

First Year University Physics Students Self Efficacy Measurement: To What Extent Are The Responses Affected By Gender.

Abstract

In an achievement context, self-efficacy involves students' confidence in their cognitive skills to learn and perform the academic course work. Unless students believe that their actions will have the desired consequences, they have little incentive to engage in those actions. How far will an interest in electrical engineering take a student who feels hopeless in physics? Whatever factors operate to influence behaviour, they are rooted in the core belief that one has the capability to accomplish that behaviour. Self-efficacy has not received much attention in tertiary physics in Nigeria. This study adapted and validated (using EFA and CFA) a short Physics Self-Efficacy Questionnaire before administering it to three hundred and seven (307) first-year General Physics I students at the Federal University Wukari (*male* = 157 and *female* = 150). Females reported lower self-efficacy than males. The finding revealed that there is a significant difference in Physics self efficacy as reported by male and female ($t = 7.7711$, $df = 305$, $p = 0.0001$, 2 tailed). The effect size is large ($d = 0.888$). This study posited that gender is a factor to consider when studying physics self-efficacy, which may have far reaching effect on the study of self-efficacy itself, and the way tertiary physics is taught.

Introduction

Effort has been on going in the disciplines of science, technology, engineering, and mathematics (STEM), to enhance the participation and advancement of marginalized groups such as female. Different studies have shown that individuals' course enrollment, degree attainment, and achievement in STEM can be influenced by fields specific motivational factors such as self-efficacy, interest, and identity (Hazari, Tai, and Sadler (2007); Marshman, Kalender, Schunn, Nokes-Malach, and Singh (2018)). These motivational variables, for students from disadvantaged groups might be impacted through negative societal stereotypes, biases about who belongs and can excel in STEM, as well as a lack of role models, which can lead to withdrawal from STEM courses, or careers. Hence, investigating motivational factors is critical to understanding and addressing diversity, equity, and inclusion issues in STEM disciplines.

Prior researches highlighted the value self-efficacy and motivation as key factors to the success of students (Choi, 2005; Pajares & Schunk, 2001). The notion that physics is a difficult and uninteresting subject is very common among the undergraduate students of universities in Nigeria. To understand the origin of this notion, it is very important to understand some of the student's affective characteristics. The most striking one is students self efficacy, which is a measure of a person's belief that he or she can perform a certain task, physics in this study. Generally, Self-efficacy refers to person's beliefs about his/her capabilities to produce certain levels of performance that exercise influence over events that affect their lives (Bandura, 1994).

Self-efficacy has generated research in areas as diverse as medicine, athletics, media studies, business, social and political change, psychology, psychiatry, and education. In psychology, it has been the focus of studies on clinical problems such as phobias, depression, social skills, assertiveness, smoking behaviour, and moral development. Self-efficacy has been especially prominent in studies of educational constructs such as academic achievement, attributions of success and failure, goal setting, social comparisons, memory, problem solving, career development, and teaching and teacher education. Self efficacy has been found to be a good

predictor of student's academic achievement (Cavallo, Rozman & Potter, 2004; Pajares, 2002), and choice of academic major and career (Hackett, 1995). Levels of self efficacy widen from task specific self efficacy (personal belief in ability to perform uncertainty calculations within a physics course) (Choi, 2005), through general academic self efficacy, to global life skill. Four sources of self efficacy have been identified, and it includes mastery experience, vicarious experience, verbal (or social) persuasion, and physiological and affective states. The situations in which students master a task, which in return influences their belief in their capability to achieve their potential is referred to as mastery experience (McInerney & McInerney, 2002; Palmer, 2006). Such task in physics could be solving a problem or understanding a new concept which leads to solving a more difficult problem or understanding how concepts are linked. The judgement of one's personal abilities through the achievement of others, that is, when a student observes a peer of similar ability mastering a task and this reinforces his or her belief to perform the same task is called Vicarious experience (Zeldin, Britner & Pajares, 2008). When a student received a positive appraisal based on his or her actual performance or achievement emphasizing he or she is making progress, such a report from significant others (teacher, family members or peer) is referred to as Verbal or Social persuasion (McInerney & McInerney, 2002; Palmer, 2006). Such appraisal can boost student's self-belief in personal achievement potential. The last source of self-efficacy is physiological and affective states of the student such as stress and irrational devaluating personal convictions. The manner in which these four sources of self-efficacy interact to produce an overall self-efficacy belief varies between individuals as well as between different domains (Bandura, 1997).

Students show fairly stable self efficacy in subjects with which they are familiar and have firm beliefs about achievement capabilities (Cervone & Palmer, 1990). Research has shown that it is rare for students to keep an impracticable self-efficacy in the face of repeated failure (Cantor & Kilhstrom, 1987). Under such condition of poor achievement, the correlation between self-efficacy and achievement is reduced. For students that are beginner in a subject area, it is implausible to expect them to have formed stable self-efficacy beliefs related to that subject. So, a novice student's belief in their potential to achieve is likely to be tentative (Cervone & Palmer, 1990). However, researches have shown that initial self-efficacy can be startlingly defiant to change, even in the face of clear failure (Lepper, Ross & Lau, 1986). Evidence in Cervone and Palmer (1990) showed that students require many rounds of feedback before a stable and well-calibrated self-efficacy is established. It is noteworthy to know that measures of self-efficacy depend on when they are made.

