Effects of Science Achievement Tests, Technology Achievement Tests, Integrated Science, Technology And Community Tests And Micro Practice on Teacher's Entry Level Abilities

Paulo Nyereugo Kwuanyanwu
University of the Western Cape, SOUTH AFRICA
pauloku@gmail.com

ABSTRACT

This study included both guidance tools and learning cases that were used to explore the entry potential of newly graduated science and technology teachers (NQSTTs). Using a semi-experimental model, the study took 106 NQSTTs, an experimental group (N = 54) and a control group (N = 52), which were subjected to a three-month Professional Certification (PQE) test program. Instruments such as the Science Performance Test (SAT), the Technology Performance Test (TAT), the Integrated Science, Technology and Society Test (ISTST) and microlearning were used to measure the entry capacity of NQSTT. All exams contained versions of the best test and test and were presented to both groups at the start of the study and at the end of the study. Significant changes in the initial ability of the teacher were detected by repeated measurements on ANOVA tests performed for each test with a significance level of 0.05. The results showed that the teachers' initial entry capacity was relatively better than expected, probably due to the type of teacher they were prepared for. It is hoped that these findings will help to show interesting differences in the programs designed to prepare teachers for certification/ admission. The didactic effects on science and technology education are discussed.

Keywords: science, technology, society, teachers, process skills, traits, ability

A. Introduction

In this day and age, the critical role of science and technology teachers in any society is no longer in doubt. What is in doubt is their capabilities and sense of duty to deliver the curriculum mandates and to manage pedagogical practices at the speed of today's learners' life world. With the emergence of the fourth industrial revolution (4IR) there has arisen an urgent need for good preparation of tomorrow's scientists and technologists decision-makers. Mankind is at risk, and science and technology teachers must recognize that they have a responsibility to future generations, beginning with today's digital and social-media age learners. In science teaching, as in technology, teachers' pedagogical innovation, knowledge resources of, and about the subject matter as well as process skills are in dire need now than before. Further to this, every science and technology teacher in Nigerian schools and elsewhere needs a solid understanding of interactions of science, technology and society (STS).

Teachers' STS proficiency is obviously necessary for learners intending to pursue careers in science, technology, engineering, and mathematics (STEM) fields and many other related fields. In parallel with the recent reforms in Nigerian economy that is largely dependent on oil explorations as main source of revenue, attention is greatly needed in areas such as science and technology. STS understanding should be an important requirement for all educated citizenry. Even individuals who do not take jobs in science and technology related fields would benefit from knowing the interactions of STS so they can participate knowledgeably as voters and consumers of science and technology. Despite widespread recognition of the benefits of teaching STS to all learners at least up to the statutory school leaving age, yet agreement on standards and agreement on specific teaching methods and programs are not at all the same world-wide (UNESCO, 2012). The contemporary shift in STS pedagogy for today's learners is consistent with recent and urgent calls on institutions, instructors and teachers to broaden the focus of science and technology education as two interrelated subject areas (Facer, 2012; Slough & Chamblee, 2017; UNESCO & UNICEF, 2013a).

While STS education means different things to different people and there are no uniform aims of STS education world-wide and how the aims are to be achieved, in Nigeria one of the aims is to present science as a human endeavour and to direct attention to the interactions of science, technology and society (Jegede, 1988; Nigerian National Policy on Education, [NNPE], 2004; Ogunniyi, 1996). The relative emphasis given to STS is to promote the development of literate citizenry who are capable of understanding the interface between STS issues (NNPE, 2004, p.23). From this, the learning outcomes present objectives of how science and technology are to be practiced and value laden ideas to the individuals receiving the information. By the same token, STS are included in the core curriculum for Basic Science at the junior secondary school level, and the other subjects of physics, chemistry and biology at the senior secondary school level (Ahmed, Oyelekan, & Olorundare, 2015). In this sense, STS is not taught as a lone subject. At the junior secondary school level STS is presented as a corpus of knowledge to be mastered, memorised and occasionally applied to the real world.

