

South African science students' perceptions of physics as a fundamental discipline

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Abstract. Meaningful development of scientific literacy is underpinned by coherent acquisition of scientific skills. The development of physics knowledge in particular hinges to a large degree on cognitive and affective factors. In light of this key imperative, students' perceptions of physics as a fundamental discipline were established through the administration of Physics Anxiety Questionnaire with first year science students at a South African university. The questionnaire provided a meaningful platform to identify students' perceptions in relation to various aspects such as physics experimental work, mathematical knowledge required to navigate physics studies, physics problem-solving, application of physics general knowledge in daily life as well as the concomitant integrated assessment of physics skills and knowledge in various instructional settings. Key findings of the study strongly suggest that the acquisition of physics skills is crucially dependent on a conflation of cognitive and affective factors forming an integral part of the learning process. Theoretical implications for meaningful development of scientific literacy are discussed.

1. Introduction

Development of scientific skills depends to a large degree on a myriad of factors. Students' perceptions of physics as an intellectually stimulating discipline ought to be taken into cognisance in order to make sense of the efficacy of instructional strategies employed in various educational settings. It is imperative to demystify the complexity of the nature of cognitive and affective factors affecting the provision of physics instruction in particular. This key consideration is largely informed by the notion that instructional strategies that regard only cognitive variables may ignore the consideration of individual's affective characteristics such as intentions, goals, experiences, and emotions [1]. As a key imperative for meaningful curriculum reform, instructors need to take into account both affective and cognitive factors of learning to help students improve their scientific thinking and abilities [2]. Physics represents a fundamental knowledge domain within the science, technology, engineering and mathematics (STEM) arena. However, inadequate student academic performance in physics within the STEM arena remains a contentious issue requiring attention with a view to foster pedagogic innovation necessary for meaningful development of scientific skills. It is against this background that this study explored South African science students' perceptions of physics as a fundamental scientific discipline.

2. Science anxiety

Science anxiety has been afforded considerable attention as a key factor underpinning the effective teaching and learning of science. The enhancement of student academic performance requires sustained creation of conducive learning environments characterised by low levels of anxiety. Anxiety is defined as an unpleasant emotional state of uncertainty, fear, worry, discomfort, loss of control, and expectation that something bad will happen [3]. It is, thus, incumbent on instructors to critically reflect on the impact of anxiety given its centrality to the learning process [4]. Anxiety can assume various dimensions commensurate with its inherent complexity. In this regard, debilitating achievement anxiety and facilitating achievement anxiety have been identified as negative and positive dimensions of anxiety, respectively [5]. Physics anxiety can be viewed as a form of science anxiety given the fact that physics is, by its very nature, a fundamental scientific discipline. Science anxiety is defined as a diffuse or vague fear which arises in science learning situations [6]. The profound role of anxiety as a key pedagogic factor in science learning situations needs to be demystified in order to develop a clear understanding of how students grapple with the complexities associated with science learning.

3. Research design and methodology

This study adopted a survey design. The survey involved the administration of Physics Anxiety Questionnaire with 100 first year science students at a South African university. The administration of Physics Anxiety Questionnaire was carried out after students were adequately exposed to university instructional environment. The cohort of students constituted a purposive sample within the context of this study.

4. Findings

This study examined physics anxiety of first year science students at a South African university. First year science students' perceptions of physics as a fundamental scientific discipline were unearthed through the administration of Physics Anxiety Questionnaire. Distribution of responses is depicted in Table 1 below. The mean scores show variations in terms of students' physics anxiety levels and reflect students' perceptions of physics as a fundamental scientific discipline. The students appeared to be comfortable when preparing and undertaking physics assessments. This assertion is corroborated by the responses to the item "*I feel very comfortable when studying for a physics exam*" with a mean value of 3.28. The students indicated that the period before the physics examination is usually stressful as evidenced by responses to the item "*I am usually stressed out before a physics exam*" with a mean value of 3.60. This implies that students panic moments before undertaking the physics examination although they are relatively comfortable with preparation. The use of mathematics in physics appeared to be problematic for the students. This finding is inferred from the responses to the item "*If I was asked to discuss the mathematical proof of a physics law, I would panic*" with a mean value of 3.60. This predicament appears to be predicated on students' inability to use appropriate units of quantities. The application of mathematical knowledge in physics is inevitable and students should be afforded meaningful opportunities to apply mathematical knowledge in solving physics problems. The students demonstrated lack of confidence in performing physics practical work. This notion is encapsulated in the responses to the item "*When preparing an apparatus for a physics experiment, I panic about whether I will be able to conduct the experiment or not*" with a mean value of 3.08. This grim reality can be attributed to lack of meaningful exposure to laboratory practical work at schools within the broader South African context. The findings in this study point to the fact that physics anxiety appears to be dependent on a myriad of factors.

