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The impact of performance-based assessment strategies on pre-service teachers' self-efficacy and academic achievement in general physics

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ABSTRACT

A quasi-experimental research design was conducted to investigate the impact of performance-based assessment (PBA) on pre-service teachers' (PSTs) self-efficacy and academic achievement in general physics at Atebubu College of Education. The study was conducted on 144 primary education students in the second year who were assigned into experimental and control groups after conducting a pre-test. 72 students each were non-randomly assigned into the experimental and control group. Information on PSTs' self-efficacy was derived by administering pre-service teachers' self-efficacy scale whiles the academic achievement was determined by general physics achievement test. Statistical package for social sciences was used to analyze data to generate descriptive and inferential statistics. The self-efficacy of the experimental group and control group differed significantly after treatment. The experimental group had significantly higher post-test scores than the control group. This study identified PBA as a useful teaching strategy that improves PSTs' problem-solving abilities and boosts their confidence in studying general physics.

Keywords: performance based-assessment, pre-service teachers, self-efficacy, academic achievement

INTRODUCTION

Several attempts have been made to reform educational systems globally to improve the quality of teaching and learning for effective outcomes (Taale, 2012). Thus, successes at all levels of professions, work and social life is dependent on students' educational achievement (AlKhateeb, 2018). As a result of this, many classroom instructors, particularly in Africa, have employed varied teaching strategies including assessment to enhance learning and understanding of concepts (Taale, 2012). Assessment (traditional) is mainly used in Ghana for grading, selection, placement and promotion of students (Butakor & Ceasar, 2021). However, its usage in the enhancement of teaching and learning has been overlooked by many classroom instructors (Butakor & Ceasar, 2021). Performance-based assessment (PBA), therefore, surfaced not only to measure students' discrete knowledge but also to assess students on scientific reasoning (Abualrob & Al-Saadi, 2019). According to Abualrob and Al-Saadi (2019), PBA is a set of strategies that enable students to perform a realistic task by demonstrating proficiency based on certain predetermined criteria.

PBA and learning as cited in Berman (2008) hinges on John Dewey idea of learning, which states that 'learning by doing' is a way of connecting information and ideas in the brain. This means, pre-service teachers' (PSTs) involvement and interactions with instructional materials during the teaching and learning process prepare the brain for better learning (Oppong Frimpong, 2021). This idea also points to the fact that PBA provides deeper understanding and promotes knowledge application to new situations (Berman, 2008). PBA is also stemmed from social-constructivist theory, which indicates that assessment is intervened with all the procedures involved in teaching and learning (Heydarnejad et al., 2022). Social-constructivist believed that assessment should be designed in authentic tasks with student self-assessment and feedback (Yan et al., 2022). Thus, PBA revolves around sociocultural theory of Vygotsky's that indicates that social interaction is central to learning process (Heydarnejad et al., 2022). Hence, knowledge and skill acquisition can be properly developed through hands-on activity or learning by doing (Yavuz & Guzel, 2020).

PBA can therefore be defined as the evaluation of concrete and authentic tasks performed by students with their knowledge and skills. For example, students demonstrating a task, writing a report or presenting. PBA and learning allow students to demonstrate their knowledge and skills in a learning environment and embrace their higher-order of thinking skills, as well as relating it to real-world situations (Hollandsworth & Trujillo-Jenks, 2020). PBA measures both the process and the product of learning (Maier et al., 2020). The performance task consists of presentation of project finding, solving calculation problems,

demonstration, inquiry into issues and development of models (AlKhateeb, 2018). PBA reinforces students' learning effort and cultivates critical thinking abilities in them (Butakor & Ceasar, 2021). PBA equips students with problem solving skills (Espinosa, 2015) and also reveals strengths and weaknesses in instructional delivery (Taale, 2012).

