followed by a one-hour one-on-one narrative interview with each of the three teachers a few days and one year after the Jua Kali and classroom learning episodes. For purposes of stimulating recall during teacher interviews and to enrich the discourse, selected critical incidents on video clips of representative groups of students who had been video recorded during their Jua Kali and in-class engagements were replayed. The narrative interviews with the science teachers were about how their pedagogy, roles and views about their experience with previously modeled science pedagogy were impacted by their students' engagement with learning during the Jua Kali visit and the entire contextualized 9-week science unit experience. Therefore, only results from analysis of data from the one-year later narrative interview with the three science teachers will be reported in this paper. The Form 3 science teachers' narratives embodying perceptions of how one year later their students' learning affected their pedagogy, roles and views about their experience with previously modeled science pedagogy as they enacted a contextualized science curriculum unit in one Kenyan high school were analyzed. Select key interview excerpts illustrate emergent themes.

3. Discussion

3.1 Analysis and findings

Consistent with the blended framework for teacher professional development purposed to influence teacher change, the teachers experienced a catalytic episode where they were introduced to the study and voluntarily accepted to participate. Borrowing from elements of the traditional model [19] we (research team or experts) made a case for teaching science using local Jua Kali production activities and products, engaged them in a one-day workshop where the research team and the teachers co-developed a framework for a 9-week science unit to be implemented in a series of lessons that included learning experiences at Jua Kali and were cued on the need to continue with this way of teaching where appropriate and if they desired to for the rest of the year and curriculum topics. This duration was in compliance with the view that traditional model effects teacher change over a longer period of time as well as

to allow teachers to try out a variety of contextualized learning activities. But at the same time we adopted principles of job-embedded model of PD where the teachers planned the learning activities as a team (community) as they monitored their student learning. This way, it was prudent to interview the teachers about the effect of student learning on their pedagogy, teaching roles and views about pedagogy that was previously modeled for them one year after the catalytic episode that modeled integration of classroom and Jua Kali learning experiences. We hoped that this was enough time for the teachers to experience any meaningful change in the way they organized learning activities. The final one year later teacher interview data were transcribed verbatim for detailed analysis that involved: examining, categorizing, testing assertions for reliability and recombining evidence from the different teacher interview transcripts to address the objectives of the study [34]; [35]. Thick descriptions of interview data in form of teacher narratives of how student learning in a contextualized science unit had affected their pedagogy, roles and views about their experience with previously modeled science pedagogy were generated. These were sifted through and in some cases reconstructed to identify evidence of teachers' views or perceptions of how student engagement or learning in the contextualized science unit had affected their pedagogy, roles and views about their experience with previously modeled science pedagogy before common patterns or themes were interpreted. This was necessary since the nature of the narrative interviews flowed as stories and reconstruction of storied data was necessary to organize the teachers' views with an additional level of logical coherence. The analysis of the one-on-one narrative interview data sets involved examining and categorizing the respective teacher interview transcripts using a thematic approach [30]; [34] to address the objectives of the study [34, 36]. This was a rigorous process, where the researchers regularly exchanged their individual insights via email, and face-to-face meetings to discuss and compare analyses that resulted in the development of a collective interpretation of the data sets [31]. The process involved several meetings of listening to interview video clips and reviewing of interview transcripts, comparing and contrasting teacher stories and engaged in in-depth discussions of the themes that emerged across the teacher data sets. This resulted in three key themes that were evident across the narrative teacher interview data sets.

1. The science teachers gained an increased awareness of and understood better their students' science learning abilities that allowed them to take increased responsibility for own learning

This can be discerned from Hana's indication of how she could do things differently including appreciation of what the students are capable of doing on their own. We see in this excerpt Hana's admission of changed ways of doing things:

> Hana: I realized that they learnt more and were able to do things I never expected them to do. So I kept telling them to go and find out. Especially when they go home they should visit some areas where some products are made. So I find myself asking them to do more on their own, which they did.

