UNDERGRADUATE PHYSICS SELF-EFFICACY MEASUREMENT AND GENDER INFLUENCE

Abstract
Using achievement framework, self-efficacy has to do withstudents' conviction in their cognitive skills to learn and carry out the academic course work. Except students are convinced that their effort will yield the desired consequences, there is little or no enticement to engage in those actions. Can a student that feels hopeless in physics sustain his or her interest in Electrical Engineering? Human behaviour is influenced by factors that are embedded in the core belief that he/she has the capability to accomplish that behaviour. Little attention has been given to Self-efficacy 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 considerin the study of physics self-efficacy, and this may have far reaching effect on research on self-efficacy, andon teaching and learning of tertiary physics.

Keywords: Self – efficacy in Physics, Confirmatory Factor Analysis, Exploratory Factor Analysis, Gender, First Year Undergraduate Students

Introduction

Effort is on going in the fields of science, technology, engineering, and mathematics (STEM), to improve the involvement and progression of marginalized groups such as female.Different researches have shownthatfield specific motivational factors such as self-efficacy, interest, and identity can shape individuals' achievement in STEM, degree attainment andcourse enrolment (Hazari, Tai, & Sadler 2007; Marshman, Kalender, Schunn, Nokes-Malach & Singh 2018). These motivational variables, for students from disadvantaged groups might be impacted through biases about who belongs and can excel in STEM, lack of role models, as well as negative societal stereotypes that can lead to withdrawal from STEM careers, or courses. Consequently, understanding, tackling and addressing equity, inclusion and diversity issues in STEM disciplines required investigating motivational factors.
Prior researches highlighted the value of 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 studentsself efficacy, which is a measure of individual's conviction that he or she can carry out a certain task, physics in this study. Generally, Self-efficacy has to do with individual's beliefs about his/her competences to achieve certain levels of performance that exercise influence over events that affect their lives(Bandura, 1994).

A lot of researches have been carried out on Self-efficacy in different field such as education, medicine, psychiatry, athletics, social and political change, media studies, business and psychology.The focus in psychology is on clinical problems such as moral development, phobias, smoking behaviour, depression, social skills and assertiveness. Also, educational constructs such asattributions of success and failure academic achievement, goal setting, social comparisons, teaching and teacher education,memory, problem solving and career development are prominent inSelf-efficacy studies.Cavallo, Rozman and Potter (2004) posited that Self efficacy is a good predictor of student's academic achievement, and their

submission was supported by Pajares (2002).Also, Hackett(1995) concluded that "self efficacy is a predictor of choice of academic major and career. There are different levels of self efficacy, task specific self efficacy, general academic self efficacy and global life skill".Choi (2005) described "example of task specific self efficacy as personal belief in ability to perform uncertainty calculation in physics course.Four sources ofself 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 refer 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 startlinglydefiant 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 efficacyfor 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; Fencl & Scheel, 2005; Shaw, 2004). Fencl 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 studentsself efficacy". "Self-efficacy was found to correlate with expected students' grades (r = 0.57, p < 0.001, N = 218)" (Fencl & Scheel, 2005). Shaw (2004) report from theinvestigation of first year undergraduate students' self-efficaciesshowed that there is gender difference in the first year undergraduate students' self-efficacies. Christine and Manjula (2011) affirmed that self efficacyinstruments 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 current study proposes to fill these gaps in the literature through thedevelopment of a short, one-factor instrument for measurement of undergraduate physicstudents' self-efficacy and to investigate physics self-efficacy of males and females first year undergraduate students.

Methodology

This is a survey research design adopting ex-post facto procedure to collect data since researcher has no direct control over independent variable as its manifestation has already occurred.

Existing items and scales on self efficacywere surveyed. Five items were selected from the work of Christine and Manjula (2011) and three items were written based on general insight derived from all items examined. Minor changes were made on the three items based on advice of the three physics education experts that appraised the items. Two hundred and fifteen (215) first year physics students were used to pilot test the questionnaire in 2019.The reliability and validity of the questionnaire was carried out using principal component analysis. Two hundred and seventy nine (279) first year physics students completed the questionnaire in 2020, and data collected was analysed using a confirmatory factor analysis. The factor structure provided by exploratory factor analysis is 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

Three experienced physics experts, one of whom is experienced in measurement and evaluation were given the eight proposed items to comment on the validity of the items. Minor changes were suggested by the experts, and the changes were carried out 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

At the end of first semester of 2019, the questionnaire was administered to first year physics students in class. 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. Using the Statistical Package for the Social Sciences (SPSS) version 15.0, the principal components analysis was used to analyse the data.Based on the eight statements in the questionnaire, the analysis found it suitable for exploratory factor analysis and satisfactory with the sample size. Kaiser's criterion of eigenvalue > 1 and the screen plot investigation were the conditions for factor extraction. The two conditions clearly indicated one factor only. Based on one factor loading, there is no need for factor rotation. The factor loading of the eight items varies from 0.697 to 0.799.This is in agreement with Field (2000), that expect at least four factors loading of over 0.6. The result of analysis confirmed the intended factor structure. The factor explained 68% of the variance which is higher than acceptable 50% of Streiner (1994). The reliability indexof the questionnaire is Cronbach alpha valueof 0.787.

Confirmatory trial

In 2020, the questionnaire was re-administered to another set of first year physics students. The process was the same with that carried out in the previous year. The questionnaire was handed out to two hundred and seventy nine students (279), all the students returned their responses. Evident for construct's validity using a confirmatory factor analysis are; $\chi 2$ =

2.116, p = 0.820 (p > 0.05). Using Kline (2005), main fit indices confirmed a very good model fit: RMSEA = 0.000 (< 0.05) having confidence interval (90%) 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). There is no any form of anomaly in the factor structure due to gender or times of administration.

The Sample

In the first semester of 2021, three hundred and seven($male = 157\ and female = 150$)first year physics students at the Federal University Wukari were selected from the General Physics I class. The General Physics I class covers mechanics, waves, and thermal physics. One of the criteria for admission into first year undergraduate programme in sciences is three years of senior secondary school physics background.There are 13 teaching weeks and a revision week in each semester. The remaining two weeks of the semester is for examination.Each of the teaching weeks has two hours lecture and one hour tutorial. The tests and assignment are components of the continuous assessment. The summative assessment is through continuous assessment and a final examination.

Data Collection

In week 9, questionnaire was handed out 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 intent of the research and the confidentiality protocols. The return rates were 100%.

Result and Discussion

The students' responses to each item were coded in the following manner: 5= very true of me, 4= true of me, 2 = slightly true of me and 1 = not at all true of me.

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. E. Mean	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 Physicsis significant (t = 7.7711, df =305, p =0.0001, 2 tailed). So, there is a significant difference between male and female students Physics self efficacyresponses.

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

From the result of this study, it is better and advisable that physics lecturers should provide help based on students' level of knowledge rather than making them to feel micromanaged and underrated. Physics lecturers should provide hints or prompts to stimulate students or jointly construct the solution with them instead of working out detailed solutions.Stimulating students will enhance the effectiveness of learning and provide students with a greater sense of success.

It is of great importance for Physics lecturers to communicate their expectations to students, express their belief about all students' ability to achieve the expectations and advise themto work hard and smart. Physics lecturers should know that having a high expectation of students does not mean they should assume that students know everything and will not have challenges. Also physics lecturers should take note of students' challenges and help students to appreciate the opportunities provided by challenges.

Consent

Informed consent was obtained from students.

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