Student Learning Impact on Science Teachers' Teaching: The Case of a Form 3 Science Class in Kenya

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Abstract

This paper reports on the study that investigated the following question: How do Kenyan science teachers perceive the impact of students' contextualized science learning on their pedagogy, roles and views about previously modeled pedagogy in an integrated classroom-local *Jua Kali* curriculum unit? A case study approach in which narrative and teacher change were respectively employed as methodological and analytical frameworks revealed that the teachers: 1) gained an increased awareness of and understood better 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 students and continuing practitioners. The paper demonstrates how the study's findings validate the emergent literature's support for contextualized science learning and teaching. Further, the paper demonstrates how the teachers' reflections revealed personal transformations in their science pedagogy. Instructional experiences mediated by a contextualized curriculum have been shown to evoke and provoke students' cultural modes of learning. In the same vein the current study has shown that student learning impacted the teachers' teaching practices. It is therefore argued in this paper that students' learning and teachers' teaching are not mutually exclusive.

Key words

Jua Kali, teaching, science pedagogy

INTRODUCTION

There is a scarcity of studies on the effect of student learning on science teachers' pedagogy, roles and views about their experience with previously modeled science pedagogy. This paper reports on the study that investigated the following question: *How do Kenyan science teachers perceive the impact of students' contextualized science learning on their pedagogy, roles and views about previously modeled pedagogy in an integrated classroom-local Jua Kali curriculum unit?* As eloquently described by UNESCO (1997), *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, wheelbarrows, etc. which are ubiquitous in Kenyan culture.

The study provides critical understanding of how students' learning in terms of engagement with contextualized science curricular activities affect their teachers' teaching. It is the researchers' 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. In this paper, student learning is used to mean student engagement with and motivation about the subject or activities (OECD, 2004). In the OECD (2004) analysis of the 2003 PISA results, it is argued that "motivation and engagement can be regarded as the driving forces for learning" .These, as is further argued in the OECD report, can influence whether the students will successfully pursue further educational opportunities. 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.

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 (Elmore, 2002). A traditional model is about experts holding workshops, seminars, lectures, etc on what they consider to be effective pedagogy or curriculum reform (Elmore, 2002). 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 (Elmore, 2002). 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 (Smith &Gillespie, 2007). Literature on the traditional model indicates that it is effective in bringing about teacher change when: 1) it is longer in duration (Porter et al., 2000) since teachers need more time (Stein, Smith & Silver, 1999), and 2) there is variety of activities (Mazzerella, 1980) to learn more about their practice. On the other hand, Job-embedded is catalytic to creating ongoing communities (Hord, 1997) and allowing teachers to do the talking, thinking and learning about their practice and student work (Feinman-Nemser, 2001. Moreover, Anderson-Levitt (2003) 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 disregard student learning as a change agency. Yet student learning is a very important motive behind any teacher change. According to Lasky (2005) social context is critical to a teacher's sense of purpose as a teacher. Individuals can act as change agency to change a context if they affect their immediate settings by using culturally, socially and historically developed resources (Fullan, 1991). This blended framework is complemented by a contextual learning theory (Hull, 1993), which portrays learning as occurring only when learners process new information in ways that make it meaningful in their frame of reference. According to Hull (1993), this approach assumes that the mind naturally seeks meaning in a context by searching for relationships that make sense. Accordingly, contextual teaching is organized in ways that allow students opportunities to engage in real world problem solving activities (Karweit, 1993). There appears to be unity in literature regarding the positive effect teaching in meaningful contexts has on student learning and teachers' teaching (Carraher, Carraher&Schleimer, 1985; Lave, Smith & Butler, 1988). As Resnick (1987) has noted, decontextualizing science is meaningless for the students since it lacks relevance outside of the school. These three theoretical perspectives were important in interpreting and understanding the study's results.