One construct that could cause temporal variations in an individual's self-efficacy is 'test anxiety'. Researches have shown that students are very anxious over higher stake tests, such as end of Unified Tertiary Matriculation Examination and end of semester examination (Zoller & Ben-Chaim, 1989). Ruthig, Perry, Hall and Hladkyj (2004) posited that test anxiety is inversely related to self-efficacy, a finding more recently confirmed by Fagbenro (2022). Reports have shown that female reports lower self-efficacy in science subjects than males (Pajares, 2002), even in physics (Cavallo et al., 2004; Fagbenro, 2022). As reported by Pajares (2002), the difference surfaces in middle to late primary school but the literature do not agree on the causes of such gender differences (Dalgety & Coll, 2006). Pajare (2002) also discovered that gender differences in self-efficacy disappeared when previous academic achievement is controlled for. The evidence from Cervone and Palmer (1990) showed that males reported a statistically significantly higher self-efficacy than females in the absence of prior knowledge. Findings from Zeldin et al., (2008) and Zeldin & Pajares (2000) showed that mastery experience appeared as the major source of self efficacy for males while vicarious experiences and verbal and social persuasion, the most important sources for women. It is of

noteworthy to know that gender difference is suggested to occur in students' physiological and affective states, with emphasis on test anxiety. This gender differences was considered in Pajares (2002) in terms of males and females operating with different 'metrics' when self-reporting both test anxiety and self-efficacy.

Alot of studies have been carried out on undergraduate physics students' attitudes and beliefs (Gire & Jones, 2009; Gray, Adams, Wieman & Perkins, 2008; Otero & Gray, 2008), but few researches have been conducted on self-efficacy in tertiary physics education (Dalgety & Coll, 2006; Fencel & Scheel, 2005; Shaw, 2004). Fencel and Scheel(2004; 2005) investigated the effect of traditional and non- traditional teaching environments on students' self-efficacy. The finding revealed that collaborative learning produced the greatest impact on students self efficacy. Self-efficacy was found to correlate with expected students' grades ($r = 0.57, p < 0.001, N = 218$) (Fencel & Scheel, 2005). Shaw (2004) report from the investigation of first year undergraduate students' self-efficacies showed that there is gender difference in the first year undergraduate students' self-efficacies. Christine and Manjula (2011) affirmed that self efficacy instruments provide better measures if they are aligned with the subject of study, thus confirming the position of Choi(2005). So, this study has as its thrust measurement of first year undergraduate physics tertiary self-efficacy, which until now has not receive the needed attention from Nigeria academic environment.

The aim of this study was to develop and evaluate a short, one-factor instrument for measurement of undergraduate physic students' self-efficacy and to investigate physics self-efficacy of males and females first year undergraduate students.

Methodology

The existing items and scales were surveyed. Five items were chosen from Christine and Manjula (2011) and three items was written based on general perception of all items perused. Three physics education experts critiqued the items and minor changes were made upon their feedback. The questionnaire was pilot tested with 215 first year physics students in 2019. Principal components analysis was carried out to check the validity and reliability of the questionnaire. The questionnaire was completed by 279 first year physics students in 2020. A confirmatory factor analysis was carried out to check the validity and reliability of the questionnaire. The exploratory factor analysis provided a consistent factor structure. The questionnaire was administered to different groups of first year physics students in 2021, to find out the effect of gender on the responses.

The Physics Self efficacy Scale

The Christine and Manjula (2011) self efficacy scale was chosen to form the basis of the Physics Self-Efficacy Questionnaire. This short scale is established, the items are appropriate to Nigeria teaching and learning context, and it had consistently yielded satisfactory internal consistencies across several research projects as measured by Chronbach's alpha between 0.75 and 0.90. All of the items in the scale were scrutinised for adaptability and appropriateness of use in our specific situation and the local teaching and learning context. Five items were chosen and three added. For each item students were asked to indicate on a five-point Likert scale of not at all true of me (1), slightly true of me (2), neutral (3), true of me (4), or very true of me (5). With a total of eight items, the draft questionnaire was short, as intended

Validation

The eight proposed items were given to three experienced physics education experts, one of whom is also an expert in measurement and evaluation. They were asked to comment on the

validity of the items. The experts were satisfied with the items suggesting only minor changes, which were incorporated in the final version of the questionnaire (logical validity index of 0.87). The items are shown in table 1.

