Performance in Science Process Skills: The Influence of Subject Specialization

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ABSTRACT

The purpose of this study was to determine how subject specialization influenced performance in Integrated Science Process Skills (ISPS). Quantitative approach was used. The target population was the 2014 second year trainees in five public Primary Teachers Training Colleges (PTTC) in the Rift Valley Zone in Kenya. Stratified proportionate random sampling techniques were used to select 300 trainees from both science and arts options. Test of Integrated Process Skills (TIPS) was used for data collection. Descriptive statistics was used to describe the data and independent t-test further used to analyze the data. This study found out that trainees specializing in science subject scored a higher mean in ISPS than trainees specializing in arts subject. The study further found out that there was statistical significant difference in performance in ISPS between trainees in the science option and those in the arts option. This study recommended that science subject in Kenya's primary schools be taught by teachers who specialized in science during training, Kenya's Ministry of Education to start in-service training for primary school teachers on implementation of Inquiry Based Science Education and Science tutors' in PTTC to use Science Process Skill (SPS) approach in teaching of science. It further recommends that Kenya National Examination Council to include practical science examination to test acquisition and mastery of science process skills in Primary Teacher Education (PTE).

Keywords: Science Process Skills, Integrated Science Process Skills, Performance

INTRODUCTION

One of the National philosophies underpinning provision of education in Kenya emphasizes on provision of holistic, quality education and training that promotes the cognitive domains of learners (Republic of Kenya, 2012). All the subjects taught in Kenyan schools are presumed to be the means through which this goal of education is to be achieved. Towards this end science education should be seen to be an active player in promoting development of the cognitive domain of the learners. This would be achieved if science education would equip learners with SPS which promotes development of the learners' cognitive domain.

Furthermore, a policy document on teacher education in Kenya identified the need for a reformed education curriculum that met the aspiration of Vision 2030 (Kenya's Development Blueprint) (Republic of Kenya, 2012). Arising out of Vision 2030, thinking skills, communication skills, observation skills, investigation skills, application and transferable skills should be included in the science curriculum. This implies that school science curriculum should equip learners with SPS.

To this end Kenya's PTE should produce human resources that have the capacity to guide learners to develop SPS and do science through science process skills as opposed to rote learning. Hence PTE should ensure that all her graduates have high mastery of SPS.

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According to Hobson and Britain (2006), most teacher trainees felt there was lack of connection between the theoretical knowledge in teacher education programmes and school-based teaching experiences. Hence there is need to provide practical guidance on how to apply SPS in teaching of science in Kenya's primary school setup. This will ensure PTE trainees develop teaching skills and competences that enable them to teach science effectively using SPS approach.

Namunga and Otunga (2012), argue that teachers are the drivers of social, economic and political development of society. Thus if science education is to play its role towards achievement of Vision 2030 in Kenya, the quality of the science teacher as human resource in education should be addressed. Kenya's Sessional Paper No. 1 of 2005 noted that there were gaps between competences and responsibilities of education staff in majority of the posts (Republic of Kenya, 2005). It is the aim of any teacher education programme to produce pre-service teachers who can start their career with sufficient competencies and skills. According to Sharbain and Tan (2012), success in teaching profession depends on knowledge, competences and attitudes. The teacher is considered to be competent when he or she has knowledge and skills required to perform as a teacher. Thus teachers who are highly competent in SPS are more likely to teach science more effectively than those without.

Towards this end, Kenya's PTE science subject focuses on pedagogy and subject knowledge content. However, according to Republic of Kenya (2012), majority of staff in teacher training institutions lack teacher trainer education qualifications. In Kenya, there is no training for teacher educators. Republic of Kenya alludes that the competence of graduates from teacher education institutes is questionable and that changing the practice towards greater learner centered approaches (SPS approach of teaching science) is a major challenge facing PTE teaching profession.

