ISSN: 2186-8492, ISSN: 2186-8484 Print
Vol. 2 No. 3 August 2013

CONCEPTUAL UNDERSTANDING OF SCIENCE PROCESS SKILLS AND GENDER STEREOTYPING: A CRITICAL COMPONENT FOR INQUIRY TEACHING OF SCIENCE IN KENYA'S PRIMARY SCHOOLS

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ABSTRACT

This paper examined Kenya's Strengthening of Mathematics and Science Education (SMASE) In-service Education Training (INSET) trainers' conceptual understanding of basic science process skills (BSPS) and their gender based stereotypes regarding pupils' ability in BSPS. Teachers Process Skills Questionnaire (TPSQ) was used to collect data from 187 trainers. Data analysis included tabulation of percentages and Chi-squire test of relationship. The findings of this study revealed that (i) SMASE trainers had very poor conceptual understanding of basic science process skills, (ii) SMASE trainers held gender based stereotypes about boys' and girls' ability in BSPS and (iii) there was a statistically significant relationship between the gender of the SMASE trainers and their gender stereotypes. The authors recommended that (i) SMASE trainers be inducted in science process skills and be subjected to a science process skill proficiency test before being recommended as INSET trainers, (ii) Primary Teacher Education for pre-service teachers to ensure trainees develops conceptual understanding of science process skills as outlined in the Kenya's Primary Teacher Education Science Syllabus and (iii) awareness on gender issues in terms of instruction and assessment be created among primary school teacher and pre-service training of primary school teachers.

Keywords: Inquiry Teaching**,** ASEI Approach, Basic Science Process Skills, Gender Stereotype

INTRODUCTION

The Kenya's SMASE project was designed to advocate for a paradigm shift in teaching approaches that were being used in teaching of science. The expected shift was from knowledge based teaching and learning to activity based teaching and learning. To realize this change the project adopted ASEI (an acronym for Activity, Student, Experiment and Improvisation) approach to teaching of science. The project is implemented by teachers in primary school who first attend In-Service Education Training (INSET) focusing on teacher development based on the ASEI innovative teaching and learning approach. The trained teachers are expected to cascade ASEI to their colleagues in addition to implementing ASEI approach in teaching and learning of science in their respective schools.

ASEI as an approach is geared towards meaningful learning of science since it is learner centered. Learners are supposed to construct their own meaning of scientific concepts by being subjected to hands-on activities, performing simple experiments and improvising simple apparatus that can be used in carrying out scientific investigations. A critical analysis of ASEI approach indicates that it advocates for inquiry learning by learners which according to Holbrook and Rannikmae (n.d.) is more than just guiding learners to acquire manipulative process skills but Inquiry Based Science Education (IBSE) which involves learners constructed learning with the teacher as a guide.

IBSE consists of experiences that enable learners to develop understanding about the scientific aspects of the world around through the development and use of inquiry skills (Harlen and Allende, 2009). Inquiry skills are science process skills used by scientists in their scientific investigations (Beerer and Bodzin, 2004). Both IBSE and ASEI propose active participation of learners in learning process where learners perform various activities and acquire scientific knowledge from the activity provided.

Teachers are supposed to inculcate these science process skills to the learners and hence teachers' conceptual understanding of these skills is critical. Science content taught in science classrooms should be used as a mean to develop science process skills (Nyakiti et al, 2010). Science process skills have been categorized into two categories (basic and integrated). Chiappetta et al. (2002) indicate that integrated process skills include defining operationally, formulating hypotheses, controlling variables, interpreting data, hypothesizing and experimenting or designing investigation. On the other hand, National Association for Research in Science Teaching (NARST) (2011) suggests that basic science process skill includes observation, measuring, inferring classifying, predicting and communicating.

According to Mei et al. (2007), basic science process skills are foundational for the development of the more complex integrated skills hence they should be given due emphasized in the early years of primary education so as to facilitate development of the more complex skills at higher levels of primary education.

ASEI paradigm shift perceives boys and girls to be having equal ability in learning of science. Thus, ASEI should be implemented in a gender sensitive environment for both boys and girls to develop science process skill and benefit equally from the science taught in schools. However, gender stereotyping among teachers where boys are perceived to have high ability to learn science than girls existed in Kenya's primary school (FEMSA (n.d). Achievement in education should not be determined by gender but by one's talent and efforts hence education should aim at ensuring both girls and boys have equal opportunities to benefit from the learning experiences offered in classrooms (World Bank, 2005). Thus gender stereotyping in learning of science is fallacious and an impediment to gender equality in accessing science education through development of science process skills. Therefore SMASE trainers should have high conceptual understanding of science process skills and hold no gender stereotypes towards boys and girls ability to learn science if ASEI approach is to be effectively implemented in primary schools in Kenya.