Colleges of education's curriculum was reformed recently to produce professional teachers with requisite professional knowledge, skills and attitude needed to make them useful in today's complex classroom settings (Yeboah & Siaw, 2020). PSTs (primary education) of the colleges of education, have since had the opportunity to undertake general physics course, which is tagged by many PSTs as abstract course (Taibu & Ferrari-Bridgers, 2020). PSTs claim might have been resulted from how the course is handled by classroom instructors, leading to their poor performance in the subject (Yeboah & Siaw, 2020). This therefore calls for an intervention strategy-the use of PBA to reinforce PSTs to learn general physics concepts and do away with their misconceptions. Even though similar work of this sort has been made in physics at tertiary level in Ghana (Taale, 2012), the study ignored an assessment use as a teaching strategy and the individuals psychological drive (self-efficacy) that reinforces students to perform more challenging tasks. Although instructors' efforts in learners' success in education systems is very important, the individual's self-efficacy is very paramount in driving behaviours and personal goals acquisition (AlKhateeb, 2018).

Self-efficacy is an individual's motivational beliefs that stimulate him/her to embark on difficult and more challenging tasks (Fitriyana et al., 2021). Learners' self-efficacy is generally associated with confidence (C) or beliefs in an individual's capabilities to organize and embark on tasks to achieve results (Ngman-Wara, 2012). Self-efficacy is an indicator of someone's ability to embark on an action or activity expected of him (Siaw et al., 2022). Thus, the level of PST's self-efficacy urges or impedes him to perform a task (Alt, 2014; Rafiola et al., 2020). Students' self-efficacy determines the effort injected into a task or activity to achieve a result (Bandura, 2001). The belief of oneself influences his decision on a particular task (Rafiola et al., 2020). Students' self-efficacy beliefs influence their achievement directly and indirectly (Pajares & Schunk, 2001). According to Bandura (1997), as cited in Bartimote-Aufflick et al. (2016), self-efficacy beliefs originate from four main sources: performance accomplishments, vicarious experiences, social persuasion, and physiological reactions. Students' success and failure experience is rooted on performance accomplishments (Bartimote-Aufflick et al., 2016). Thus, success experiences lead to an increase in efficacy expectations whereas failure experiences lead to a decrease in efficacy expectations. Individual self-efficacy stems from efforts exerted in a particular activity and associated perseverance to face and overcome any impediment in the teaching and learning situation (AlKhateeb, 2018). Thus, the greater the students' self-efficacy, the greater the energy impute on a confronted task and the higher the outcome (Suryadi & Santoso, 2017). A PSTs' mastery of physics task is largely dependent on a belief in his personal abilities to do so based on his past experience (Freiberger et al., 2012).

Many studies have revealed that performance-based impact positively on students' self-efficacy and academic achievement (AlKhateeb, 2018; de Fátima Goulão, 2014; Etherton et al., 2022; Tenaw, 2013). However, some studies have identified additional factors that contribute to academic performance of students. Bandura (2001) found self-efficacy beliefs together with students' academic, social, and self-regulatory learning as the main predictors to students' scholastic achievements.

This study was aimed at using the PBA strategy to enhance PSTs' self-efficacy and performance in general physics. It is expected that this study will bring to fore the importance of diversifying assessment strategies in the teaching and learning process (AlKhateeb, 2018). The assessment strategy adopted will arouse and sustain individual students' interest in the lesson and boost their confidence in general physics and other related courses. The findings of this study will also help classroom instructors and other key stakeholders of education to find appropriate strategies that develop students' potentials, abilities, skills, and creativity.

Statement of the Problem

Many educational researchers in the world advocate for curriculum that fosters student's creativity, critical thinking, problem solving and above all collaborative-based behavioural performance. However, most science teachers and other educationist in Ghana, hold firmly to only one side of assessment strategy that measures only students' discrete knowledge (for grading, selection, placement, and promotion of students) and ignore its use as a teaching strategy regardless of its numerous benefits in the teaching and learning (Butakor & Ceasar, 2021). This approach lowers students' critical thinking and problem-solving abilities, making the course (general physics) difficult and more challenging (Taibu & Ferrari-Bridgers, 2020). The traditional mode of assessment used by many physics instructors only encourages student's memorization without any proper understanding (Arhin, 2015). It is worth noting that PBA does not only measure the product of learning but also assesses the processes of teaching and learning (Maier et al., 2020). Therefore, adopting a PBA that promotes understanding, critical thinking, problem-solving, and boost confidence in PSTs will contribute significantly to improving educational systems in the country.