Deborah and Williamson (n.d.) further states that if teachers possess inaccurate information or conceive knowledge in narrow ways, they may pass the same to their students. They further argue that teachers who possess misconception on science concepts may fail to challenge pupils own misconceptions, use science textbooks uncritically or alter them inappropriately. Debora and Williamson conclude that teachers' conception of science knowledge shapes their practice, the kind of questions they ask, the ideas they reinforce and the sort of tasks they assign to pupils.

In Kenya, the PTE science syllabus has given due emphasis to mastery of science content matter and acquisition of SPS by trainees (KIE, 2002). However, for many years primary science in Kenya has been perceived mainly as the study of accumulated scientific knowledge (content) with no focus on developing pupils' scientific skills. Kerre (2008) observed that one major problem in training of primary school teachers in Kenya is that PTE trainees have a very weak background in science content and pursued a general curriculum yet they are expected to teach science among other subjects in the primary school curriculum. In the second year of PTE training, trainees specialize into either science or arts.

Khatete (2010) further indicate that teaching approaches used in primary schools in Kenya are ineffective and facilitates rote learning of science. Khatete indicates that teachers are not guiding pupils to use the scientific skills to develop understanding of scientific concepts they learn at school. Instead pupils are drilled to memorize scientific concepts, laws and principles and reproduce them during examinations. This type of teaching does not allow learners to develop SPS and use them to construct their own understanding of scientific knowledge.

Kerre (2008) conclude that PTE trainees are often secondary school graduates who could not make it to higher level of training and in most cases they had performed poorly in sciences. Again in secondary school in Kenya very few schools teach the three sciences (biology, physics and chemistry) for the four years of secondary education. Most schools offer chemistry and biology as a compulsory cluster and very few students take a science subject cluster with physics (Amunga, Amadalo, and Musera, 2012). That notwithstanding, not all the PTE trainees specialize in science as a teaching subject yet they are all expected to teach science once they graduate.

According to KIE (2002), PTE trainees study integrated science (science, home science and agriculture) in the first year in addition to other subjects in the syllabus. In the second year trainees specialize into science or arts. Placement into either the science or arts option depends on trainees mean score of integrated sciences and mathematics in the mid course examination which is done at the end of the first year. Mid-course examination is an internal examination which is set by the subject teachers and internally moderated. The criteria used to decide who specializes in science or arts do not guarantee that only those trainees who are good in science specialize in science. A trainee may score low grade in science and score high grade in mathematics reflecting a better mean grade and hence qualify to specialize in science subject yet poor in science.

The other set back with the criterion is that the mean grades are ranked from the highest to the lowest and the first upper half joins the science option while the second lower half join the arts option. Thus there is no clear minimum qualification for one to be allowed to specialize in science. This selection criteria therefore does not consider the quality of the scores attained by the trainees but simply ensures there is a science stream and an arts stream.

Since subject specialization in PTE training was introduced in Kenya in the year 2005, no studies had been carried out to determine how subject specialization may influence PTE trainees' performance in SPS. Hence this study investigated influence of subject specialization on PTE trainees' performance in ISPS. The ISPS which were the focus of this study were: identifying and controlling variables, operationally defining variables, stating hypotheses, designing investigations and graphing and interpreting data.

LITERATURE REVIEW

Li and Klahr, (2006) observe that the main aim of science education is to teach children about accumulated knowledge of the natural world and discover scientific knowledge through application of SPS. SPS are defined as the skills used by scientists to create scientific knowledge, think about a problem and make conclusions about the problem (Karsili and Sahin, 2009). Mei, Kaling, Xingi, and Khoon, (2007) suggest that SPS describe a set of broadly transferable abilities that reflects what scientists do while Ostlund (1992) assert that SPS are the tools used by scientists to produce and arrange information about the world.

