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Comparing the Effectiveness of an Inquiry-Based Approach and Conventional Teaching in the Development of Students' Self-concept towards Practical Laboratory Experimentation

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Abstract
Educational studies in the area of motivation have led to the conclusion that learners with a high sense of self-concept tend to approach school related tasks with confidence and that success in those tasks reinforced their self-confidence. The major aim of this study was to compare the effectiveness of an inquiry-based approach and conventional teaching in the development of students' self-concept towards practical laboratory experimentation. The study used genetic as the case study to find out whether or not these two styles of teaching genetics would develop differently students' perceived self-concept towards science experimentation. Inquiry-based approaches to science have been heavily emphasized by the newly adopted curriculum policy in Tanzania. Two months (08weeks) of February and March 2015 were spent in teaching themes within genetics at the selected schools in Morogoro Municipality using two different methods. These genetics lessons were not designed specifically to contribute to students' self-concept towards scientific experimentation. Yet, it was assumed that it might have a positive effect on the student attitudes. The study employed a quasi-experimental research design with pre and posttests. The FSWEx self-concept scale by Damerau (2012) was used as a data collection tool. The questionnaire measures students' self-concept in three subscales of experimentation namely planning of experiments, actual experimenting and analyzing data. Although it was conceptualized that the experimental group would develop higher positive self-concept towards experimentation in science than the control group, this was not the case in this study. No statistically significant difference was found on students the development self-concept posttest scores in all three subscales based on the type of instruction they received when null hypothesis was subjected to independent samples t-test. However, the linear model with repeated measures found that regardless of the method of teaching, there were significant gains in the self-concept of students towards scientific experimentation overtime.

1. Introduction and Problem Statement

1.1. Introduction

Self-concept is our perception or image of our abilities and our uniqueness. Several science education and psychology researchers have studied extensively the concept of self and its connection to motivation and academic achievement (Reese et al. 2007; Bellmore, & Cillessen, 2006; Brendgen, 2002; Chapman et al. 2000; Fleming, 1984; Gans et al. 2003; Marsh et al. 2005; Marsh et al. 1988; Trautwein, et al. 2006). Marsh et al. (2005) defines self-concept as a collection of beliefs about one's own nature, unique qualities, typical behavior and self-perceptions. It is a multidimensional construct that refers to a person's perception of self in terms of both academic and nonacademic aspects (Brendgen, 2002; Chapman et al. 2000; Fleming, 1984; Gans et al. 2003; Marsh et al. 2005; Marsh et al. 1988; Trautwein et al. 2006). According to Marsh et al. (1988) the self of an individual consists of attributes and personality traits that differentiate one from other individuals. Trautwein et al. (2006) provided the meaning of self-concept as the individual's belief about himself or herself, including the person's attributes and who and what the self is. Academic self-concept, on the other hand, refers to a person's perception of self with respect to achievement in school (Chapman et al. 2000). In particular, a person's science self-concept refers to the perception or belief in his or her ability to do well in science or confidence in learning science (Marsh et al. 2005; Reese et al. 2007; Bellmore & Cillessen, 2006; Brendgen, 2002).

Science curriculum reforms in Tanzania emphasize for more inquiry oriented and investigative scientific activities into science classes (URT, 2005). As a result, laboratory experiences become a solid integral part of the science education programs. The current curriculum policy for example states that science learners should be able to use appropriate methods and technology to generate relevant information in science. Other objectives according to the syllabus (URT, 2010) students should be able to develop necessary science practical skills and have the ability to apply scientific skills and procedures in interpreting various scientific data. Emphasizing on the need of laboratory experiences, Hofstein and Lunetta (2004) believe that the laboratory has been given a central and distinctive role in science education, and science educators have suggested that rich benefits in learning accrue from using laboratory activities.

Experiences of laboratory work, feel of apparatus and materials and natural phenomena, events, and working with hands are essential and vital part of science education. If students do not get opportunities to design activities, experiments, working models, and projects, they have to face lots of difficulties in managing laboratory experiences for their students. Laboratory experiences mean direct experiences with the natural and physical world using tools and apparatus accompanied by engagement with process and inquiry skills in science.

As in many countries, the enhancement of children's self-concepts is a desirable educational goal in Tanzania. Educational and social policy statements emphasize the importance of developing and maintaining positive self-concepts as important goals of education. On the other hand, attainment of positive academic self-concepts has been shown to affect academic behaviours, academic choices, educational aspirations, and subsequent academic achievement (Marsh,et al 2005 & Chapman,et al. 2000). Those who consider themselves "good students" according to Marsh et al. (2005) tend to pay more attention, follow directions in class in a better way, use effective learning strategies are more likely to work independently and tirelessly to solve difficult problems, and often get enrolled in challenging courses. On the other hand, those who believe they are "poor students" misbehave in class, study rarely or not at all, abandon to turn in their homework assignments and mostly avoid taking difficult subjects (Marsh et al. 2005). Chapman et al. (2000) observed that there is a persistent and significant relationship between the self-concept and academic achievement and that change in one seems to be associated with a change in the other. Dambudzo (2005) for example conducted a study about the relationship between learner self-concept and achievement in secondary schools in Zimbabwe. The sample consisted of 1281 adolescent learners in urban and rural government and nongovernmental secondary schools. A positive and reciprocal relationship between learner self-concept and academic achievement was found.