Methodology

An interpretive case study design and narrative methodology were used to investigate Kenyan science teachers' stories on the effect of student learning on their pedagogy, roles and views about their experience with previously modeled science pedagogy. A narrative, according to Moen (2006), is "a story that tells a sequence of events that [are] significant for the narrator or his/her audience". 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. This paper reports only on the results of the investigation of the effect of student science learning on their science teachers' pedagogy, roles and views about their experiences with previously modeled science pedagogy. The investigation was undertaken during the implementation of a contextualized science unit in a Form three class in Kenya.

Procedures

Initially the study was introduced to three science (physics, chemistry and biology) teachers in a select Form 3 science class in one urban girls 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 a variety of products, production activities and also, the artisans themselves. 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 (Table 1) and developed guiding questions (Table 2) that enabled the students to engage in discussions 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.

Table 1: Curricular topics &Jua Kali activities

Physics
Curriculum topic I:
Work, energy, power and machines; law of conservation of energy; vacuum flasks; Fireless cookers.
***Jua Kali experience*: Fireless cookers, hot pots, Jua Kali Jiko, and Jua Kali ovens**
Curriculum topic II:
Quantity of heat: Elements of conservation of energy; Pressure cooker. *Jua Kali experience:* Charcoal refrigerator
Chemistry
Curriculum topic I: Energy conservation, organic fuels, e.g., graphitic charcoal;
Explaining energy conservation and wastage (efficiency) in the different types of Jiko; suggesting and justifying modifications to the types of Jiko to maximize energy conservation.
Jua Kali experience: Local types of burners (Jikos): Three stones, Chepkube (the Kalenjin version of cooker), Jiko, Modified clay Jiko; fuels: Charcoal (Amorphous carbon), Wood charcoal, Animal charcoal (bones), Cow dung, and Msogoro (maize cobs)
Biology
Curriculum topic I: Animal Nutrition: Energy requirement in man and factors that determine energy requirement. *Jua Kali experience*: See cart pushers; chicks in the brooder with Jiko as a source of heat.
Curriculum topic II: Respiration: Anaerobic (fermentation). *Jua Kali experience*: Processing of yoghurt, cheese, mala (sour milk), and beer; Biogas
Curriculum topic III: Ecology: Energy sources including solar and conservation
Jua Kali experience: Solar cookers, sterilization of drinking water, Heat energy produced during germination, hot food storage baskets.

Table 2 - Student's Work Sheet

Student – artisan interaction: Guiding questions/tasks during Jua Kali visit
1. What are the main materials that you work with? 2. What is the source of the materials you use in your products? 3. Are the materials recyclable or reusable? 4. Are there other materials that can be used for the same purpose? 5. Why have you not used these others? 6. Show us the different types of Jiko/products? 7. Which ones are commonly bought and why? 8. (i) What other products besides the Jikos have you produced? (ii) How well does each product sell? 9. (i) What properties do you consider when choosing these materials? (ii) How durable are these products? 10. Can they be improved upon? 11. How suitable are the final products to the user? 12. What possible improvements or alternatives are you considering?

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. Also the students were prepared on how to use the questions above as a way of engaging with the Jua Kali artisans and how to probe further unclear responses. The canonical nature of the artisan's responses was not to be judged but rather probe the artisan just to clarify their thoughts.

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 (Table 2) to interact with Jua Kali artisans as they sought important information on the products and production activities for about three hours.

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 (Table 3) 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.

Table 3: Post Jua Kali visit classroom questions/tasks

1. Out of the total number of production stations you visited, identify **three** production activities that you found most interesting and where you learnt most. Rank them in order of merit and give reasons in each case.
2. Out of the activities in the **three** identified Jua Kali stations in (Q. 1) above, identify the product that requires the **highest skill level** to produce and give reasons for your suggestions.
3. Out of the **three**Jua Kali production activities identified in (Q. 2) above, identify ONE that gave you the most important learning experience and justify.
4. What product in Jua Kali evoked your science knowledge most and why?
5. How, in your view, can the production process and the final product identified in (Q. 3) above be improved?
6. What personal strategies of learning science does this way of experiencing science (in Q.5) evoke?
7. Make a 10-minute class presentation of your group responses to Qs. 3, 4, 5, & 6. Decide on a presentation strategy where all members participate.