According to Karamustafaoglu (2011), science process skills are the thinking skills used to get scientific information. Karamustafaoglu note that science process skills are the skills used by scientists in their studies and reflects on the correct behaviors of scientists when solving a problem and planning an experiment. Hughes and Wade (1993) further indicate that science process skills are ways and methods used by scientists to access and process information. It can therefore be concluded that scientific thinking involves the use of science process skill in the discovery of scientific knowledge. According to Mei et al. (2007), the two categories of SPS are basic SPS and Integrated Science Process Skills (ISPS). This study focused on ISPS. Chiappetta and Koballa (2002) indicate that ISPS include defining operationally, formulating

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hypotheses, controlling variables, interpreting data, hypothesizing and experimenting or designing investigation.

Rohaida and Kamariah (2005) argued that learning primary science should include the acquisition of cognitive skills such as SPS which are essential for scientific inquiry. PTE training should therefore help trainees to gain mastery of SPS in addition to science content. This ensures that once PTE trainees graduate from PTTC they are able to facilitate learners to acquire SPS which enables them understands scientific information, investigate, interrogate, experience, discover and solve problems in their immediate environment. The most effective way towards achievement of this aim of science education is by equipping learners with SPS which enables them do science instead of learning about science (Nuhoğlu, 2004).

Bennell and Akyeampong (2007) posit that lack of the necessary competencies to teach science effectively by teachers may influence their choice of teaching approach. Advocates of SPS indicate that these skills simplify learning of science, activate learners' sense of responsibility in their own learning as well as equip them with science research methods (Carey et al, 1989 & Okere, 1996). It is therefore more important that pupils in primary schools are taught how to acquire scientific knowledge on their own through the use of SPS rather than learning scientific knowledge as reality to be memorized for purposes of passing examinations.

STATEMENT OF THE PROBLEM

If anything is to be regarded as specific preparation for teaching science in Kenya's primary schools, priority must be given to thorough grounding in application of SPS in teaching of science. Despite the fact that not all the PTE trainees specialize in science as a teaching subject during PTE training in Kenya, they are all expected to be science teachers in primary schools. Thus even teachers who specialize in arts end up teaching science in primary schools. This has raised questions on how PTE prepares teachers for teaching science in primary schools in Kenya. The concern is whether those trainees who specialize in arts acquire SPS that would enable them guide learners do science as opposed to learning about science. It is not clear how the practice of subject specialization in PTE influenced trainee's performance in SPS. Hence this study evaluated how subject specialization influenced PTE trainees' performance in ISPS.

CONCEPTUAL FRAMEWORK

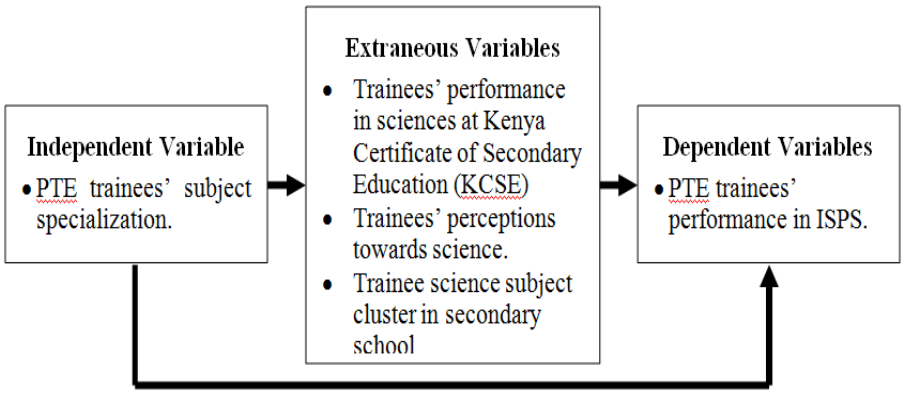

Figure 1. The Conceptual Framework for determining influence of PTE trainees' subject specialization on PTE trainees' performance in ISPS.