In order to enhance development of students' positive self-concept and confidence, the current curriculum policy of Tanzania emphasizes the use enhance participatory and inquiry approaches to teaching (Tilya & Mafumiko, 2008). In the advanced level Biology syllabus of Tanzania of 2010 for example it is stated that… …

….. Teachers are advised to use participatory teaching and learning strategies as much as possible to help learners demonstrate self-esteem confidence and assertiveness (Pg.vii).

Learner-centered participatory learning is an approach to teaching in which learners choose not only what to study but also how and why and sometimes where. Learners are encouraged to participate actively in the lesson, use their pre-concept knowledge, and engage in classroom activities so as to construct meaning out of the lesson (Kelly, 1991). As one of the participatory methods of teaching, inquiry based approach, is a form of active learning that starts by posing questions, problems or scenarios rather than simply presenting established facts. The process is often assisted by a teacher as a facilitator. Inquiry-based learning includes problem-based learning, and is generally used in small scale investigations and projects, as well as research. The approach provides opportunities to understand the scientific inquiry process and to develop general investigative abilities (such as posing and pursuing open-ended questions, synthesizing information, planning and conducting experiments and analyzing and presenting results), as well as to gain deeper and broader science content knowledge that has real-world application (Prawat, & Floden, 1994).

1.2. Problem Statement

Student academic self-concept and its relations with other factors have been the focus of education and have attracted much attention over the past two decades (Abu-Hilal & Bahri, 2000). Studies have clearly demonstrated how important teaching approaches are, in influence the development of students' self-concept (Schweinhart, Weikart, Larner, 1986). The argument is that the process leading to an enhancement of or decrease in the learner's self-concept begins with the interaction between teachers and students. In this respect, the purpose of this quasi-experimental study was to compare the effectiveness of inquiry and traditional methods of teaching in developing students' self-concept towards scientific practical investigation and experimentation. As it has been stated in section 1.1, lab practical skills have also been heavily emphasized in the new curriculum scheme in Tanzania (URT, 2010). The current curriculum policy of Tanzania (URT, 2005 & URT, 2010) further encourages teachers to use participatory teaching and learning strategies as much as possible to help learners demonstrate positive self-concept, self-esteem, confidence and assertiveness (P.viii). However, few studies if any have been conducted to assess the effectiveness of this approach (inquiry participatory) way of teaching in the development of students' self-concept compared to the traditional way of teaching. This was the essence of the current study. Students with a strong sense of self-concept tend to approach difficult tasks as challenges to be mastered with assurance in themselves about their capabilities. This type of outlook is seen to produce personal accomplishments, reduce stress, and lower vulnerability to depression. On the other hand, students with low self-concept tend to have low aspirations and weak commitment to the goals they pursue. They easily develop stress and depression which in turn, hamper their potentials to perform actions effectively (Marsh et al. (2005).

1.3. Aim of the Study

The major aim of this study was to compare the effectiveness of an inquiry-based approach and conventional teaching in the development of students' self-concept towards practical laboratory experimentation

2. Research Method

2.1. Research Design

Quasi-experimental design involving experimental and control groups was employed in this study. Quasi-experimental methods that involve the creation of a comparison group are most often used when it is not possible to randomize individuals or groups to treatment and control groups. This design was appropriate to this study because school classes exist as intact groups and school authorities do not normally allow classes to be dismantled and reconstituted for research purposes (Shadish, et al. 2002 & Njoroge et al, 2014). Quasi-experimental researches are widely used in the evaluation of teaching interventions because it is not practical to justify assigning students to experimental and control groups by random assignment (Randolph, 2008 & Njoroge et al, 2014). Quasi-experimental research offers the benefit of comparison between groups because of the naturally occurring treatment groups (Cohen et al. 2007). In this study, the experimental groups were exposed to inquiry-based approach and the control groups received no treatment as they were taught using conventional style only. The aim was to determine whether the two methods of teaching would develop differently students' self-concept towards practical laboratory experimentation. The performances of the two groups were then compared to determine whether there are any treatment effects as a result of different teaching styles on the same contents.

2.2. FSWEx Self-concept Scale by Damerau (2012)

In assessing the level of students' self-concept towards laboratory scientific experimentation before and after teaching intervention, the FSWEx self-concept scale by Damerau (2012) was used (see appendix VI). This questionnaire was designed to enable researchers and science teachers to gain a better understanding of the self-concept of students in doing science and to examine in which ways it affects the interest of doing science. FSWEx Self-concept questionnaire consists of 18 items which are further subdivided into three subscales, i. planning experiments (06 items), ii. practical experimentation, (06 items) and iii. analyzing data (06 items). The scale is based on the model of experimental skills (Schreiber et al. 2009) and uses a 5-point Likert scale ranging from 0 (strongly disagree), 1 (disagree), 2 (neutral), 3 (agree) to 4 (strongly agree). The internal consistency reliability of the instrument (FSWEx Self-concept scale) was established by Damerau (2012) using 177 grade 11 to 13 science learners to be $\alpha = 0.77$ (Cronbach's alpha). The three subscales of FSWEx i. planning experiments, ii. practical experimentation, and iii. analyzing data had Cronbach's alpha values of the reliability of 0.789, 0.729 and 0.766 respectively. There is a relative strong inter correlations (Pearson) of the three FSWEx subscales. For example, the correlation coefficient (r) between planning experiments and carrying out practical experimentation is 0.567, planning experiments and analyzing data is 0.671 while carrying out practical experimentation and analyzing data is 0.619. Lastly, the scale correlates fairly well with its academic self-concept in Biology as a covariate. Damerau (2012) correlated FSWEx sub scales with the self-concept scale in Biology developed by Englin (2004) and found that the coefficient (r) of planning for experiments was 0.336, the coefficient (r) for carrying out experiments was 0.550 while that of analyzing data was 0.554.