Purpose of the Study

The purpose of the study was to determine the effect of PBA on

(a) PSTs' self-efficacy and

(b) PSTs' academic achievement in general physics.

Significance of the Study

The findings of the study will highlight the need to diversify assessment strategies in the teaching and learning process. The intrinsic motivation in the assessment strategy adopted will arouse and sustain individual students' interest in a lesson and enhance their confidence in general physics and other related courses. It is expected that the outcome of this study will help classroom instructors and other key stakeholders of education to find appropriate strategies that develop students' potentials, abilities, skills, and creativity. This study will lead to improved learning by engaging students in meaningful activities that are

Table 1. Demographic characteristics of the participants in terms of age & gender

Item	Experimental group		Control group	
	n	%	n	%
Age				
20	7	9.7	6	8.3
21	6	8.3	8	11.1
22	7	9.7	9	12.5
23	21	29.2	19	26.4
24	16	22.2	14	19.4
25	12	16.7	13	18.1
26	2	2.8	1	1.4
27	1	1.4	2	2.8
Gender				
Male	38	53.4	40	55.6
Female	34	46.6	32	44.4

Table 2. Cross-sectional representation of the research design

Group	Pre-test	Independent variable	Post-test
Experimental	Y_1	X	Y_2
Control	Y_1	-	Y_2

intrinsically motivating. The involvement of teachers in the development of performance assessments and scoring rubrics, as well as in the scoring of student performances and keep teachers in discussion of what should be valued in the curriculum.

Research Questions

The following research questions were formulated to guide the study:

1. To what extent would PBA improve PSTs' self-efficacy?
2. What impact do PBA strategies have on PSTs' performance in general physics?

METHODOLOGY

Primary education PSTs of Atebubu College of Education constituted the participants of the study. PSTs were non-randomly assigned into two groups, experimental group and control group after a pre-test.

Participants

Level 200 PSTs pursuing primary education program at Atebubu College of Education were used in the study. A total of 144 PSTs participated in the study. 72 participants each were non-randomly allocated into two groups-experimental and control groups. Demographic characteristics of the participants of this study on age and gender are summarized in **Table 1**. The ages of 144 participants of this study ranged from 20 to 27 (**Table 1**). The bulk of the participants of the experimental group and the control group were found in ages 23 to 25 at 68.1% and 63.9%, respectively (**Table 1**). The experimental group consisted of 38 males and 34 females whereas the control group were constituted by 40 males and 32 females (**Table 1**).

Research Design

This study adopted a quasi-experimental nonrandomized group using a pre-/post-test design. The research design was adopted in this study because in the college setting random assignment is very difficult. Thus, the researchers used intact classrooms as experimental and control groups. The cross-sectional representation of the research design as described in Arhin (2015) is shown in **Table 2**. Prior to administering the treatment, a pre-test was administered to both groups to ascertain the group equivalence on dependent variable. The span of the experiment lasted for 10 weeks. The treatment was divided into three phases: pre-treatment stage, treatment stage, and post-treatment stage.

Research Instruments

The students' self-efficacy was assessed on pre-service teachers' self-efficacy scale (PTSES). PTSES is a Likert-type scale consisting of 10 items as used in Fitriyana et al. (2021). PTSES designed consisted of four point-Likert scales-no confidence (NC), somewhat confidence (SC), confidence ©, and very confidence (VC) corresponding to one, two, three, and four points, respectively for all positive statements. General physics achievement test (GPAT) was used in both pre- and post-test to ascertain students' achievement in general physics before and after treatment respectively. GPAT consisted of 40 open ended questions, multiple-choice questions, matching and fill in blank spaces questions, screened by expect tutors from science department of the college. Cronbach's alpha value of PTSES reliability was found to be 0.79.