Subject specialization (science or arts) is conceptualized to influence PTE trainees' performance in ISPS. The relationship between dependent and independent variable of the study were conceptualized as illustrated above.

Figure 1 illustrates the conceptual framework that relates the various factors considered to have an effect on PTE trainees' performance in ISPS. In an ideal situation, the trainees' performance in sciences in KCSE, trainees' perceptions and attitude towards science and trainee science subject cluster in secondary school would affect the trainees' performance in ISPS. These were the extraneous variables and were also studied to understand their effects. Randomization was further used to get a representative sample.

Null Hypothesis

The null hypothesis tested in this study was: There is no significant statistical difference in performance in ISPS between trainees in the science option and those in the arts option.

METHOD

This study employed quantitative research method. Quantitative research has been defined as a type of research that explains phenomena by collecting numerical data that are analyzed using statistics (Cohen et. al, 2000 and Creswell, 1994). This study sought to explain whether subject specialization influenced trainees' performance in ISPS and used a test which collected numerical data and hence quantitative methodology was appropriate for this study.

To test the hypotheses of this study, causal-comparative research design was used. A research design is a set of guidelines by which a researcher obtains answers to research questions and or tests hypotheses in a research study (Fain, 1999). A causal comparative design is a non experimental design since there is no manipulation of the independent variables because their manifestations has already occurred (Cohen and Manion, 1994; Kerlinger, 2000; Nachiamas and Nachiamas, 1996). Causal comparative research attempts to determine the cause and effect relationship for pre-existing differences in groups of individuals (Borg and Gall, 1989 and Fraenkel and Wallen, 2000).

To explore the effects of subject specialization on PTE trainees' performance in ISPS, the researchers used two pre-existing groups (science option and arts option). The effects on the two groups had already occurred hence the independent variable was not manipulated thus causal-comparative design was appropriate. The two groups were then compared in order to investigate if there was statistically significant difference in performance in ISPS between the two groups.

Sampling Procedures and Sample Size

Stratified proportionate random sampling techniques where elements selected from each group were in the same proportion of the groups in the target population was used to select trainees from science and arts option in each PTTC. Records from the five PTTCs in the Rift Valley Zone indicated that there were a total of 2014 PTE trainees (science option 989 and arts option 1021). Sample size was determined using the formula for calculating samples size by University of Florida (2012) which was found to be 322 trainees. However, 300 trainees (Science option 172 and Arts option 178) which translated to 93.2% of the sample size finally participated in the study.

Instruments

TIPS was used to investigate trainees' performance in ISPS. TIPS was a paper and pencil test developed by Kazeni (2005) and consisted of 30 multiple-choice items. This test was adopted and modified to suit the context of the study. Each item had four optional responses whereby

only one response was correct and the other three options served as distracters. The respondents were informed of the intensions of the test before it was administered.

DATA ANALYSIS

TIPS was scored using a scoring key developed by the researchers and the mean and the standard deviation *(SD)* calculated and used to describe trainees' performance in ISPS according to subject specialization. The mean is the most commonly used measure of central tendency when data represent is in either interval or ratio scale (Fain (1999). The *SD* indicated how trainees' scores in TIPS from each group spread out around the mean. Fain further indicate that the *SD* is the most commonly used measure of dispersion and like the mean *SD* is the most stable measure of variability that takes into account each score in a distribution.

Independent *t*-test was further used to determine whether subject specialization influenced PTE trainees' performance in ISPS. The *t*-test is an inferential statistical procedure used to determine whether the means of two sample groups are significantly different (Fain, 1999). The dependent variable (performance in ISPS) is data in ratio scale and the two groups (science option and arts option) were randomly drawn from a normal distribution, and were mutually exclusive hence independent *t*-test was appropriate for this study (Gall et al., 2003, Fain, 1999). The *t*-test analysis was conducted with the aid of the Statistical Package for Social Sciences (SPSS) computer application package. Statistical significance was tested at alpha is equal to 0.05.