2.3. Genetics contents that were Taught

Genetics is one of the central topics addressed by the competence-based curriculum of 2005 in Tanzania for the Advanced level Biology students. According to the advanced level Biology syllabus of Tanzania (2010), Genetic contents are categorized into the following subtopics i. Hereditary materials (DNA/RNA), ii. Genetic coding and protein synthesis, iii. Mendelian inheritance and pedigree, iv. Non-Mendelian inheritance v. Sex linked inheritance and vi. Gene and chromosomal mutation. The emphasis was on the understanding of the nature, function and correlations between the basic genetic concepts (e.g. DNA, genes, chromosomes, and meiosis) and the phenomenon of Mendelian inheritance protein synthesis and Mutation. None of the participants had been taught genetics at higher levels in the past. Genetics was taken as a case study because the topic is considered one of the most important and difficult topics in the school science curriculum (Tsui & Treagust, 2010). Researchers in science education have consistently criticized the traditional teaching approach and suggested the development of more effective alternatives such as the inquiry-based approach.

2.4. Participants in the Study

The participants of the study were 263 advanced level Biology students from selected secondary schools in Morogoro Tanzania. Three schools namely Kilakala (145 students), Alfagerms (87 students) and Bigwa sisters (31 students) were involved in the study. Activities that used inquiry, hands-on models and problem-solving were targeted to form five students while conventional methods were employed to teach form six students. This is because of the fact that Form six students didn't have much time for inquiry activities. These are finalist students and always busy for the preparation of their final national examination. Hence, they were 169 experimental group students and 94 control group students. As summarized in table .1 below, the number of female students involved was 200 (130 in inquiry classes and 70 in conventional method) while there were 63 male students 24 being in conventional approach and 39 were involved in inquiry classes.

			Sex		Total
			Female	Male	
Kilakala sec school	Type of instruction	Conventional approach	49		49
		Inquiry based method	96		96
			145		**145**
Alfagerms	Type of instruction	Conventional approach	7	24	31
		Inquiry based method	17	39	56
			24	**63**	**87**
Bigwa Sisters	Type of instruction	Conventional approach	14		14
		Inquiry based method	17		17
			31		**31**
	Grand total		**200**	**63**	**263**

Table 1: Distribution of students by type of instruction and sex in each school
Source: Research survey (2014)

3. Result and discussion

3.1. Introduction
The genetics lessons were not designed specifically to contribute to students' self-concept towards laboratory scientific experimentation. Yet, it was assumed that it might have a positive effect on the student attitudes. The FSWEx self-concept scale by Damerau (2012) was used as a data collection tool. This questionnaire was designed to enable researchers and science teachers to gain a better understanding of the self-concept of students in doing science and to examine in which ways it affects the interest of doing science. FSWEx self-concept questionnaire consists of 18 items, which are further subdivided into three subscales, i. planning experiments (06 items), ii. practical experimentation, (06 items) and iii. analyzing data (06 items). The scale is based on the model of experimental skills (Schreiber et al. 2009) and uses a 5-point Likert scale ranging from 0 (strongly disagree), 1 (disagree), 2 (neutral), 3 (agree) to 4 (strongly agree). With FSWEx Self-concept questionnaire each subscale was measured with six items and the maximum score a student could get was 24. Students' self-concept towards laboratory scientific experimentation in both the experimental and control groups were scored prior to and after the genetics teaching intervention.

3.2. Pretest Findings on the on the Level of self-concept of Students
To establish whether the previously described experimental and control group students had similar levels of self-concept towards laboratory scientific experimentation, pretest scores on FSWEx questionnaire were analyzed descriptively and then by using independent sample t-test. The students were asked to rate statements measuring their self-efficacy by ticking either strongly disagree, disagree, neutral, agree or strongly agree depending on their feelings and perception. Planning experiments self-concept was measured by the following statements.

- i. In my daily life, it often happens that questions emerge which can be solved by experiments.
- ii. It is easy for me to formulate theoretically based hypotheses.
- iii. It is quite easy for me to develop lab experiment to solve a given problem.
- iv. I am good at choosing suitable laboratory equipment for experiments.
- v. It is easy for me to develop an experimental instruction to solve a specific scientific lab question.
- vi. I find it easy to transfer an idea for a lab experiment into an experimental setting.

Self-concept of students towards the experimenting, on the other hand, was measured by the following statements on FSWEx questionnaire.

- i. I don´t have a good hand for carrying out experiments.
- ii. I am good at working with laboratory equipment.
- iii. Writing down experimental observation is always hard for me.
- iv. I have no problem with arranging experimental setups.
- I am good at doing experiments.
- vi. Handling lab equipment is very easy for me.