Instructional Procedure

At the pre-treatment stage, the level of PSTs' self-efficacy of both the experimental and control groups were assessed using PTSES. The pre-test was used to ascertain the group equivalence on the dependent variable before treatment on general physics

Table 3. Semester modules

Module	Topic
1	Scientific units and measurements
2	Density and relative density
3	Density and relative density
4	Forces
5	Machines
6	Basic electronics
7	Optics
8	Optics
9	Electricity
10	Magnetism

Table 4. Normality test for pre-service teachers' efficacy data

Stage	Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre-treatment	Experimental	0.114	72	0.021	0.966	72	0.050
	Control	0.108	72	0.036	0.974	72	0.140
Post-treatment	Experimental	0.108	72	0.037	0.979	72	0.274
	Control	0.138	72	0.002	0.935	72	0.001

concepts using GPAT. GPAT consisted of 40 open ended questions, multiple-choice questions, matching and fill in blank spaces questions.

The treatment commenced, having obtained a statistical similarity in the means of the experimental and control groups in the pre-test. At this stage, the experimental group was taken through performance tasks in general physics in each lesson, prepared from general physics course outline. The control group was also taken through different form of treatment (placebo) from that of the experimental group in terms of the mode of assessment during the period of treatment. The performance task of the experimental group consisted of presentation of project finding, solving calculation problems, demonstration, inquiry into issues and development of models as described in the study conducted by AlKhateeb (2018). The control group's tasks were the activities found in the course book. The performance tasks were presented in the form of 10 minutes of class training after providing them with the required knowledge in each lesson. Students' rubrics were then distributed to the class to perform the task. Feedback and evaluation of students' responses were thereafter made before the closure of each lesson. Both the experimental and the control groups undertook the same semester modules every week (**Table 3**).

Each module includes two lecture periods every week, consisting of two contact hours each, and one laboratory session of three contact hours. Throughout the 10 weeks treatment, PSTs' self-efficacy was also taken care of during the task performance. After the treatment stage, PSTs' self-efficacy of both the experimental and control groups were assessed using PTSES. A post-test was also conducted on both the experimental and the control group, using the same questions (GPAT) used in the pre-test but arranged in different order.

Data Collection Procedure

PSTs' self-efficacy before and after treatment was assessed on PTSES administered through Google Forms. Data on pre-service achievement in general physics was obtained from pre- and post-test conducted for both experimental and control groups using GPAT.

Data Analysis

Responses obtained in PTSES, and scores obtained in the pre- and post-test constituted the data of the study. Statistical package for social sciences (SPSS) statistical program (version 20) was used to analyze data to generate descriptive statistics and inferential statistics on self-efficacy data and pre-/post-test scores. Prior to the analysis of the self-efficacy and pre-/post-test data, a Kolmogorov-Smirnov test was conducted to assess the normality of the data. Kolmogorov-Smirnov test was used since the sample size was above 50. Paired sample t-test was used in the inferential analysis of the self-efficacy data and pre-test scores whereas Mann-Whitney U test was used to analyze the post-test scores.

RESULTS AND DISCUSSION

Test for Normality

Normality test was conducted on PSTs' self-efficacy and pre-/post-test data with Kolmogorov-Smirnov test. This was done to evaluate the distribution of the data. The summary of the results obtained was recorded (**Table 4** and **Table 5**). As shown in **Table 4**, both the experimental and control groups recorded a lower level of significance in PSTs' self-efficacy before and after treatment than the alpha level (0.05) in Kolmogorov-Smirnov test. Thus, self-efficacy data obtained by the experimental and control groups before and after treatment was normally distributed (parametric).

Table 5. Normality test for pre- & post-test scores

Stage	Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	Experimental	0.104	72	0. 049	0. 953	72	0.009
	Control	0. 131	72	0. 004*	0. 944	72	0.003
Post-test	Experimental	0.137	72	0.002	0.974	72	0.136
	Control	0.091	72	0.200*	0.979	72	0.270