One of the indicators that should be used in future to evaluate the impact of the SMASE project on primary school teachers is the ability of primary school teachers to apply the ASEI approach through application of science process skills in teaching of science in a gender stereotype free environment. Hence this study investigated SMASE trainers' conceptual understanding of basic science process skills and their gender based stereotypes towards boys and girls ability in the skills to generate baseline data for evaluation of the SMASE project.

LITERATURE REVIEW

Since science process skills are critical for implementation of inquiry teaching (Anderson, 2002; Minstrell & van Zee, 2000). ASEI paradigm shift in Kenya should be modeled to apply science process skills. SMASE project requires baseline data to measure its impact in changing primary school conceptual understanding of the tenets of the ASEI paradigm. Studies have indicated that pre-service teachers have poor understanding of science process skills (e.g. Emereole, 2009; Mbewe, Chabalengula & Mumba, 2010). However, few studies if

ISSN: 2186-8492, ISSN: 2186-8484 Print
Vol. 2 No. 3 August 2013

any discuss the conceptual change in understanding of science process skills gained by practicing science teachers as they advance in teaching experience.

Following the Jomtien Declaration on Education for All (EFA) of 1990, to which Kenya was a signatory, the National Symposium on Education of Girls was held (Chege and Sifuna, 2006). This symposium recommended that efforts be made to equitably distribute science equipment to girls and boys secondary school. This was an effort to provide equal opportunities for boys and girls to learn science and develop science process skills. However, gender stereotypes have undermined these efforts by labeling boys as scientists girls socialized to take art based subjects. To this effect boys excel in sciences while girls perform dismally in science. According to FEMSA (n.d.), gender stereotypes by the society have contributed to the way teachers perceives girls ability to learn science which has undermined opportunities for girls to learn science.

RESEARCH QUESTIONS AND NULL HYPOTHESIS

This study sought to answer the following two research questions and the one null hypothesis:

I. What are the SMASE trainers conceptualize understanding of Basic Science Process Skills?

II. What gender based stereotypes are held by SMASE trainers regarding learners' ability in Basic Science Process Skills?

III. There is no difference between male and female SMASE trainers' gender based stereotypes towards primary school pupils' ability in basic science process skills.

METHOD

This study was conducted during an in-service training for science and mathematics teachers in Narok North District in Kenya. All the 187 (101 male and 86 Female) teachers attending the SMASE cluster INSET in 9 centers participated in the study. The in-service training focused on implementation of the ASEI paradigm aimed at making science in primary schools in Kenya to be activity based and learner centered. All the attendants had school teaching experience.

Instrument

Data was collected through Teachers Process Skills Questionnaire (TPSQ). TPSQ was made of sections A which had 6 open ended question and section B which was likert type scale with 6 items. The TPSQ collected information teachers' conceptual understanding of basic science process skill and teachers' gender based stereotypes towards boys and girls ability in basic science process skills. Definition of basic science process skills was adopted from Okere (1996), Ango (2002) and Chiappetta & Koballa (2002). The basic science process skills were described and respondents were asked to indicate by writing the science process skill defined by the statement. This section required the trainers to identify the definitions of the following basic science process skills: *predicting, communicating, measuring, classifying, observing and inferring*. The questionnaires were officially administered by the researcher and a research assistant with permission from the Kenya's Ministry of Education. On average the respondent took one hour to fill the questionnaire.

Sample

The resulting data set was not collected from all the districts of Kenya and for that reason it does not fully represent the Kenyan population of the SMASE cluster INSET trainers.

Therefore, the results cannot be totally generalized to the country population as a whole. However, the entire SMASE cluster trainers were all experienced trained primary school teachers which provide some degree of uniformity across all the trainers in Kenya.

DATA ANALYSIS

Content analysis techniques were applied on the qualitative data generated by the TPSQ. Content analysis is a multipurpose method for data collection, analysis and for investigating a variety of problems in which the communication serves as the basis for inference (Majumdar, 2005). Descriptive statistics in form of percentages were used to describe the sets of categories formed from the data. Descriptive statistics enable the researcher to meaningfully describe a distribution of measurements and summarize data (Mugenda & Mugenda, 2003 and Fain, 1999).