Lastly, the self-concept levels of students towards analyzing experimental data were measured by the following statements.

- i. Analyzing experimental data is easy for me.
- ii. I often have problems with interpreting experimental results.
- iii. Interpreting experimental observation is easy for me.
- iv. I do well in analyzing experimental results.
- v. Detecting possible errors in an experiment that went wrong is easy for me.
- vi. I can easily generate graphs based on experimental data.

Descriptive analysis of pretest scores on FSWEx self-concept subscales indicated that in both groups, students had lower self-concepts towards analyzing experimental data than their self-concept towards planning experiments and the actual experimenting. In this subscale (data analysis), the 169 experimental group students had the mean score of 8.57 out of 24 possible while the 94 control group students had the mean score of 8.77 before the intervention. Furthermore, Morogoro students had better scores on self-concept towards planning experiments than their self-concept towards actual experimentation and analyzing data subscales. The result means that Morogoro students had a positive picture of their ability to plan experiments than doing actual experiments and analyzing data before intervention (table 2).

Group Statistics					
	Type of Instruction	N	Mean	Std. Deviation	Std. Error Mean
FSWEx(planning experiment subscale)	Conventional approach	94	10.6596	2.24113	0.23115
	Inquiry Based Method	169	10.8047	2.30754	0.17750
FSWEx (experimenting subscale)	Conventional approach	94	9.5319	3.13736	0.32359
	Inquiry Based Method	169	9.2071	2.96181	0.22783
FSWEx (Data analysis subscale	Conventional approach	94	8.7766	3.15259	0.32516
	Inquiry Based Method	169	8.5740	3.14276	0.24175

Table (2) pretest scores on FSWEx self-concept subscales (Planning experiments, experimenting a& analyzing data) (n=263)
Source: Field data (2015)

In the planning experiment subscale, the item statement number iv. I find it easy to transfer an idea for an experiment into an experimental setting had lowest mean scores with 1.22 out of 4.0 possible. This means that before intervention students in both groups had the feeling that it is difficult for them to transfer an idea for an experiment into an experimental setting. The item number one in this subscale, (in my daily life it often happens that questions emerge, which can be solved by experiments) was higher rated by Morogoro students of both groups than any other items. It had the mean of 3.34 even before the intervention. On the other hand, scores in the data analysis subscale indicated that item number iv. (detecting possible errors in an experiment that went wrong is easy for me) had lowest scores with a mean of 1.96 and standard deviation of 0.411. This implies that before intervention students in both groups perceive themselves as incapable of detecting errors in experiments.

However, it was also necessary to find out whether the mean of the control and experimental groups observed above differed statistically or not. It has to be noted that these are pretest scores (scores before intervention). Hence the SPSS independent samples t-test was used with the FSWEx self-concept subscales pre-test scores for i. planning experiments, ii. practical experimentation and iii. data analysis. In both cases, however, no statistically significant differences between the experimental and control groups were found in students' sense of self-concept pretest scores when null hypothesis was subjected to independent samples t-test. For planning experiments subscale for example, Levene's test for equality of variances of IBA classes (M=10.65, SD= 2.24) and that of TM classes (M=10.8, SD= 2.30); found t (261) =-0.494, p = 0.622, at alpha = 0.05. Hence the null hypothesis that regardless of their groups, Morogoro students did not differ significantly in their sense of ability towards planning science experiments before the intervention was accepted. Levene's test for equality of variances for pretest scores of practical experimentation subscale also failed to reject the null hypothesis at α = 0.05. Independent samples t-test for practical experimentation subscale pretest scores of the IBA (M=9.20, SD= 2.96) and that of TM classes (M=9.53, SD= 3.13); produced t (261) =0.834, p = 0.405, at alpha = 0.05. Hence the null hypothesis that there is no statistically significant difference in the perceived ability for practical experimentation between the control and experimental group students was also accepted. Table 2(b) below summarizes findings from t-test for equality of means from pretest scores of both groups at α = 0.05 (all three FSWEx subscales).

		F	Sig.	t	df	Sig. (2-tailed)	Mean Diffe	Std. Error Differ	95% Confidence Interval of the Difference	
									Lower	Upper
preFSWEPLANING	Equal var assumed	.217	.642	-.494	261	.622	-.145	.293	-.723	.433
	Equal var not assumed			-.498	197.08	.619	-.145	.291	-.719	.429
preFSWEXPERI	Equal var assumed	.266	.606	.834	261	.405	.324	.389	-.441	1.09
	Equal var not assumed			.821	183.14	.413	.324	.395	-.456	1.10
preFSWEANAL	Equal var assumed	.062	.804	.501	261	.617	.202	.404	-.594	.999
	Equal var not assumed			.500	191.78	.618	.202	.405	-.596	1.00

Table 2(b) Independent Samples t-test on self-concept pretest scores (Planning experiments, experimenting a& analyzing data) (n=263)
Source: Field data (2015).