Little is done to convey to learners that STS are social activity laden with values, beliefs and conventions, situated in a particular time, context and culture (Pedretti, 2003), and little is done with respect to critiquing the institution and practice of STS in this digital age. Various reasons account for this. This, in particular, is probably due to the pedagogical mode of training science and technology education teachers in Nigeria (Ojebiyi & Sunday, 2014). At large, traditional method of teaching seems to reflect a clean practice for many of the teacher training colleges in Nigeria. This raises questions about the readiness of newly qualified science and technology teachers to manage STS teaching and learning at the speed of today's learners' life world when they join the teaching profession. Some years ago in Nigeria, a program (Professional Qualifying Examination-PQE) was created to manage the diagnostic process for the induction of newly qualified teachers into the teaching profession.

The PQE program is the go-between the Nigerian Teachers Registration Council (NTRC) and the Nigerian Basic Education Department (NBED). Teacher candidates seeking to enrol for the Professional Qualifying Examination (PQE) must prepare adequately for the examination, induction and certification process. In the Eastern part of Nigeria, the process is loosely known as entry level capability program. The program aims to enhance the NQSTTs' entry level capability in relation to: (1) process skills, (2) pedagogical practice, (3) knowledge of the subject matter, and (4) professional traits of the teachers. Henceforth, for ease of reference, the four sources of entry level capability are termed as 'sources of entry level capability' (SELC). Furthermore, the program is premised on the belief that giving adequate mentoring and encouragement to newly qualified science and technology teachers would be valuable for them to survive their first years of teaching. Every quarter of the year thousands of newly qualified teachers (graduates with degrees and certificates, B.Ed, B.Sc, PGDE, M.Sc, M.Ed, etc.) enroll into the program to be prepared for certification. To prepare these newly qualified teachers, the PQE program is used variously to unite teachers' SELC.

The classroom experience thus indicates that the latter perspectives be gradually introduced to the newly qualified teachers inductively or deductively over the period of their induction into the science and technology teaching fields. Formally, they are required to: (1) use different teaching strategies to demonstrate a micro-teaching activity in a teacher-learner ratio of 1:40, (2) write achievement tests in their area of specialization including societal issues around the subject matter. Therefore, this study specifically examined newly qualified science and technology teachers (NQSTTs) exposed to PQE program in Nigeria.

B. Literature Review

Recent research confirms the prevalence of inadequacies amongst newly qualified teachers to teach science, technology and other related fields of learning (e.g., Dias-Lacy & Guirguis, 2017; Kwaah & Palojoki, 2018; Petersen, 2017), including not knowing how to use ICT in harmony with subject area (Özdemir, 2017; Villalba, González-Rivera & Díaz-Pulido, 2017). Although difficulties facing NQSTTs vary from country to country, many of them appear to be common phenomena in most developing countries, especially the difficulties with teaching STS to digital and social-media age. Part of their struggle has been attributed to the sheer claims of not being fully equipped for the demands of teaching (Sunde & Ulvik, 2014), insufficient content knowledge (Kola, 2016), problems of resource materials and teaching aids (Boakye & Ampiah, 2017), and managing pedagogical knowledge and practices at the speed of today's learners life world (Iwuanyanwu, 2019), as well as the pressures mounted on them to finish the syllabus at the specified time (Ahmed et al., 2015).

Consequently, the learner acquires an unstable level of knowledge which is not transferrable to problem solving situation (Akinsolu, 2010). This is a matter of great concern because teachers form the hub of the education process. Above all, the teacher is an important factor in the quality of education in any nation as he is the last post to translate government policies and intentions into practical form (Akindutire & Ekundayo, 2012). Therefore, the importance of enhancing the amount of newly qualified science and technology teachers as well as motivating the active ones to remain in the profession should be our priority to keep abreast with the rapid progress of science and technology.

But, as some studies have shown non-availability of qualified teachers is the key area Nigeria suffers most (Akindutire & Ekundayo, 2012; Kola, 2016; Okemakinde, Adewuyi & Alabi, 2013). And, due to the scarcity of teachers, the large proportion of school authorities employ untrained graduate teachers with little or inadequate knowledge to teach subjects they were not trained to teach or want to teach. This is being done, with the hope of addressing the scarcity of teachers, but known or unknown to the school authorities is that if one has a PhD in Physics without teaching qualification, he is not a teacher; he is just a physicist. It is when you have taken a teaching qualification and passed that you become a teacher. Surely the general belief that everyone is naturally a teacher in his or her own way is so dangerous. An unqualified science or technology teacher can destroy a generation of learners by teaching them wrong things about, and of the subject matter. Merely presenting science or technology concepts to learners, i.e. making it available in the teaching-learning situation does not automatically mean the gaining of knowledge and insight and the effective application of that knowledge in functioning situations.