All the activities above constituted student learning experiences that the science teachers experienced and whose impact on the teachers' pedagogy, roles and views of previously modeled pedagogy were being investigated through a post experience one-on-one teacher interview. 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. Therefore, what follows is the analysis of teachers' perceptions that is reported below in the form of themes.

Results and Discussion

Consistent with the blended framework for teacher professional development purposed to influence teacher change, the teachers experienced catalytic episodes where they were introduced to the study and voluntarily participated. Drawing from elements of the traditional model (Elmore 2002), the research team (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 that was implemented in a series of lessons that included learning experiences at Jua Kali. Moreover, they 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.

The final one year later teacher interview data were transcribed verbatim for detailed analysis that involved: examining, categorizing, testing assertions for consistency and recombining evidence from the different teacher interview transcripts to address the objectives of the study (Miles &Huberman, 1994; Yin, 2003). The analysis used a thematic approach (Merriam, 1998; Miles &Huberman, 1994) to address the objectives of the study (Miles &Huberman, 1994; Yin, 2003) and resulted in three key themes:(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; (2) The science teachers developed and accepted new understanding of their teaching roles; and (3) The science teachers became more critical of how science pedagogy was modeled for them as students and continuing practitioners. These are illustrated using select interview excerpts to provide a sense of how the teachers reflected on their pedagogy, roles, and prior practices.

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 the statement from Hana, which is representative of the voices from the other teachers who were interviewed, as admitting to have changed her way 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.

Fidel: We noticed that they were able to achieve better when we mixed them up. We did not have a brilliant lot, but we had the brilliant, average and poor, and yet they were all able to share ideas.

Suzy: Most of these students were interested in jikos and normally like in chemistry we talk of heat conductors, non-conductors, but here they really got the practical aspect.
Students who never asked questions in class did participate at the Jua-Kali because they were coming into contact with things they have experienced in real life situations.

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 Professional Development (PD) (Elmore, 2002). This kind of teacher change was conveyed in the illustrative interview excerpt below:

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 …!

Hana: I felt the need to change my science teaching skills. In other words, I leave the lab, get out of its confines; it breaks the walls that seem restrictive to exploratory learning.

Fidel I discovered from the experiences that students came to appreciate the Chemistry they learn; I realized that whatever we do in class, they could see it outside. I felt good as a teacher. I was impacted the way it impacted my students, how they felt it, what they saw, how enthusiastic they were.

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 ones represented below:

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.

Suzy: It also got me motivated to see that I don't have to stay in the class; I can go outside and teach from the real world.

Hana: I realized that Jua-Kali place had many things to learn and teach from. My role now became one of facilitating student exploration.

These teachers' reflections are influenced by their experience of student learning. The reflections reveal personal transformations in their science pedagogy. What this paper demonstrates is how teacher change can effectively be mediated through student learning. The two models for professional development are silent on student learning as a change agency. But what seems demonstrated here is the centrality of student learning in effecting teacher change in addition to social context (Lasky, 2005), and immediate settings (Fullan, 1991) that use culturally, socially and historically developed resources**.** Consistent with the study's theoretical framework, the teachers learned more about student learning and their own pedagogy. Given that the contextualized experiences involved learning and teaching science in a local context, teachers felt the need to move away from the idea of teaching as giving students knowledge that they cannot apply to their everyday life situations. The study further validated the emergent literature's support for contextualized science learning and teaching. The teachers realized that the theoretical model of teaching they had rigidly adhered to was inadequate at attending to students' learning. They further realized the need to move a step forward to guide students into knowledge application. The three teachers evidently became aware of the need to change their approach/model of teaching to make relevant to students social cultural environment of Jua-Kali and hence effecting change in students' attitude towards science. This way of teaching awakened them to the need to guide students to see the relationship between what they learn and what they experience in real life situations. And as one of the teachers, Fidel, noted, "… so the students can meaningfully apply what they learn in their everyday life".

REFERENCES

Anderson-Levitt (Ed.). (2003). *Local meaning, global schooling: Anthropology and world culture theory*. New York: Palgrave Macmillan.