Suzy expresses her newfound awareness of teaching even better and concedes that she used to do most of the working by getting all the information but has realized how much the students can do on their own. She now involves the students more in finding out information for themselves. We also note an admission of change in her approach to teaching after realizing what her students were able to do on their own as revealed in the following except:

> Suzy: It has opened up my way of teaching even better . . . For the first time I have been giving students work—they do it first, they think about it, they write it down and then I come and now we explain it and do experiments... Like Suzy . . . I was saying . . . why was I cramming all these things and doing it alone when the students were capable of finding for themselves? . . . Yesterday I told [them to] . . . go and check on things for this morning's lesson and for sure they did. I have found this way of letting students find out things for themselves to help them learn better and more things.

Similarly, although Fidel indicates that what he was doing was not different from what was being implemented in the study, he nonetheless acknowledged having gone further and actualized the ideas as conveyed in the excerpt below:

> Fidel: To me it was consistent with what I was in fact already doing. However, I am now able to actualize it. I feel like they learn so much outside class even before they come to school and have encouraged them to do more and even given them very challenging tasks to do on their own outside of the classroom.

2. The science teachers developed and accepted new understanding of their teaching roles.

During the interview, the teachers acknowledged redefining their teaching roles, which allowed them to transfer responsibility to the students. Previously, they had been burdened with providing the information but through this project they experienced

change consistent with the job-embedded model of PD [24]. This kind of teacher change was conveyed in the interview excerpts below:

> Hana: I felt that I've been overworking; doing some of the things students should be able to do on their own. I had been overworking myself trying to explain so many things they can actually see for themselves. As the teacher you are not giving, giving, giving. There are certain things students can also 'get' without me. They should be more independent. I have realized that mine is to guide them, challenge them and explain very difficult things.
>
> Suzy: Our students were learning and we were learning our roles from their learning. I think this approach is much better . . . I have learnt in a different way and I appreciate that there is a lot . . . we have been ignoring. I said 'how could I have not seen this? Did you people have to come from Canada to show me this?' To send students out to find information for themselves, to only be consulted when they need assistance and to even challenge me and their friends . . .
>
> Fidel: This study has supported my thoughts and what I was doing in a big way. I now can organize students into research groups. They can think of methods of testing their ideas and can check with me and other teachers for accuracy. I see my role having changed. They can even do better on tests.

3. The science teachers became more critical of how science pedagogy was modeled for them as students and continuing practitioners.

The project's effect on student learning prompted the teachers to reflect on how they were taught as students and the way they had been trained as well as teaching and raised questions about some of the teaching models. This was apparent in excerpts such as those represented below:

> Hana: A lot of what I have been doing came from my teachers, which was good. But now I start to question some of the things and I can be creative and teach even better.
>
> Suzy: I was used to giving, giving, giving and giving and . . . forgetting that this student can also do a lot of work by herself. Now, I just come and give a bit so that has really changed my approach. Because I was taught so poorly, I would not wish to teach the way I was taught. After . . . this experience . . . I am saying . . . 'where did something go wrong?
>
> Fidel: I can now do what is different from the way I was taught because I can now use . . . the resources around here and maybe, I can tell students to go out and collect A, B, C, D and then come back . . . Or they collect in advance and bring them, . . . I still remember the ones [(teachers)] who did not teach me well ... and have been thinking seriously some of those teaching approaches . . . but I don't want to teach like them.

4. Conclusions

These science teachers' reflections are influenced by their experience of student learning. The reflections reveal personal transformations in their pedagogy, roles and views about their experience with previously modeled science pedagogy. What this paper demonstrates is how teacher change can effectively be mediated through student learning. Although the two models for professional development have traditionally not framed agency as residing in individuals, what seems demonstrated in this study is the centrality of student learning as agency. And, consistent with the study's teacher change framework, the teachers learned more about student learning and their own pedagogy. Moreover, given that the contextualized experiences involved learning and teaching science in a local context, this further validated the emergent literature's support for contextualized science learning and teaching.

These outcomes have implications on insights into science teaching and learning in cultural contexts beyond Western settings. Importantly, this research provides teachers with understandings that point to the need to make science learning more meaningful to their students. Hence there is the need for the science teachers to appreciate the power of student learning as a change agency.

Endnote

"Jua Kali" is a small-scale manufacturing and technology-based service sector where artisans manufacture equipment and other household items such as charcoal stoves, kerosene lamps and chicken brooders which are ubiquitous in everyday Kenyan culture while also providing related services to other small-scale producers [36].

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