Therefore, unqualified or poorly trained science and technology teachers may find it difficult to provide important opportunities for STS learners to become engaged in real world issues confronting them, their communities, societies and environments in which they grew up. The imperative in recent years about improving learner STS outcomes is about recruiting and retaining quality teachers who are capable of creating good learning environment as well as possessing those qualities pointed out by Curtis (2015), Holmqvist (2019), and Hsu and Chen (2018) in the following paragraph. Kola (2016) in his study of employment of untrained graduate teachers in Nigerian schools, agreed with Oluremi (2013) that because of lack of good governance, recognition and motivation regarding teachers' working conditions, salary and other incentives, newly qualified teachers are demotivated to teach and the experienced active ones are leaving the profession (Kola, Gana, & Olasumbo, 2017).

In their study, Marshall, Smart and Alston (2017) investigated 48 elementary teachers in 21 schools in the United States to determine their familiarity, interest, conceptual knowledge of, and performance on science process skills. Results indicate that most teachers demonstrated low conceptual knowledge, despite expressing high levels of familiarity with science process skills. Boakye and Ampiah (2017) explored the challenges that five newly qualified teachers (NQTs) faced in teaching integrated science at the Junior High School in Ghana and how they addressed their challenges. Results from their study identified deficiency in content knowledge among all the NQTs. They recommended that teacher training colleges should equip prospective teachers with pedagogical content knowledge and skills to help them resolve the challenges they are likely to face in their professional practice. Qualified teachers who are adequately equipped with the knowledge of subject matter, skills, attitudes, dispositions and values as well as competence to deliver the curriculum mandate are paramount, but as Kola (2016) pointed out they are not enough in most schools in Nigeria, in the USA (Bales, 2015), in South Africa (Holmqvist, 2019), in Taiwan (Hsu & Chen, 2018), and in Australia (Curtis, 2015).

Therefore, it is essential that teachers, especially those in the fields of science and technology be given a thorough training in the subject matter as well as have sound conceptual knowledge of science and technology (ST) process skills to effectively teach them to their learners (Mumba, Miles, & Chabalengula, 2019; Opateye, 2012). From didactic point of view, teaching about ST process skills largely depend on the teachers' ability to implement science and technology inquiry activities that will enhance learners' acquisition of scientific and technological knowledge as well as process skills. Researches have shown that ST process skills foster significant increases in learners' science and technology contents knowledge (Marshall et al., 2017; Opateye, 2012). Given that ST process skills and content knowledge are mutually valuable and complementary (Nugent el al., 2012), on the one hand, they provide a foundation for inquiry (Kang, Bianchini, & Kelly, 2013), and on the other hand, develop favourable scientific attitudes and disposition in learners which enable them to explain deeper understanding of scientific and technological processes (Opateye, 2012), they should be taught together (Marshall at al., 2017).

Likewise, the integration of process skills from science and technology problem solving while searching for solutions to a societal issue is generally considered an important goal. In addition, the variations in 'opportunities to learn' that teachers provide in science and technology classrooms can help learners acquire the relevant skills they'll need to be creative problem solvers to the complex environmental issues confronting them (Franklin, 2015; UNESCO-IBE, 2013). From this consideration NQSTTs should be able to demonstrate sound science and technology process skills in order to produce learners who are prepared to collaborate and resolve the ever-expanding global, diverse, and technical economy challenges.

C. Methodology

The sample of the study comprised 106 newly qualified science and technology teachers recruited from two classes (G1 and G2) of Professional Qualifying Examination (PQE) program aimed at certifying the entry level capability of teachers in Eastern Nigeria. Teachers (71 females and 35 males) ranged between 31 and 43 years old. 54 out of 106 teachers taken from class G1 hold B.Sc degree in various fields of sciences, e.g., agricultural sciences, physics, biology, chemistry, environmental sciences, ICT engineering and in addition have completed Post Graduate Diploma in Education (PGDE), with science and technology majors. Class G2 comprised 52 teachers who hold B.Sc degree in science and technology education. At the time of the study both groups have zero years of teaching experience, except that class G2 have been exposed to school teaching and learning situations during their undergraduate studies as part of experiential learning. The process by which the control and experimental groups were selected is further described in the following section.