RESULTS

Comparing Performance in ISPS between the Two Subject Specialization Groups

This study describes the difference in performance between PTE trainees in science option and those in arts option. The results are shown in Table 1.

Table 1. PTE Trainees Performance in ISPS According to Subject Specialization (N=300)

Subject of Specialization	*Mean*	*N*	*Std. Deviation*
Science Option	19.5	169	5.58373
Arts Option	12.4	131	7.46701
Total	*16.4*	*300*	*7.34155*

Results in table 1 show that mean performance score in ISPS for trainees in science option was higher (19.5) with a lower standard deviation (5.6) compared to that of trainees in art option (12.4) with a higher standard deviation (7.5). To find out if there was statistical significant difference in performance in ISPS between the two groups, independent-sample *t*-test was applied.

The results in Table 2 revealed that there was statistical significant difference between scores (M=19.5, SD=5.6) for trainees in the science option and scores (M=12.4, SD=7.5) for trainees in the arts option, $t(298)=8.98$, P=0.001. These results suggest that there is statistical significant difference in performance in ISPS between trainees in the science option and those in the arts option. The null hypothesis (H_o) is thus rejected and alternative hypothesis (H_A) accepted. Specifically these results suggest that performance scores in ISPS for trainees

who specialized in science subject were better than scores for trainees who specialized in arts subjects. The results are shown in Table 2.

Table 2. Independent Samples T-Test between Subject Specialization and Performance in ISPS

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*T*	*Df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
									Lower	Upper
Over all Score	Equal variances assumed	27.645	.000	9.307	298	.000	7.01	.75	5.53	8.50
	Equal variances not assumed			8.978	233.216	.000	7.01	.78	5.47	8.55

DISCUSSION

The study revealed that there was a statistical significant difference in performance in ISPS between trainees in science option and those in arts option in Kenya's PTE. Trainees who specialize in science subject during training got better scored in ISPS than those who specialized in arts subject. This finding are supported by a study by Mutisya and Rotich (2013) which found out that primary school teachers in Kenya's Narok County had poor conceptual understanding of SPS. Hence it is fallacious to assume the two groups are equally qualified to teach science in primary schools in Kenya.

These findings further concur with findings by Abdulraheem (2011), Musa (2004) and Aina, (2013) which indicated that subject specialization influenced students' conceptions. Application of ISPS was tested using concepts from chemistry, biology and physics which are part of the PTE science content in Kenya. Hence trainees from the science option had an advantage over trainees in the arts option because of the longer exposure to science content in their second year.

Trainees in arts option studied science in the first year of PTE only. Thus the higher performance in ISPS by trainees in the science option can be attributed to the fact that they had longer exposure to science content than their counterparts the arts option.

This implies that though all the graduates of PTE are expected to teach science in Kenya,s primary schools, they don't have equal qualification in terms of mastery of science inquiry skills (Kerre, 2008). According to Kerre, some PTE trainees in Kenya had a very weak background in science because they had performed poorly in sciences. Kerre observes that PTE is a general course and does not produce teachers who are science subject specialist. Amunga et al. (2012) indicates that proficiency in science subjects is very important as it plays an important role in professional development of teachers.

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CONCLUSION

This study concludes that trainees who specialize in science subject during training will score higher grades in ISPS than trainees who specialize in arts subject. Hence there is statistical significant difference in performance in ISPS between trainees specializing in science and those specializing in arts.

RECOMMENDATIONS FOR PRACTICE

This study recommends the following policy changes by Kenya's Ministry of Education:

1. Science subject in Kenya's primary schools be taught by teachers who specialized in science during training.
2. Science tutors' in PTTC to use SPS approach in teaching of science.
3. In-service training for primary school teachers on implementation of Inquiry Based Science Education in primary school be introduced.
4. Kenya National Examination Council to test acquisition and mastery of SPS in PTE science examination.

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