Lastly, as shown in table 2(b) above, Levene's test for equality of variances for pretest scores of analyzing data subscale also failed to reject the null hypothesis at α = 0.05. Independent samples t-test for data analysis subscale pretest scores of the IBA (M=8.57, SD= 3.14) and that of TM classes (M=8.77, SD= 3.15), produced t (261) =0.501, p = 0.617, at alpha = 0.05. Hence the null hypothesis that there is no statistically significant difference in the sense of ability to analyze and interpret experimental data between students exposed to inquiry-based teaching (IBA) approach and those exposed to traditional method (TM) before the intervention was also accepted. These findings imply that the two groups (experimental and control) of Morogoro students that were involved in this quasi-experimental study had a similar sense of ability both in planning experiments, actual experimenting and in data analysis. The two groups were, therefore, suitable for study.

3.3. General Linear Model for Self-Concept Pretest Posttest Results (Comparison of the Control and Experimental Groups)

Repeated measures analysis of variance (ANOVAs) was also conducted FSWEx self-concept subscales posttest scores to compare groups change in the sense of their ability towards planning experiments, actual implementation and data analysis over the two testing occasions. This measure analyzed both the between and within-group differences overtime with regard to students self-concept changes towards science experiments (the laboratory scientific experimentation). The study intended to compare statistically the effectiveness of inquiry-based approach and traditional method in the development students' self-perception of their ability in i. planning experiments, ii. actual implementation and in iii. data analysis (the processes of science) overtime. In the test of between-subjects the factor was the two groups (control n= 94 and experimental group n= 169) overtime (pretest week and posttest week 8) and the dependent variable was student scores in the FSWEx self-concept subscales. In the test of within-subjects, the within subject factor was time with two levels (pretest in week 01 and posttest week in 08) and the dependent variables was the FSWEx self-concept subscales scores at the pretest and posttest levels. The computer SPSS version 21 general linear model with repeated measure was used for comparing the pretest and posttest scores for within and between groups effects with respect to students change in their sense of self concept towards science experimentation.This part presents the findings from general linear model with repeated measures for the control and experimental group students.

3.3.1. Repeated Measures Analysis of Variance (Anovas) for within and between Group Effects Self-Concept on Planning Experiments

For the effect of time, SPSS computation of general linear model with repeated measure within groups on planning experiments FSWEx subscale pretest and posttest scores (Sphericity Assumed) found F (1,261) = 1285.156, p < 0.001, eta squared =0.831. Hence a significant effect on students' changes in their self-concept towards planning experiments was noted with time. This means that regardless of the method of teaching used (inquiry and conventional) there was a significant within groups effect on students self-concept towards science experiments (laboratory scientific experimentation). The null hypothesis which stated that with time, there were no statistically significant within-group differences between control group and experimental group students in their self-concept level towards science experimentation was rejected at alpha = 0.05. This means that the intervention brought significant within groups differences (control and experimental) over two testing occasions (pretest and posttest). Eta square value within groups was acquired as 0.831. This result shows that the time-effect magnitude is large and that almost 83% of the change in self-concept results from the application of the methods of teaching (inquiry and traditional). Table 3 (a) below presents the findings from the test of within-subjects on scores from the self-concept on planning experiments subscale of FSWEx.

Measure							
Source		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
FSWEx scores	Sphericity Assumed	3352.393	1	3352.393	1285.156	0.000	0.831
FSWEx scores * type of instr	Sphericity Assumed	0.636	1	0.636	0.244	0.622	0.001

Table 3 (a) ANOVA for within and between-subjects effects on self-concept on planning experiments (control group n= 94 & experimental group n= 169)
Source: Field data (2015)

Repeated measures analysis of variance (ANOVAs) was also conducted on FSWEx (planning experiment subscale) pretest and posttest scores to investigate and compare the between- group interaction effects (method * groups* time). The aim was to answer the question, is there the statistical significance between groups effects in their self-concept towards the ability of planning experiments after they had undergone different method of teachings? However, no significant difference in student' self-concept towards planning experiments was found between- group (experimental and control group) with F (1, 261) =0.224, p = 0622. This means that linear model accepted the null hypothesis at alpha = 0.05. The hypothesis stated that with time and treatment interactions, there was no statistically significant between-group difference with respect to their self-concept towards planning experiments (laboratory scientific experimentation). Overall, this implies that there were significant gains over time but there was no statistically significant differential improvement among the groups over time. Hence, regardless of the teaching method employed, there was an improvement of students' self-concept towards their ability to plan science experiments in both, the control and experimental groups.

3.3.2. Repeated Measures Analysis of Variance (Anovas) for within and between Group Effects Self-concept on Actual Experimenting

In comparing the effectiveness of inquiry and traditional method in enhancing students self-concept towards undertaking practical experimentation over time of intervention, the FSWEx experimenting subscale posttest scores were analyzed. For the effects of treatment with time, the general linear model with repeated measure within groups (Sphericity Assumed) found F (1,261) = 1669.541, p < 0.001, eta squared =0.865. Hence a significant effect on students' changes in their self-concept towards actual experimentation with time was noted. This means that in both groups, the teaching method used (inquiry for the experimental group and conventional control group) had a significant within-group effect on students' self-concept towards experimenting (laboratory scientific experimentation). The null hypothesis which stated that with time, there was no statistically significant within-group effects between the control group and experimental group students on their self-concept towards experimenting was rejected at alpha = 0.05. This means that the intervention brought significant within groups differences (control and experimental) over two testing occasions (pretest and posttest). Eta square value within groups was acquired as 0.865. This result shows that the time-effect magnitude is large and that almost 86.5% of the change in students self-concept towards their ability in experimenting results from the application of the methods of teaching (inquiry and traditional). Table 3 (b) summarizes findings from the repeated measures ANOVA for within and between subjects effects on the self-concept of both the control and group students towards conducting experiments.