Research design and context

This study is guided by a quasi-experimental pre-posttest design (Creswell, 2014), and involved both learning tasks and instructional tool. The design of the study included one experimental group (G1) and one Control group (G2). The length of the study was approximately 16 weeks, with the first week of the study devoted to orientation and baseline data collection and the rest of the weeks to pertinent training and post-intervention data collection. In Nigeria, the Teachers Registration Council (TRC) has criteria for recruiting teachers into the teaching profession. These include among other things examining teacher candidates' entry level capability in the areas of process skills, pedagogical practice, knowledge of the subject matter, and professional traits (referred earlier as SELC). In some cases a teacher candidate can be exempted from attending the content sessions of the PQE program and be allowed for induction into the teaching profession depending on his/her academic history and other related factors. It is on this consideration that class G2 was exempted from attending the content sessions of the PQE program on the basis they have passable relevant pedagogical content knowledge for delivering the subject matter. As such, they only attended the PQE program for purpose of job selection and other benefits TRC has to offer.

Instruments development

As in most cases where the need arises to investigate the entry level capability of science and technology teachers, tests must be carried out. In this regard, a thorough search of the available tests for similar program to PQE program was completed. No test reviewed possessed the face or content validity suitable for the purposes of the study and as a result, the decision to construct a new instrument was made. In order to assess SELC, three instruments were used, namely, Science Achievement Test (SAT), Technology Achievement Test (TAT), and Integrated Science-Technology and Society Test (ISTST). These instruments consisted of various items in science, technology and society with emphasis on SELC, including practical work and pedagogical innovation. Of the selected areas of learning, 50 multiple choice questions (MCQ) were developed, plus 16 problem-solving activities requiring the teacher candidates to solve them at a set time considered by the instructors as reasonable. Additional 6 long science, technology and society STS-design activities were included for practical skills. In all, SAT consisted of 28 items (21 MCQ and 7 problem-solving items); TAT contained 26 items (17 MCQ and 9 problem-solving items), while ISTST included 18 items (6 design activity-based items and 12 MCQ).

Content and construct validities of the instruments (SAT, TAT and ISTST) were established with the help of two science and technology education experts. They independently checked for the extent to which the items were assessing the science and technology teachers' entry level capability prescribed in PQE program by the Teachers Registration Council (TRC). As part of review process, the experts looked at whether the items in the instruments were worded so that the research participants could understand them. In doing so, inadequacies were identified by the experts. Few items were advised to be removed on the basis of the criteria followed. In all, 70 items considered appropriate by the reviewers were subjected to Cohen's kappa computation. The interrater measure of agreement, Cohen's kappa values were (k=.77 for SAT, k=.80 for TAT and k=.781 for ISTST). Further, the reliability of the SAT, TAT and ISTST were determined by computing

Cronbach's alpha ( ) values. Cronbach's alpha ( ) values were .761 for the SAT, .824 for the TAT, and .743 for the ISTST. The above results indicated the three instruments had appropriate construct validity and internal reliability. Following this rigorous processes of instruments validation and reliability, the SAT, TAT and ISTST were deployed for data collection. At the beginning of the study convenient arrangements were made between the researcher and the two participating groups to collect the baseline data on Tuesday, Wednesday and Thursday of the first week of the study. Thus, data were collected from: the SAT on Tuesday (60min), the TAT on Wednesday (60 min), and the ISTST on Thursday (70 min).

Treatment and Procedure

In weeks 2 – 13 each group received one didactic session on Thursday afternoons (60 min) per week based on concepts of science, technology, and society (STS). The experimental group (G1) was exposed to 'teacher modelling approach' (TMA) in which they learn how to model desired STS learning outcomes. The TMA involves learning about inquiry-based teaching, hands-on and problem-solving experiences that differ from traditional teaching approaches (Minner, Levy, & Century, 2010). It includes various ways of developing an individual's skills, knowledge, expertise and other characteristics to support learners' inquiry minds. It is premised on the belief that science and technology process skills, pedagogical practice, content knowledge, and professional traits among teachers need to be engaged and challenged so as to promote teaching efficacy, pedagogical innovations, new insights and understandings of, and about science, technology and society. During weeks 2 – 7, the instructors presented various ways of modelling science and technology instruction so the teacher candidates could experience the features of: 1) discipline specific, 2) content specific, 3) process, 4) method, and 5) thematic. Discipline specific is centered on two or more branches of science and technology, content specific is creating a lesson or activity on science and technology which is relevant to the lives of learners with focus on knowledge resources, strategies and contexts that learners will encounter in real-life.