Table 6. Pre-service teachers self-efficacy before treatment

Items	Experimental group		Control group	
	M	SD	M	SD
Participating in physics practical activities	2.26	0.62	2.22	0. 72
Contributing to discussions during instructional hours	2.31	0.96	2.11	0. 76
Studying physics concepts at leisure hours	2.22	0.69	2.19	0. 83
Solving calculation questions in physics	2.12	0.91	2.13	0. 84
Obtaining good grade in physics examination	2.28	0.77	2.33	0. 73
Assisting colleagues to solve problems in physics	2.10	0.79	2.14	0. 76
Ability to learn physics concepts without assistance	2.26	0.82	2.25	0. 71
Applying concepts in physics in other field of study	2.35	0.75	2.24	0.88
Ability to pursue physics to the highest level	2.31	0.86	2.24	0. 81
Applying knowledge and skill acquired in physics to solve problems in daily life	2.28	0.89	2.31	0. 85
Overall mean	2.25	0.08	2.22	0.07

Note. M: mean & SD: Standard deviation

Table 7. Pre-service teachers self-efficacy after treatment

Items	Experimental group		Control group	
	M	SD	M	SD
Participating in physics practical activities	2.89	0.70	2.51	0.69
Contributing to discussions during instructional hours	2.88	0.74	2.42	0.62
Studying physics concepts at leisure hours	2.74	0.85	2.44	0.67
Solving calculation questions in physics	2.74	0.80	2.46	0.65
Obtaining good grade in physics examination	2.71	0.67	2.42	0.71
Assisting colleagues to solve problems in physics	2.71	0.69	2.56	0.67
Ability to learn physics concepts without assistance	2.66	0.79	2.44	0.77
Applying concepts in physics in other field of study	2.73	0.71	2.51	0.82
Ability to pursue physics to the highest level	2.84	0.85	2.53	0.80
Applying knowledge and skill acquired in physics to solve problems in daily life	2.64	0.81	2.56	0.76
Overall mean	2.75	0.87	2.48	0.55

Note. M: mean & SD: Standard deviation

Kolmogorov-Smirnov test for the pre-test scores of both the experimental and control groups yielded a significant level lower than the alpha level (0.05) (**Table 5**). Hence, the data distribution was normal (parametric). However, the control group had a significant level greater than that of the alpha level (0.05) in Kolmogorov-Smirnov test of normality (**Table 5**). The data distribution was therefore non-parametric.

Research question 1: To what extent would PBA improve PSTs' self-efficacy?

PSTs' self-efficacy in learning general physics before and after treatment was determined by gathering respondents' data via Google forms. The rating scale used were 1 (NC), 2 (SC), 3 (C), and 4 (VC). The benchmark value (2.5) was obtained by determining the average of the sub-scales (1, 2, 3, and 4). The benchmark value (2.5) indicates the average self-efficacy of PSTs. The summary of PSTs-self-efficacy results computed is found in **Table 6** and **Table 7**.

PSTs' overall self-efficacy mean score for both the experimental (mean [M]=2.25, standard deviation [SD]=0.08) and control groups (M=2.22, SD=0.07) were both below the benchmark value (2.5) set for the study. The mean score of the experimental and control groups lower than the benchmark value (2.5) indicated that PSTs' self-efficacy in learning physics before treatment was below average. Paired sample t-test results on pre-service self-efficacy before treatment showed no significant difference between the mean scores of the experimental and control groups, t(71)=0.69, p=0.545. This result corresponds favorably with the findings reported by Mahasneh and Alwan (2018). The statistical similarity in the overall self-efficacy means of the experimental and control group indicated that both groups were equivalent on dependent variable.

The overall self-efficacy mean score of the experimental group (M=2.75, SD=0.87) was above benchmark value (2.5) and that of the control group counterpart (M=2.48, SD=0.55) was below the benchmark value (2.5) after treatment (**Table 8**). This result showed that the mean self-efficacy of the experimental group was above average after treatment while the control group counterpart was below average. However, the mean self-efficacy scores of the experimental group was statistically higher than that of the control group after treatment, t(71)=5.46, p=0.000 (**Table 8**). This result is consistent with that reported in a similar study (Manowaluilou & Reeve, 2022).