Tests of Within-Subjects Effects							
Source		Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
FSWEx scores	Sphericity Assumed	15113.962	1	15113.9	1669.541	0.000	0.865
FSWEx * type of instruction	Sphericity Assumed	5.696	1	5.696	0.629	0.428	0.002

Table 3(b) ANOVA for within and between-subjects effects on self-concept on conducting experiments (control group n= 94 & experimental group n= 169)
Source: Field data (2015)

Repeated measures analysis of variance (ANOVAs) was also conducted on FSWEx (experimenting subscale) posttest scores to investigate and compare the between- group interaction effects (method * groups* time). The aim was to answer the question, is there statistically significant between groups differences in their self-concept towards the ability to experiment after they had undergone different teaching methods. No significant difference in student' self-concept towards experimenting was found between- group (experimental and control group) with F (1, 261) =0.629, p = 0428 at eta squared of 0.002. This means that linear model accepted the null hypothesis at alpha = 0.05. The hypothesis stated that with time and treatment interactions, there was no statistically significant between-group difference with respect to their self-concept towards experimenting (laboratory scientific experimentation). Overall, this implies that there were significant gains in the self-concept towards experimenting over time, but there was no statistically significant differential improvement among the groups over time. Hence regardless of the teaching method employed, there was an improvement of students' self-concept towards their ability to experimenting in both the control and experimental groups.

3.3.3. Repeated Measures Analysis of Variance (Anovas) for within and between Group Effects Self-Concept on Data Analysis

Data analysis and interpretation was one of the important kinds of laboratory scientific experimentation focused in this study. It entails the ability of students in assigning meaning to the collected information and determining the conclusions, significance, and implications of the experimental findings. In comparing the effectiveness of inquiry vs and traditional methods in enhancing students' self-concept towards undertaking analyzing experimental data, the FSWEx data analysis subscale pretest and posttest scores were analyzed. For the effects of treatment with time, the general linear model with repeated measure within groups (Sphericity Assumed) found F (1,261) = 3446.789, p < 0.001, eta squared =0.93. Hence a significant effect on students' changes in their self-concept towards analyzing data with time was noted. This means that in both groups, the teaching method used (inquiry and control group) had a significant within-group effect on students' self-concept towards analyzing data (laboratory scientific experimentation). The null hypothesis which stated that with time, there was no statistically significant within-group differences between control group and experimental group students on their self-concept towards analyzing data was rejected at alpha = 0.05. This means that the intervention brought significant within groups differences (control and experimental) over two testing occasions (pretest and posttest). Eta square value within groups was acquired as 0.93. This result shows that the time-effect magnitude is large and that almost 93% of the change in students self-concept towards their ability in analyzing data results from the application of the methods of teaching (inquiry and traditional). Table 3(c) summarizes findings from the repeated measures ANOVA for within and between subject's effects on self-concept towards analyzing experimental data.

Tests of Within-Subjects Effects							
Measure							
Source		Sum of Squares	df	Mean Square	F	Sig.	Eta Square
FSWEx scores	Sphericity Assumed	18395.8	1	18395.8	3446.78	0.000	0.930
FSWEx * type of instruction	Sphericity Assumed	0.126	1	0.126	0.024	0.878	0.000

Table 3(c) ANOVA for within and between-subjects effects on self-concept towards analyzing data (control group n= 94 & experimental group n= 169)
Source: Field data (2015)

As seen in table 3(c) above repeated measures analysis of variance (ANOVAs) was also conducted on FSWEx (analyzing data subscale) posttest scores to investigate and compare the between- group interaction effects (method * groups* time). The aim was to answer the question, is there statistically significant between groups differences in their self-concept towards the ability to analyze data from experiments after they had undergone different teaching methods. No significant difference in student' self-concept towards analyzing data was found between- group (experimental and control group) with F (1, 261) =0.24, p = 0.878. This means that linear model accepted the null hypothesis at alpha = 0.05. The hypothesis stated that with time and treatment interactions, there was no statistically significant between-group difference with respect to their self-concept towards analyzing experimental data (laboratory scientific experimentation). Hence, regardless of the teaching method employed, there was an improvement of students' self-concept towards their ability to analyze data in both, the control and experimental groups.

These findings that the control group and the experimental group did not differ significantly in their self-concept towards planning experiments, actual experimentation analyzing data resembles the conclusion put forward some researchers. For example Suk Kim (2005) conducted a study on the effects of a constructivist teaching approach on student academic achievement, self-concept and learning strategies and concluded that constructivist teaching is not effective in terms of student self-concept enhancement and student learning strategy changes in general, but have some effect upon motivation to learn academic tasks, causing anxiety in the academic learning process and self-monitoring in terms of learning for tests.