Method is centered on using information and communications technology (ICT) and new technological devices to create opportunities for learner-driven forms of learning. Thematic is centered on scientific and technological dimension of phenomena and events of natural world, role of science and technology in society, adaptability, appreciation of the potentialities and limitations of science and technology, and their contribution to citizenship. In this respect, scaffolding was used by the instructors when warranted. The instructors also presented various videos of science and technology teachers who have designed and implemented successful TMA in their classes. At some point (week 8) teacher candidates had to present their conceptions of the modelling and their concerns about this kind of instruction. From weeks 9 – 11, the instructors encouraged teacher candidates to work in small groups to design and implement teacher modelling lesson plans, and present topics of their interests to the class. This means, for example, that each group participated in task engagement at least one time in each of the didactic sessions throughout the study.

Micro teaching practice and evaluation

As required in the PQE program all the participants were tasked to develop lesson plans (usually 10-15 min in length) for their micro-teaching demonstration and evaluation in weeks 12 and 13. Additional task of demonstrating science and technology process skills were given to the experimental groups (G1 and G2). No teaching approach was prescribed to the control group. However, they were told to fulfil the delivery of science and technology contents with the inclusion of process skills which they believe to reflect STS activities.The criteria used for reviewing and evaluating the micro-teaching demonstrations were: 1) The lesson plan must be based on the contents of STS for secondary education learners, 2) The lesson activities should include the essential 21st century skills such as learning how to solve difficult, ill-defined problems and learning how to collaborate, 3) The lesson content must include practical activities with verbalism held to a minimum, and 4) The learning outcomes should reflect the STS outcomes as outlined in the syllabi. A scoring rubric for the four-point criteria was constructed with the guidance of the previously mentioned science and technology experts who reviewed the research instruments. For each of the variable, a four-point scale was used for grading according to the extent that the necessary steps were included in the teachers' demonstration, for example, 1 Unacceptable, 2 = Emerging, 3 = Acceptable, and 4 = Target. Soon after the assessment of the micro-teaching, the next assessment was undertaken. The two groups (G1 and G2) demonstrated their ability by responding to the SAT activities (60 min in week 14), TAT activities (60 min in week 15), and ISTST activities (70 min in week 16). Data from these instruments provided an index for establishing an estimate of entry level capability of the newly qualified science and technology teachers.

D. Results and Discussion

Data generated from the SAT, TAT, and ISTST activities and micro-teaching demonstration were summarized and analysed using both descriptive and inferential statistics. For each problem solving item in the SAT and TAT, a five-point scale (0 – 4) was used for scoring according to the extent that the necessary steps for solution were included in the teachers' response. The maximum score for the SAT was 28 and the TAT was 36. For each item in the ISTST, a ten-point scale (0 – 9) was used in the scoring process. According to the rubric, since each item was inspired by practical process skills, innovative design and problem solving process, it was scored with 9 points if the solution included all necessary steps to address the problem. The maximum score was 54. The MCQ was scored with one point, and each question left blank or given wrong answer was scored with zero point.

The maximum score for the SAT was 21, TAT was 17 and ISTST was 12. In order to compare the experimental group's (G1) and control group's (G2) entry level capability, a repeated-measures of analysis (ANOVA) was completed on each test (SAT, TAT and ISTST) to identify whether there was any significant difference between mean pretest and mean posttest scores of the experimental and control groups. For each repeated measures ANOVA, the between-subjects factor was group (experimental or control) and the within-subjects factor was time (pretest or posttest) at the significant level of .05. Under the premise that teachers forming the control group (G2) would have relevant passable pedagogical knowledge advantage in science and technology over the teachers of the experimental group (G1), comparisons of each test (SAT, TAT and ISTST) scores were separately examined to see the changes in the groups over the period of the study.