RESULTS

Trainers Conceptual Understanding of Basic Science Process Skills

To evaluate SMASE trainers' conceptual understanding of Basic Science Process Skills (BSPS), trainers were presented with statements of correct definitions of the various process skills to identify the BSPS defined by each statement by writing the name of the process BSPS. There were six defination numbered (i) to (vi) defining the process skill of predicting, measuring, classifying, observation, inferring and communication respectively. The results are shown in Table 1.

Table 1. Percentage for Conceptual Understanding of Basic Science Process Skills

Item	*Male (N=101)*		*Female (N=86)*	
	Wrong	*Correct*	*Wrong*	*Correct*
1. Guessing what will happen next based on previous information.	61.4%	29.7%	66.3%	25.6%
2. Determining the length, width, area, volume, mass, volume or temperatures to describe and quantify objects.	41.6%	50.5%	41.9%	53.5%
3. Placing objects or events into groups based on some common characteristics.	40.6%	54.5%	30.2%	65.1%
4. using the 5 senses to learn and collect information about objects or events	60.4%	27.7%	75.6%	17.4%
5. Guessing or drawing a conclusion about an object or event after first observing something.	88.1%	3.0%	88.4%	2.3%
6. Describing an object or event to another person.	84.2%	2.0%	87.2%	1.2%

The results revealed that majority of the SMASE trainers both male and female did not have complete conceptual understanding of most of the BSPS. More than 60% of both male and female trainers could not identify the definitions for predicting, observation, communicating and inferring. It is only 29.7% and 25.6% of the male and female trainers respectively who identified the correct definition of the process skill of predicting. The results further revealed that slightly more male trainees than female trainees identified correctly the definition for the process skill of predicting.

ISSN: 2186-8492, ISSN: 2186-8484 Print
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The same trend was observed in the process skills of observing where the number of male trainers who correctly identified the definition of this skill was 27.7% and 17.4% for male and female respectively. Very few male and female trainers (3.0%) and (2.3%) respectively correctly identified the definition of the process skill of inferring and slightly more male trainers than female trainers correctly identified the definition this process skill.

The same trend was noted in the identification of the definition for the process skill of communicating where only 2.0% and 1.2% of the male and female trainers respectively correctly identified this skill. Again, slightly more male trainers correctly identified the definition of this process skill. About half of the male and female trainers (50.5% and 53.4%) respectively identified the correct definition for measuring. Slightly more female trainees than male trainees correctly identified the definition of this skill. On the other hand a greater gender difference was seen in identification of the correct definition for the process skill of classification where 65.1% of the female trainers correctly identified the definition of this skill as opposed to 54.5% of the men (See table 1).

Trainers Perception of Boys and Girls ability in Basic Science Process Skills

To evaluate SMASE trainers' gender based stereotypes in their perception of boys and girls ability in BSPS, trainers were presented with statements describing application of the various process skills and asked to state comparatively the pupils gender they perceived to be better in the described ability. There were six items numbered (i) to (vi) describing application of the process skill of predicting, communicating, measuring, classifying, observation and inferring respectively. The results are shown in Table 2.

Table 2. Trainers Perception of Boys and Girls ability in Basic Science Process Skills According to Gender

Item	*Gender*	*Frequency (%)*			
		Boys	*Girls*	*Both*	*None*
1. Best in using experience and acquired knowledge to tell about the future.	Male	10.9	52.5	31.7	2.0
	Female	26.7	41.9	31.4	0.0
2. Best in describing an object or event to another person.	Male	43.6	30.7	21.8	1.0
	Female	62.8	14.0	19.8	0.0
3. Best in determining the length, width, area, volume, mass, volume or temperatures of objects.	Male	8.9	54.5	33.7	0.0
	Female	5.8	72.1	22.1	0.0
4. Best in placing objects or events into groups based on some common characteristics.	Male	36.6	19.8	40.6	0.0
	Female	52.3	22.1	24.4	0.0
5. Best at using the 5 senses to learn and collect information about objects or events.	Male	22.8	20.8	52.5	1.0
	Female	32.6	18.6	47.7	1.2
6. Best at guessing or drawing conclusion about an object or event after first making observation.	Male	22.8	43.6	26.7	3.0
	Female	22.1	53.5	20.9	2.3

The results revealed that SMASE trainers had gender based stereotypes about boys and girls ability in BSPS. Majority of the male and female trainers (52.5%) and (41.9%) respectively indicated that girls were better than boys in the process skill of predicting. Almost equal number of both male and female trainers (31.7% and 31.4%) respectively indicated both boys and girls were good in this process skill. This finding implies that majority of the male and female trainers held a positive gender based stereotype towards girls' ability in this process skill.