3.4. Findings on Posttest Scores: Comparison of the Control and Experimental Group Students on self-concept towards Science Experimentation (Laboratory Scientific Experimentation)

Descriptive analysis and two independent samples t-test were conducted to follow up the significant interaction and assess differences among teaching method groups with respect to their self-concepts towards experimentation in science. The aim was to compare the effectiveness of inquiry-based teaching approach vs traditional method on students' self-concept towards laboratory scientific experimentation. This part of the study compared the effectiveness of inquiry approach with the traditional method in developing the positive self-concept of students towards i. planning experiments ii. actual experimenting, and iii. analyzing experimental data. The null hypothesis stated that there is no statistically significant difference in students' self-concept between? those exposed to inquiry-based teaching (IBA) approach and those exposed to the conventional traditional method (TM).

Descriptive analysis of posttest scores on FSWEx self-concept subscales indicates a massive change in both groups with respect to the investigated concepts at the end of teaching intervention. Table 4(a) is a summary of group statistics for FSWEx questionnaire posttest scores for all three subscales of students based on the type of instruction they received. The planning experiment subscale posttest scores in both groups show that the item number i. in my daily life, it often happens that questions emerge which can be solved by experiments and item number ii. It is easy for me to formulate theoretically based hypotheses to have the highest mean scores than other items. After the intervention, these items had mean scores of 3.84 and 3.65 respectively. Contrarily to pretest, in posttest the item number v, it is easy for me to develop an experimental instruction to solve a specific scientific research question had the lowest mean score than other items. The item still had a mean score of 2.25 and standard deviation of 0.478. Table 4(a) summarizes the mean score and standard deviation for FSWEx planning experiment subscale posttest.

For changes in self-concept towards experimenting from pretest to posttest, the table indicates, for example, the 94 control students obtained (M= 21.14, SD= 1.49) in their post-test scores out of a possible 24 compares to (M= 9.53, SD= 3.13) in their pretest scores. The mean scores of 169 experimental group students also rose from (M= 9.2, SD= 2.96) in their pretest to (M= 20.88, SD= 1.43) after teaching genetics using inquiry-based approach. In the experimenting subscale, posttest scores in both groups show that the item number v. handling lab equipment is very easy for me and item number ii. i am good at working with laboratory equipment to have the highest mean scores than other items. After the intervention, these items had mean scores of 3.75 and 3.73 respectively. Contrary to pretest, in posttest the item number v, I am good at doing experiments had the lowest mean score than other items. The item still had a mean score of 2.43 and standard deviation of 0.485 even after posttest. Table 4(a) below have a summary of the mean score and standard deviation for FSWEx questionnaire experimenting subscale posttest results.

Changes in the self-concept of Morogoro Biology students towards their ability in analyzing experimental data were also assessed. The mean scores of 169 experimental group students also rose from (M= 8.57, SD= 3.14) in their pretest to (M= 18.28, SD= 1.27) after teaching genetics using inquiry approach. In data analysis subscale, posttest scores in both groups show that the item number iv. I do well in analyzing experimental results and item v. detecting possible errors in an experiment that went wrong is easy for me to have the lowest mean scores than other items. Even after the intervention, these items had mean scores of 2.12 and 2.13 respectively. Item number v, I am good at doing experiments had the lowest mean score than other items. Biology students, on the other hand, scored high the item number vi (I can easily generate graphs based on experimental data) with a mean score of 3.11 and standard deviation of 0.761 as seen in the table 4 (a) below.

On the other hand, the heterogeneity of control group students in their self-concept towards their ability to plan science experiments decreased from 2.24 to 1.55 and of the experimental group from 2.30 to 1.58 as shown by the standard deviation. This means that at the end of intervention students were more uniforms in terms of their self-concept towards planning experiment. This is also true to other self-concept variables assessed in this study.

For example, the standard deviation of the control group in FSWEx questionnaire (experimenting subscale) decreased from 3.13 in their pretest to 1.49 after intervention (posttest) while that of the experimental group also decreased from 2.96 to 1.43 after the intervention. In the data analysis subscale, posttest results show that the heterogeneity of the control group decreased from 3.13 to 1.26 while that of the control group also decreased from 3.14 to 1.27 after the intervention.

	Type of Instr	N	Mean	Std. Deviation	Std. Error Mean
FSWEx (Panning subscale)	Conventional Approach	94	20.5	1.55	0.159
	Inquiry Based Method	169	20.6	1.58	0.122
FSWEx (experimenting subscale)	Conventional Approach	94	21.1	1.49	0.154
	Inquiry Based Method	169	20.8	1.43	0.110
FSWEx (data analysis subscale)	Conventional Approach	94	18.4	1.26	0.130
	Inquiry Based Method	169	18.2	1.27	0.098

Figure 4 (a): Students FSW Exposttest scores (control group, N =94; experimental group, N= 169)
Source: Field data (2015)