Table 1. Descriptive statistics for the SAT, TAT and ISTST instruments

			Full Sample N=106			
Instrument	***Group***	***N***	***Pretest mean***	***SD***	***Posttest mean***	***SD***
SAT	G1 (Exp)	69	50.93	9.56	53.61	9.78
	G2 (Ctr)	34	51.72	10.51	50.11	11.6
TAT	G1 (Exp)	69	43.11	7.42	51.22	10.34
	G2 (Ctr)	34	42.82	10.34	48.07	10.7
ISTST	G1 (Exp)	69	53.67	13.43	56.48	11.02
	G2 (Ctr)	34	54.18	10.31	55.02	12.61

Table 1 presents descriptive statistics for SAT, TAT and ISTST instruments containing pretest and posttest mean scores as well as standard deviations for each group. Pretest scores estimating the initial entry level capability of teachers for the SAT and ISTST yielded mean and standard deviation scores which were less for the experimental group (G1) than the scores derived from the control group (G2). The experimental group only outscored their counterpart on TAT. The variation in mean

scores between the experimental and control groups may be due to the greater exposure of science and technology education experiences which the control group had during their first degree training at universities. This was further supported by the overall results of variables tested on both groups' personality traits about teaching profession (**Table 5**). At the end of the study both groups differed from each other on scores of achievement. To determine if any growth has taken place in the interim between the pretest and posttest, the gathered data were treated by the analysis of repeated measures of ANOVA. In this respect, the experimental group (G1) achieved significant gains over their initial scores, whereas, the control group (G2) tended to remain at a stable level (see **Tables 2 – 4**).

Table 2. Results of repeated measures of ANOVA and pairwise comparisons for the SAT

Source	*Sum of Squares*	*F*	*p-value*	η 2	*Observed power*
Time	7542.57	14.89	.000***	.078	.834
Group	1435.50	.53	.371	.013	.161
Time × Group	8978.05	17.83	.000***	.16	.834

Pairwise comparison between G1's and G2's entry level capability scores on SAT

Comparisons	*Mean difference*	*SE*	*p*	*95% confidence interval for difference*	
				Lower bond	*Upper bond*
PostSATexp – PreSATexp (G1)	2.68	1.62	.062	4.67	1.83
PostSATctr – PreSATctr (G2)	–1.61	2.31	.000***	–9.32	7.12
PreSATexp– PreSATctr (G1-G2)	–0.79	4.49	.01*	-5.21	-1.26
PostSATexp –PostSATctr (G1-G2)	3.50	4.02	.0173	3.14	6.39

*exp=experimental group, ctr = control group pre=pretest, post = posttest (*p<.05, **p<.005, ***P<.001)*

Table 2 presents the results for the Science Achievement Test (SAT). At an alpha of .05, the analysis of variance revealed a statistically significant interaction effect between time and group (F =17.83, p < 0.001, $\eta 2$=.15) and a statistically significant main effect of time (F = 14.89, p < 0.001, $\eta 2$ = .13). However, the main effect of group on SAT showed no significant (F = 0.53, p < 0.37, $\eta 2$ = .005). Thus, the analysis of pairwise comparisons for the SAT by group and time revealed a significant mean difference between postSAT and preSAT mean scores for the experimental group (G1) F = 7.9, p < .001, *η2* =.071), no significant mean difference between postSAT and preSAT scores for the control group (G2) was found F = 4,68, p = .62, *η2* =.043. However, the preSAT mean score for G2 was significantly higher than that for G1 (F = 5.12, p <.05, *η2* =.047). No significant difference between the two groups' posttest mean scores for the SAT was found (F = 3.09, p = .173, *η2* =.029).

Table 3. Results of repeated measures of ANOVA and pairwise comparisons for the TAT

Source	*Sum of Squares*	*F*	*p-value*	*η 2*	*Observed power*
Time	485.96	62.04	.000***	.43	1
Group	59.73	2.79	.186	.001	.256
Time × Group	271.62	39.24	.000***	.19	1

Pairwise comparison between G1's and G2's entry level capability scores on SAT

Comparisons	*Mean difference*	*SE*	*p*	*95% confidence interval for difference*	
				Lower bond	*Upper bond*
PostSATexp – PreSATexp (G1)	8.11	0.62	.000***	4.62	7.87
PostSATctr – PreSATctr (G2)	5.25	0.37	.001**	2.81	4.63
PreSATexp– PreSATctr (G1-G2)	0.29	0.22	.214	-.53	1.31
PostSATexp –PostSATctr (G1-G2)	3.15	1.29	.001**	2.04	5.28