Table 8. Descriptive & inferential statistics of pre-service teachers' self-efficacy

Test	Groups	n	Mean	Standard deviation	df	t	p-value
Pre- treatment	Experimental	72	2.25	0.33	71	0.69	0.545
	Control	72	2.22	0.36			
Post- treatment	Experimental	72	2.76	0.29	71	5.46	0.000
	Control	72	2.48	0.26			

Table 9. Descriptive & inferential statistics of pre-test scores

Group	Mean	n	Standard deviation	df	t-value	p-value
Experimental	17.43	72	4.92	71	1.40	0.17
Control	17.10	72	4.76			

Table 10. Mann-Whitney U test of experimental & control post-test scores

Groups	n	Mean	Standard deviation	Mean rank	Sum of ranks	Median
Experimental	72	30.08	4.96	89.69	6,458.00	31.00
Control	72	25.90	3.91	33.31	3,982.00	25.50

Note. Mann-Whitney U=135.000; Wilcoxon W=3,982.000; Z=-4.958; & Asymptotic sig. (2-tailed)=0.000

The elevated self-efficacy of the experimental group was as a result of the interventional strategy used (PBA) (Ali, 2021). Similar studies have shown that that PSTs with high self-efficacy performed extremely well, and this enhances their self-regulation, self-development, and self-adjustment in order to appropriately handle challenges (Kazempour & Sadler, 2015; Manowaluilou & Reeve, 2022). High confidence in participating in instructional activities, their willingness to study physics in the absence of any assistance and solving confronted problems with knowledge and skills acquired was as a result of the enhanced self-efficacy.

Research question 2: What impact does PBA strategies have on PSTs' performance in general physics?

The descriptive and inferential statistics of the pre-test score were computed and the result is summarized in **Table 9**. Paired sample t-test results indicated that there was no significant difference between the experimental group (M=17.43, SD=4.92) and control group (M=17.10, SD=4.76), t(71)=1.4, p=0.170 (**Table 9**).

Comparison of the means of the experimental and control group post-test scores was not possible due to non-normality of the data. Mann-Whitney U test was therefore carried out to evaluate the statistical difference between the medians of the experimental and control group and the result obtained was recorded (**Table 10**).

Results in **Table 10** showed that the experimental group has a larger mean rank (89.69) than the control group counterpart with mean rank (33.31). However, a statistically significant difference was found in the experimental (median=31.00) and control group (median=25.50), U=135.000, Z=-4.958, p=0.000. This result is consistent with similar studies (AlKhateeb, 2018; Arhin, 2015; Hussein &Tawfik, 2016; Mahasneh & Alwan, 2018).

The statistical difference between the experimental and control groups might have resulted from the interventions (PBA) used. This was expected due to the fact that PBA enhances PSTs' thinking ability and skills for problem-solving and increases their strength and personal efficacy (AlKhateeb, 2018; Espinosa, 2015). Additionally, PBA promotes students' participation in the development of evaluation criteria and responsibility for demonstrating learning due to elevated personal efficacy. PBA also encourages seriousness of performance and progress, attention to teacher or student feedback, figuring out students' mistakes, critique of students' performance and feedback about it (AlKhateeb, 2018). Above all, PBA offers students the opportunity to use their skills and knowledge to perform authentic and realistic tasks that is based on certain predetermined criteria (Abualrob & Al-Saadi, 2019).

CONCLUSIONS

PBA strategy used in the teaching and learning process in general physics yielded a positive change in the experimental group by increasing their self-efficacy and performance than the control group counterpart who were only taken through course book activities and traditional testing systems. PSTs' self-efficacy determines the effort injected into a task or activity, thus impact on result. The changes in the performance of PSTs in general physics did not automatically occur, even with diligent effort of the classroom instructors and the commitment put up by the team of researchers. The enhanced performance of PSTs in this study, however, confirms our belief that student can develop conceptual understandings when exposed to rich and more challenging problems and offered the opportunity to learn.

Hence, incorporating the use of PBA into the teaching and learning process of general physics at the colleges of education will equip PSTs with problem solving abilities and promote conceptual understanding and assimilation. It is a fact that PBA governed by instructional goals elicits instructional changes. The assessment strategy also provides valuable feedback to students. The results of the study have implications on classroom instructors and PSTs by building their self-efficacy and improving their competencies and skills to solve any confronted problem.

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