It was also necessary to analyze and find out whether the mean of the control and experimental groups observed differed statistically or not after the genetics teaching intervention. Hence the SPSS independent samples t-test was used. The FSWEx self-concept subscales pre-test scores for i. planning experiments, ii. practical experimentation and iii. data analysis was analyzed. However, in all three subscales understudy (i. planning experiments, ii. practical experimentation and iii. data analysis) no statistically significant difference was found on students self-concept posttest scores based on the type of instruction they received when null hypothesis was subjected to independent samples t-test. Details of t-test findings for all subscales are summarized in table 6.18 (b) below). For example analysis of posttest scores in the planning experiment subscale with t-test for equality of means of IBA (M=20.6, SD= 1.58) and that of TM classes (M=20.5, SD= 1.55); found t (261) =-0.540, p = 0.590, at alpha = 0.05. Hence the null hypothesis that regardless of their groups, Morogoro students did not differ significantly in their sense of ability towards planning science experiments after the intervention was accepted. Independent samples t-test for equality of means for from posttest scores of practical experimentation subscale also failed to reject the null hypothesis at $\alpha = 0.05$. Independent samples t-test for practical experimentation subscale posttest scores of the IBA (M=20.88, SD= 2.96) and that of TM classes (M=21.14, SD= 1.49); produced t (261) =1.429, p = 0.154, at alpha = 0.05. Hence the null hypothesis that there is no statistically significant difference in the sense of ability (self-concept) to conduct practical experimentation between students exposed to inquiry-based teaching (IBA) approach and those exposed to the conventional traditional method (TM) was also accepted.

Lastly, as shown in table 4(b), independent samples t-test for equality of variances for posttest scores of analyzing data subscale also failed to reject the null hypothesis at α = 0.05. Independent samples t-test for data analysis subscale posttest scores of the IBA (M=18.2, SD= 1.27) and that of TM classes (M=18.44, SD= 1.26); produced t (261) =0.957, p = 0.340, at alpha = 0.05. Hence the null hypothesis that there is no statistically significant difference in the sense of ability to analyze and interpret experimental data between students exposed to inquiry-based teaching (IBA) approach and those exposed to the conventional traditional method (TM) after the intervention was also accepted. These findings imply that the two groups of students that were involved in this quasi-experimental study had a similar sense of the ability in planning experiments, actual experimenting, and data analysis even after eight weeks of genetics intervention. These contradict the initial conception that the students in the experimental group taught using the inquiry-based approach would have higher self-concept towards planning experiments, actual experimenting, and data analysis than the control group taught traditionally.

		F	Sig.	t	df	Sig. (2-tailed)	Mean Differ	Std. Error Diffe	95% Confi. Interval of the Differ	
									Lower	Upper
FSWEx planning subscale	Equal variances assumed	0.46	0.495	-0.540	261	0.590	-0.109	0.202	-0.50	0.28
	Equal variances not assumed			-0.544	196.3	0.587	-0.109	0.201	-0.50	0.28
FSWEx experimenting subscale	Equal variances assumed	0.09	0.759	1,429	261	0.154	0.267	0.187	-0.10	0.63
	Equal variances not assumed			1.411	185.1	0.160	0.267	0.189	-0.10	0.64
FSWEx data analysis subscale	Equal variances assumed	0.04	0.832	0.957	261	0.340	0.156	0.164	-0.16	0.47
	Equal variances not assumed			0.959	193.8	0.339	0.156	0.163	-0.16	0.47

Figure 4 (b): Independent samples t-test for posttest scores on FSW Ex self-concept sub scales(n=94 and experimental group n=169)
Source: Field data (2015)

Although it was conceptualized that the experimental group would develop higher positive self-concept towards experimentation than the control group, this was not the case in this study. No statistically significant difference was found on students self-concept posttest scores in all three subscales (i. planning experiments, ii. practical experimentation and iii. data analysis) based on the type of instruction they received the when null hypothesis was subjected to independent samples t-test (table 4(b). These findings differ from those by VeisiKahre et al. (2015) on their quasi-experimental pretest-posttest study with a control group of the first-grade high school male and female students in Holilan in the academic year 2013 to 2014. In this study with multistage cluster sampling, the experimental groups received training in the problem-solving method. The findings showed that problem-solving training causes increased self-concept academic students than the control group. The findings from the current study, however, are in line with the findings by Nath (2015) in his study on constructivist approach as a way of promoting self-concept and achievement in the science of upper primary students. In his study Nath (2015) found that the self-concept of the students was found to be almost the same before and after the treatment. There was no significant difference between self-concept scores of the two groups after the study. After the treatment, the two groups of respondents did not vary statistically in terms of their self-concept (Nath, 2015). This finding signifies that constructivist approach-based experiments as a tool in teaching science did not enhance the self-concept of students compared to traditional teaching.

4. Conclusion

The aim of this study was to compare the effectiveness of an inquiry-based approach and conventional teaching in the development of students' self-concept towards practical laboratory experimentation. Although it was conceptualized that the experimental group would develop higher positive self-concept towards experimentation in science than the control group, this was not the case in this study. No statistically significant difference was found on students the development self-concept posttest scores in all three subscales based on the type of instruction they received when null hypothesis was subjected to independent samples t-test. However, the linear model with repeated measures found that regardless of the method of teaching, there were significant gains in the self-concept of students towards scientific experimentation overtime. It can be concluded that it is the teacher, more than the material, the method, or any other variable, that makes the greatest difference in children's self-concept achievement. In this study, both groups of students were taught by the same teacher, the researcher. However, a growing body of research points to the essential role that student self-concept plays in the learning process. Hence the study recommends that, policymakers and educators must understand the importance of student self-concept in the learning process, as well as the conditions that promote or discourage its development. Policymakers in particular must be attentive to the ways that well-intentioned education policies, such as high-stakes testing, may constrain educators from creating environments that support student self-concept.

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