*exp=experimental group, ctr = control group pre=pretest, post = posttest (*p<.05, **p<.005, ***P<.001)*

As presented in **Table 3**, both the main effect of time on TAT scores (F = 62.04, p < .001, *η2* = .37) and the interaction effect between group and time were significant (F = 39.24, p < .001, *η2* = .28). There was, however, no significant main effect of group on TAT scores (F = 2.79, p = .186, *η2* = .003). Looking at **Table 3**, the pairwise comparisons by group and time for the TAT indicates the mean difference between postTAT and preTAT scores was significant for both G1 (F =3.39, p <.001, *η2* =.032) and for G2 (F = 4.61, p <.005, *η2* =.042). In addition, the mean difference between preTAT scores in G1 and G2 groups was not significant (F = 8.92, p =.214, *η2* =.079), however, the mean difference between the two groups' posttest mean scores for the postTAT was significant (F = 0.67, p < .005, *η2* =.006).

Table 4. Results of repeated measures of ANOVA and pairwise comparisons for the ISTST

Source	*Sum of Squares*	*F*	*p-value*	η 2	*Observed power*
Time	3937.36	47.03	.000***	.31	.97
Group	1091.47	18.59	.000***	.15	.86
Time × Group	673.22	24.08	.000***	.19	.97

Pairwise comparison between G1's and G2's entry level capability scores on SAT

Comparisons	*Mean difference*	*SE*	*p*	*95% confidence interval for difference*	
				Lower bond	*Upper bond*
PostSATexp – PreSATexp (G1)	2.81	0.74	.000***	1.24	2.66
PostSATctr – PreSATctr (G2)	0.84	0.32	.000***	0.72	3.41
PreSATexp– PreSATctr (G1-G2)	–0.51	0.41	.309	-1.28	0.06
PostSATexp –PostSATctr (G1-G2)	1.46	0.59	.000***	0.93	3.16

*exp=experimental group, ctr = control group pre=pretest, post = posttest (*p<.05, **p<.005, ***P<.001)*

Table 4 presents the results of repeated measures of ANOVA and pairwise comparisons for the Integrated Science, Technology and Society Test (ISTST) scores. The interaction effect between group and time (F = 24.08, p < .001, $\eta 2$ = .19) and the main effect of group on ISTST scores (F = 18.59, p < .001, $\eta 2$ = .15) as well as the main effect of time on ISTST scores were all significant (F = 47.03, p < .001, $\eta 2$ = .35). Also, the analysis of the pairwise comparisons for ISTST scores revealed significant mean difference between postISTST and preISTST scores for both G1 (F = 7.43, p <.001, $\eta 2$ =.067) and for G2 (F = 3.21, p <.001, $\eta 2$ =.03). Moreover, no significant mean difference between preISTST scores for both G1 and G2 groups (F = 11.03, p = .309, $\eta 2$ =.096). But the mean difference between the two groups' mean scores for the postISTST was significant (F = 6.96, p < .001, $\eta 2$ =.063).

Results presented in **Table 5** were derived from supplemental questionnaire in which the teachers selected, in rank order; the modes of traits that they felt were important reflection of themselves for entry level capability into the teaching profession. As a preference, teaching profession was by far the career choice of the majority of teachers, of which the experimental and control groups scored 8.4% and 65.3%, respectively.

Table 5. Traits among newly qualified science and technology teachers about teaching profession

Attributes of newly qualified teachers	*Positive attributes (%)*		*Negative attributes (%)*	
	G1 (exp)	**G2(ctr)**	**G1(exp)**	**G2(ctr)**
Teaching as career choice	8.4	65.3	72.4	23.7
Attitudes	33.2	54	42.3	31.3
Interest	41.5	60.2	31.4	-
Motivation	35.7	42.5	12.34	10.2
Zeal	46	44.2	-	-
Administration skills	30.6	38.6	42.9	43
STS concept program	40.1	58.4	60.3	33
Self-confidence (capability)	45.3	68.6	28.6	19.2