Carraher, T., Carraher, D., &Schleimer, A. (1985).Mathematics in the streets and in schools.*British Journal of Developmental Psychology.3*, 21-29.

Clandinin, D. J. & Connelly, F. M. (2004).*Narrative Inquiry: Experience and story in qualitative research*. San Francisco: Jossey Bass Publishers.

Elmore, (2002). *Bridging the gap between standards and achievement.* Washington DC: *The Albert Shanker Institute*. Retrieved on September 10, 2009 from http://www.ashankerinst.org/downloads/Bridging_Gap.pdf

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record.103*(6), 1013-1055.

Fullan, M. (1991). *The new meaning of educational change*. New York: Teachers College Press.

Gallagher, J. J., & Tobin, K. G. (1991). Reporting jnterpretive research. In J. J. Gallagher (Ed.), *Interpretive research in science education* (pp. 85 – 95). NARST Monograph, Number 4, Kansas State University.

Hord, S. (1997). Professional learning communities: Communities of continous inquiry and improvement. Eric Document 410659.

Hull, G. (1993). Hearing other voices: A critical assessment of popular views literacies and work. *Harvard Education Review. 63*(1), 20 – 49.

Karweit, D. (1993). *Contextual learning: A review and synthesis*. Baltimore, MD: Center for the Social Organization of Schools, Johns Hopkins University Press.

Lasky, S. (2005).A socio-cultural approach to understanding teacher identity, agency and professional vulnerability in a context of secondary school reform.*Teaching and Teacher Education. 21*, 899 – 916.

Lave, J., Smith, S., & Butler, M. (1988). *Problem solving as an everyday practice.*In Learning mathematical problem solving (Report IRL 88-0006). Palo Alto, CA: Institute for Research and Learning.

Mazzerella, J. A. (1980).Synthesis of research on staff development. *Educational Leadership. 38*, 182 – 185.

Merriam, S. B. (1998).*Qualitative research and case study applications in education*. San Francisco: Jossey-Bass Publishers.

Miles, M. B &Huberman, A. M. (1994).*Qualitative data analysis*, 2nd Edition. Thousand Oaks: SAGE Moen, T. (2006). Reflections on the narrative research approach. *International Journal of Qualitative Methods.5*(4), 1-11.

Moen, T. (2006). Reflections on the narrative research approach. *International Journal of Qualitative Methods, 5*(4), 1-11.

OECD (2004). What makes school systems perform: Seeing school System through the Prism of PISA. www.oecd.org/dataoecd/30/24/3385946.pdf.

Porter, A. C.,Garet, M. S., Desimone, L., Birman, B. F., Suk Yoon, K. (2000). Does professional development change teaching practice? Results fronm a three year study. Washington,DC: U.S. Department of Education.

Resnick, L. (1987). *Education and learning to think.* Washington, DC: National Academy Press.

Schwandt, T. (2003). Three epistemological stances for qualitative inquiry: Interpretive, hermeneutics, and social constructivism. In N. Denzin& Y. Lincoln, *The landscape of* *qualitative research: Theories and issues* (pp. 292-327).

Smith, C. & Gillespie, M. (2007). Research on professional development and teacher change: Implications for adult basic education. *Review of Adult Learning and Literacy. 7*. Retrieved September 10, 2009 from http://www.ncsall.net/fileadmin/resources/ann_rev/smith-gillespie-07.pdf

Stake, R. (1995).The art of case study research. Thousand Oaks, CA: Sage.

Stein, M. K., Smith, M. S., & Silver, E.A (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review*, 69,237-269.

UNESCO (1997). Under the sun or in the shade? Jua Kali in African countries. National Policy Defintion in Technical and Vocational Education:Beyond the Formal Sector. A subregional Seminar for Eastern and Southern African Countries, Nairobi, Kenya, 15-19 September, 1997, Document Nr ED/IUG/014.

Yin, R. K. (2003). *Case study research: Design and methods*, Third Edition. Thousand Oaks, California: Sage.