Regarding the process skill of communicating, more female trainers (62.8%) than male trainers (43.6%) perceived boys to be better in the science process skill of communicating. On the other hand, it is only 21.8% of the male trainers and 19.8% of the female trainers who perceived both boys and girls to have equal ability in the process skill of communicating. This implies that majority of the male and female trainers held gender based stereotype that labeled boys as being better than girls in the science process skill of communicating.

The results further indicated that majority of the female trainers (72.1%) and male trainers (54.5%) perceived girls to be better than boys in the science process skill of measuring. More male trainers (33.7%) than female trainers (22.1%) believed that both boys and girls had equal ability in this process skill. This finding again shows that both male and female trainers held gender based stereotype which was favorably biased towards girls.

Furthermore, majority of the female trainers (52.3%) perceived boys to better than girls in the science process skill of classifying with (36.6%) of the male trainers having similar opinion. A good number of the male trainers (40.6%) were of the opinion that both boys and girls have equal ability in the skill of classifying. The number of female trainer having a similar opinion that boys and girls have equal ability in this process skill was (24.4%).

Hence more female trainers than male trainers held gender based stereotype with a perception that boys were better in ability in the science process skill of classifying than girls. More male trainers than female trainers had a balanced perception of boys and girls ability in the process skill of classifying. However, majority of the trainers held a gender stereotype that labeled boys as being better than girls in the process skill of classification.

The result further revealed that majority of the male trainers (52.5%) perceived both boys and girls to be good in the process skill of observation. The number of female trainers who held this opinion was (47.7%). These findings also revealed that slightly more female trainers than male trainers held gender based stereotypes. Both male trainer (22.8%) and female trainers (32.6%) perceived boys to be better in the process skill of observation than girls. Hence the trainers held a gender stereotype that was favorably biased towards boys.

Again the result revealed that both male and female trainers held gender based stereotype regarding the process skill of inferring. About 43.6% of the male trainers perceived girls to be better in this skill with 53.5% of the female trainers having the same perception. The percentage of the trainers who did not show to be holding gender based stereotype regarding the ability of boys and girls in the process skill of inferring was 26.7% of the male trainers and 20.9% of the female trainers. However, these results shows that majority of the trainers held a gender stereotype that labeled girls to be better in the science process skill of inferring.

Comparing Gender and Trainers' Gender Based Stereotyping

The extend of difference between trainers gender and their gender based stereotypes about boys and girls ability in Basic Science Process Skills (BSPS) was determined using the chi-square test. The results are shown in Table 3.

ISSN: 2186-8492, ISSN: 2186-8484 Print
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Table 3. SMASE Trainers Perceptions of Boys and Girls Abilities in Basic Science Process Skills

			Pupils			
			Girls	*Boys*	*Both*	*Total*
Trainers' Gender	Female	Count	54	12	20	86
		Expected Count	45.1	19.8	21.2	86.0
	Male	Count	44	31	26	101
		Expected Count	52.9	23.2	24.8	101.0
Total		Count	98	43	46	187
		Expected Count	98.0	43.0	46.0	187.0

$\chi^2 = 9.053$ Degrees of freedom = 2 sign. Value (p-value) = 0.011

The results revealed a significant statistically difference, X^2 (2, N=187) = 9.05, p = .01 (an alpha level of .05 was adopted). The Chi-squire P- Value was 0.01 (see table 3) which is less than the level of significance (0.05) and hence the null hypothesis was rejected. This means that the differences observed in the cross-tabulation of perceptions of male and female SMASE trainers towards boys and girls abilities in BSPS related activities were not due to sampling chances and are indeed significant.

Thus both genders of the trainers have significant differences in perceptions of boys' and girls' abilities in BSPS related activities. This finding are in agreement with results in Table 2 which indicated that male and female trainers perceived boys and girls differently regarding their ability in BSPS. The results further revealed that the gender stereotypes varied across the various BSPS.

DISCUSSION

The purpose of this study was to evaluate SMASE trainers' conceptual understanding of basic science process skills and if they held gender based stereotypes regarding girl's ability in BSPS. The results show that majority of the SMASE trainers had poor conceptual understanding of BSPS. Majority of the participants could not identify the correct definitions for: *predicting, communicating, observing and inferring* with a good number of the participants giving the correct definition of *measuring and classifying.*

Similar studies by Farsakoglu et al. (2008) and Emereole, (2009) that focused on pre-service high school science teachers found out that teachers had insufficient conceptual understanding of science process skills. Another study by Chabalengula et al. (2011) found that pre-service elementary teachers did not have sufficient conceptual understanding of science process skills. Similar studies by Lotter et al (2007) and Luft, (2001) on teachers' understanding of inquiry skills (science process skills) revealed that that teachers teaching different grade levels lacked sufficient understanding of science process skills.