Results (**Table 5**) also indicate that most of these teachers are likely to grapple with demonstrating the level of administrative skills needed in carrying out their professional duties. The low percentage positive attributes (8.4 percent observed) shows that the experimental group (G1) would not prefer teaching profession as a career if alternative jobs are available. This was taken to indicate that between 72.4% of the experimental group and 23.7% of the control group are dissatisfied with teaching career (i.e. considered the profession as last resort), and may drop out of the teaching profession if desirable jobs become available. In this regard, the fluctuation of teachers' interests, attitudes, motivation, and administrative skills serve as possible indicators. Therefore, the expectation of requiring a teacher in the experimental group to make a long term commitment to the teaching profession at this stage cannot be guaranteed. A possible reason advanced for this is that large number of teachers forming the experimental group is entering the teaching profession due to lack of job opportunities in their first degrees and not as a result of passion for the profession.

E. Conclusion

The results of this study show there are potential benefits of using induction program to equip newly qualified science and technology teachers (NQSTTs). Analysis of data derived from SAT and TAT showed the participants (G1) instructed with TMA improved their entry level capability scores than their counterpart (G2) that were not exposed to such instruction. Results of the ISTST achievement showed a significant change in participants' performance for both groups. The differences in results in terms of their entry level capability scores may be due to various traits (**Table 5**). In almost all the lesson plans prepared by both groups (G1 and G2) during their micro-teaching practice, except for few, the lesson templates showed lack of embodied recognition of interconnectedness of science, technology and society. It was not clear in some cases what becomes deemed as scientific, technological and societal knowledge, and for whose interests are being served in the lessons.

The analysis of data derived from the micro-teaching practice revealed that 63.8% of the NQSTTs had a challenge with delivering comprehensive STS activities. This is because the criteria guiding their micro-teaching instructional practice involve decisions about what to include in the STS lesson activities, for whom, what to teach, how to teach, and improvisation among other things. In delivering the actual lessons, about one-third showed mismatch between STS concepts in that the teacher's own content preparation and field experiences were lacking. Besides, conventional teaching strategies also seem to reflect teaching practice adopted by majority of the experimental group despite being told to make use of innovative teaching and learning strategies. However, those who use creative and interactive design in their practical tasks showed great enthusiasm during the presentation of their work. After going through 10 -15 minutes presentation, and having gained coping strategies, they gained some confidence and become more optimistic about their capabilities. Findings such as these lend support to the Professional Qualifying Examination program into which newly qualified teachers can achieve entry level skills over a shorter period of time.

As reported in **Tables 1-4**, data derived from scores of achievement on science, technology, and society tests were consistent with studies that found a significant influence of STS constructs in Nigeria (Afuwape & Oriola, 2017; Ahmed et al., 2015; Umoren, 2007). The results indicate that the objectives of the PQE program in accordance with the Nigerian Teachers Registration Council are attainable, but more engagement is needed in the area of teachers' personality traits (**Table 5**) than was previously assumed about their academic performance. The need for such engagement is even more pressing considering the noticeable gaps, imbalances and sterile view that often arise when teachers begin to address STS issues in classroom (Marshall et al., 2017; Sunde & Ulvik, 2014). In general, there were other issues about motivation for all the NQSTTs. Results in **Table 5** showed they need to be motivated.

However, the challenge of motivating NQSTTs in this study is a subject of many issues ranging from teachers' working conditions, expectations, salary, poor remuneration, service benefits, and so on (Kola et al., 2017; Omorogbe & Ewansiha, 2013). Aside the latter issues, to better support NQSTTs for the future, Dias-Lacy and Guirguis

(2017), Holmqvist (2019), Petersen (2017), UNESCO and UNICEF (2013a) suggested that programmes must be put in place to help teachers to learn from practice how to address difficult problems of teaching and learning, as well as dispositions toward an open and searching mind and a sense of responsibility and commitment to learners' learning (Iwuanyanwu & Ogunniyi, 2018; Zeichner & Liston, 2013). Finally, the results of this study are parallel with many studies around the world that have revealed challenges newly qualified science and technology teachers faced in adapting to professional practices of delivering curricula activities to learners (Ahmed et al., 2015; Boakye & Ampiah, 2017; Kwaah & Palojoki, 2018; Mumba et al., 2019; Petersen, 2017). The findings of the current study add to the extant literature on using mentoring and/or induction programs to equip newly qualified teachers to survive their first years of teaching (Dias-Lacy & Guirguis, 2017; Moir, 2009; Sun, 2012).

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