Table 1: Physics self efficacy items and Factor loadings

S/N	Physics self efficacy items	Factor loadings
1	I usually help my classmates when they ask for help in Physics	0.788
2	When I came across a tough Physics question, I worked at it until I solved it.	0.782
3	I generally manage to solve difficult Physics problems if I try hard enough	0.799
4	I usually didn't worry about my ability to solve Physics problems	0.710
5	I will remain calm in my Physics exam because I know I will have the knowledge to solve the problems	0.723
6	I know I can pass the Physics exam if I put in enough work during the term	0.708
7	The motto 'If other people can, I can too' applies to me when it comes to Physics	0.712
8	Listening to the instructor and other students in question-and-answer sessions made me think that I could not understand Physics.	0.697

The pilot testing

The questionnaire was administered in-class to first year physics students at the end of the first semester in 2019. Two hundred and fifteen students (215) completed the questionnaire. The items in the questionnaires were scored as follows: 5= very true of me, 4= true of me, 2 = slightly true of me and 1 = not at all true of me. The data were analysed by principal components analysis, using the Statistical Package for the Social Sciences (SPSS) version 15.0. With only eight statements in the questionnaire, the sample size was satisfactory and analysis of the data found it suitable for exploratory factor analysis. The condition for factor extraction was based on a combination of Kaiser's criterion of eigenvalue > 1 and an investigation of the Screen plot, both of which clearly indicated one factor only. Since there was only one factor, factor rotation did not apply. The eight items had factor loadings in the range 0.697 to 0.799, confirming the intended factor structure (at least four factor loadings over 0.6) (Field, 2000). The factor explained 68% of the variance (values over 50% are acceptable according to Streiner (1994)), and evidence for the reliability of the questionnaire was provided by a Cronbach's of 0.787.

Confirmatory trial

The questionnaire was administered to a fresh first year physics in 2020. The same procedures were carried out as in the previous year. Two hundred and seventy nine students (279) completed the questionnaire, a return rate of 100%. A confirmatory factor analysis provided evidence for the construct's validity; $\chi^2 = 2.116$, $p = 0.820$ ($p > 0.05$). Main fit indices also showed a very good model fit (Kline, 2005): RMSEA = 0.000 (< 0.05) with a 90% confidence interval of [0.000, 0.041]; RMR = 0.089 (< 0.05); GFI = 0.969 (> 0.95); NFI = 0.985 (> 0.95); and CFI = 1.000 (> 0.95).

No anomalies in the factor structure were found between either gender or times of administration.

The Sample

The first year physics classes at the Federal University Wukari were sampled in first semester, 2021. The General Physics I class is for students with three years of senior secondary school physics background and covers mechanics, waves, and thermal physics. Each semester has 13 teaching weeks and one revision week followed by two examination weeks. During each teaching week students attend two hour lectures, one one-hour tutorial. The summative assessment is through test and assignments, together with a final examination held during the examination weeks. Three hundred and seven students completed the questionnaire, a return rate of 100%

Data Collection

The self-efficacy questionnaire was administered in weeks 9 to three hundred and seven students (307). The administrations took place in lectures halls. The eight self-efficacy items were part of a page questionnaire, with information about the purpose of the research and the privacy protocols. The return rates were 100%. Informed consent was obtained from students.

Analysis and results

In other words, students' responses to each item were coded as follows: 5= very true of me, 4= true of me, 2 = slightly true of me and 1 = not at all true of me.

Result and Discussion

To answer this research question, to what extent are the responses of the students affected by gender. The descriptive statistics and t-test were used.

Table 2: Comparison of male and public female students' Physics Self - efficacy

	Sex	N	Mean	Std. Deviatn	Std. Mean	E. t	df	Sig. (2-tails)
Physics Self Efficacy	Male	157	34.9248	3.26024	0.26019	7.7711	305	0.0001
	Female	150	32.1667	2.94134	0.24015			

As indicated in table 2, the male students showed more confidence in their ability to do well in Physics (mean = 34.9248) compared to their female counterpart (mean = 32.1667). The mean difference between male and female students was 2.76. The independent t-test showed that the difference between male and female students' confidence in their ability to do well in Physics is significant ($t = 7.7711$, $df = 305$, $p = 0.0001$, 2 tailed). So, there is a significant difference between male and female students Physics self efficacy responses.

This result is in agreement with Cwik and Singh(2022); Li and Singh(2021); Whitcomb, Kalender, Nokes-Malach, Schunn, and Singh(2020); Marshman, Yasemin Kalender, Nokes-Malach, Schunn, and Singh(2018); Williams and George-Jackson (2014) that reported a lower level of self-efficacy for female students compared to their male peers in physics.

Conclusion

It is advised that physics lecturers can provide help based on students' current level of knowledge rather than making students feel micromanaged and underestimated. Also, when

helping students, instead of working out very detailed solutions for them, the lecturers could provide hints or prompts to stimulate students' thinking and encourage them to jointly construct the solution with them, which has the potential to not only enhance the effectiveness of learning but also provide students with a greater sense of accomplishment.

Physics lecturers should communicate their expectations with students and express their belief about all students' ability to achieve the expectations by working hard and working smart as well as taking advantage of all of the resources. It should be noted that having a high expectation of students does not mean instructors should assume that students know everything and will not have difficulties. On the contrary, physics lecturers should recognize students' difficulties and also help students understand that difficulties are normal and are opportunities to improve rather than a sign of lack of ability.

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