The importance of science process skills in the implementation of inquiry teaching cannot be over emphasized (Anderson, 2002; Minstrell & van Zee, 2000). Since the ASEI approach of teaching science is a form of inquiry teaching it requires that science teachers have good conceptual understanding of science process skills. The poor conceptual understanding of

BSPS by SMASE trainers is thus a great impediment to the implementation of ASEI approach in the SMASE INSETs and in Kenya's primary school teaching of science.

The results further revealed that SMASE trainers held gender based stereotypes about boys' and girls' ability in BSPS and there was a relationship between the gender of the SMASE trainers and their gender based stereotypes. Ifegbesan (2010) studying gender-stereotypes, belief and practices in the classroom in Nigeria found that teachers held gender stereotypes and practiced gender stereotypes in schools. According to Ifegbesan there was significant difference between the gender stereotype practice of male and female teachers. Hence these findings are plausible.

Studies by Tiedemann (2002) analyzing effect of teachers' gender stereotypes on their impressions of their students' competence and effort in mathematics reported similar findings where teachers' perceptions were consistent with stereotypes of gender differences. Sadker and Sadker (1982) assert that many teachers operate with preconceptions about the skills, behavior, and performance of girls and boys based on their gender.

Several other studies have also reported results that are consisted with the findings of this study. For example Aladejana (2002) found that the Nigerian Integrated Science Curriculum for junior secondary school contained more activities that favored boys than girls creating gender inequality in learning in the classroom. Erinosho (1997) analyzed 76 science textbooks and reported great disparity in gender representation while Subrahmanian (2002) found that teachers and curriculum in general reinforced gender stereotypes and discriminatory practices against women through the content and methods of teaching employed in schools.

According to FEMSA (n.d.), gender stereotypes by the society have contributed to the way teachers perceives girls ability to learn science. World Bank (2010) indicates that achievement in education should not be determined by gender but by ones talent and efforts. Both girls and boys should receive equal treatment, equal attention and equal opportunity to learn (USAID, 2008) since they have different learning styles.

CONCLUSION

The SMASE trainers had very poor conceptual understanding of basic science process skills especially *predicting, communicating, observing and inferring*. At the same time a good number of the SMASE trainers had good conceptual understanding of the skill of *measuring and classifying*. The results suggest that this group of SMASE trainers did not have sufficient conceptual understanding of BSPS and so they would face challenges in helping their peers understand the skills during the INSET training. This would also jeopardize their competence in helping their pupils to understand BSPS and their application in teaching of science in a meaningful way, impeding the implementation of ASEI in primary schools.

The study further concludes that the SMASE trainers held gender based stereotypes about boys' and girls' ability in BSPS and there was a relationship between the gender of the SMASE trainers and their gender based stereotypes. This implies that SMASE trainers' stereotypical perceptions of boys and girls would affect their attitudes and classroom practice when implementing the ASEI approach.

RECOMMENDATIONS

The findings from this study have great implications for SMASE INSET training and implementation of ASEI approach in classroom. The poor conceptual understanding of BSPS by SMASE trainers is of great concern bearing in mind they are supposed to train their peers

ISSN: 2186-8492, ISSN: 2186-8484 Print
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on the ASEI approach and also implement the ASEI approach in primary schools. As such, we recommend the SMASE trainers be inducted in science process skills and be subjected to a science process skill proficiency test before they can be allowed to train their peers during the SMASE INSET trainings. Those who pass the test to become SMASE INSET trainers.

Primary Teacher Education for pre-service teachers to ensure trainees develops conceptual understanding of science process skills as outline in the Kenya's Primary Teacher Education Science Syllabus.

The study further found that the SMASE trainers held gender based stereotypes about boys' and girls' ability in BSPS and there was a relationship between the gender of the SMASE trainers and their gender based stereotypes. To this end, the study recommends awareness on gender issues in terms of instruction and assessment. As such, teachers must learn to recognize and eliminate gender bias in their pupils' teachers' interactions both within and outside the classroom. SMASE trainers and primary school teachers should be sensitize on gender and consequences of stereotyping learners' ability based on gender.

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