Table 1: Distribution of responses

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean
<i>I feel very comfortable when studying for a physics exam</i>	0	20	40	32	8	3.28
<i>I feel very comfortable and peaceful in physics courses</i>	8	24	24	44	0	3.04
<i>Physics experiments make me very tense</i>	16	28	20	32	4	2.80
<i>I am very comfortable with using lab materials</i>	4	16	24	44	12	3.44
<i>I am afraid to raise my hand to ask a question in physics courses</i>	16	32	28	16	8	2.68
<i>I am usually stressed out before a physics exam</i>	4	16	28	20	32	3.60
<i>I would feel very embarrassed if the instructor corrected the answer that I gave to a physics question in front of the class.</i>	16	56	12	12	4	2.17
<i>When preparing an apparatus for a physics experiment, I panic about whether I will be able to conduct the experiment or not</i>	4	36	20	28	12	3.08
<i>If I was asked to discuss the mathematical proof of a physics law, I would panic</i>	8	4	28	40	20	3.60
<i>I am very comfortable when solving physics problems</i>	0	32	36	20	12	3.12
<i>Discussing the physics laws with my friends outside the school tenses me up</i>	20	40	32	4	4	2.32
<i>I usually feel uncomfortable and worried when taking physics exams</i>	4	48	8	24	16	3.00
<i>I am worried about becoming an underachiever in physics due to my lack of mathematical knowledge</i>	8	44	24	8	16	2.80
<i>If my instructor asked me to explain a physical event from daily life, I would be worried</i>	4	24	40	16	16	3.16
<i>Taking a physics exam usually scares me</i>	4	20	40	24	12	3.08
<i>Among all the other courses, the course which makes me most anxious is physics</i>	16	24	20	32	8	2.92
<i>Being unable to use units of quantities appropriately in physics courses makes me very anxious</i>	4	24	20	32	20	3.40
<i>Being watched by a friend while conducting a physics experiment makes me anxious</i>	12	52	24	8	4	2.40
<i>When the instructor is solving a problem, I worry that the others understand the solution better than I do</i>	12	24	12	32	20	3.24
<i>When solving a physics problem, I worry about not being able to recall relevant formulas or physics laws</i>	8	12	24	36	20	3.48
<i>I would be worried if my math instructor wrote some physics formulas on the board</i>	12	36	40	4	8	2.60
<i>Explaining my opinion about a physical event occurring in nature concerns me</i>	4	20	48	24	4	3.04
<i>Compared with other courses, I worry more about succeeding in the physics course</i>	8	20	16	28	28	3.48
<i>I worry about not being able to remember the mathematical formulas of physics laws</i>	8	28	8	40	15	3.28
<i>Helping a primary school student with her/his physics project tenses me up</i>	32	40	20	8	0	2.04
<i>When I open a physics book, seeing a page full of formulas without any explanation scares me</i>	12	28	20	20	20	3.08
<i>I am usually very nervous when I am studying for a physics exam</i>	4	24	28	32	12	3.24
<i>Explaining the findings of an experiment that I have conducted in the physics lab to the instructor stresses me out</i>	12	32	36	20	0	2.64
<i>Being obliged to use mathematical expressions in the physics course makes me feel very anxious</i>	0	52	16	24	8	2.88
<i>Trying to read a sentence full of mathematical physics formulas involving symbols of which I do not know the meaning scares me a lot</i>	0	24	24	40	20	3.64
<i>Being watched by the physics instructor while I am conducting an experiment stresses me out</i>	12	32	32	12	4	2.40
<i>I worry about running out of time to complete the experiment in the physics lab</i>	12	12	12	16	16	2.80

5. Discussion

Clear understanding of students' physics anxiety levels is crucially important for the provision of contextually appropriate instructional activities. While participants in this study were largely comfortable with the examination preparation process, the period just before the examination is undertaken proved to be stressful. High stress levels may engender unpalatable levels of anxiety on the part of students and this can adversely affect their academic performance in physics in particular. The application of mathematical knowledge in solving physics problems ought to be demystified. The interdisciplinary nature of the relationship between physics and mathematics ought to be explicated for the benefit of students in order to avoid a complex dichotomy involving the conflation of physics anxiety and mathematics anxiety. Lack of confidence in performing physics laboratory practical work can be addressed through the development of a clear understanding of students' physics anxiety levels. This claim is consistent with a research study which alluded to the significance of emotions in both learning and performance situations [7]. In addition, it has been established that positive emotions are related to learning and performance situations [8]. Theoretical clarity in relation to students' physics anxiety levels would assist instructors in making sense of the differences between male and female students' science anxiety levels. Several studies demonstrated that females were usually found to be more anxious than males [9, 10, 11]. Physics anxiety has been found to be a significant predictor of physics self-efficacy and significant differences between physics anxiety and self-efficacy depend upon the level of achievement in the physics course [12]. As a key psychological construct, anxiety is certainly an inevitable pedagogic hurdle for instructors. Meaningful development of a clear understanding of students' physics anxiety levels remains a key strategic imperative for fostering contextually appropriate pedagogic innovation underpinned by well-structured instructional activities.

6. Conclusion

Acquisition of physics skills is crucially dependent on a conflation of cognitive and affective factors forming an integral part of the learning process. The identification of science students' anxiety levels is of vital significance for the improvement of instruction and meaningful curriculum reform. Clear understanding of students' physics anxiety levels may potentially facilitate the enhancement of student academic performance in physics in particular. Clarity of understanding in relation to students' physics anxiety levels can serve as a key component required for meaningful pedagogic innovation.

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