Understanding senior high school students’ difficulties in learning physics

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Abstract

This empirical study aims to develop a reliable tool for understanding why senior high school students perceive physics courses as particularly challenging and to delve into the reasons behind their struggles in learning physics. The research entails the development and validation of the Difficulty in Learning Physics (DiLP-S) Scale for High School Students. Exploratory factor analysis revealed three distinct factors: “Teacher” (ten items, α=0.892), “Content” (ten items, α=0.853), and “Student” (five items, α=0.851). Confirmatory Factor Analysis demonstrated a strong fit between the proposed theoretical model and empirical data (Chi-Square = 720.53 (p=0.00), df=272, p-value=0.00000; RMSEA= 0.064 and CFI = 0.97). Results indicate that students predominantly attribute the difficulty of physics courses to the content itself, followed by personal factors, with teacher-related aspects ranking last. Furthermore, analysis by student grade level revealed that 9th and 11th graders encounter more challenges in learning physics compared to 10th graders. However, there was no significant difference in perceptions between students of varying academic success levels, indicating that students perceive physics as difficult regardless of their performance in the course. By understanding students' perspectives, educators can tailor teaching methodologies and course materials to better meet students' needs and enhance their engagement and comprehension of physics concepts.

Keywords: Development, learning, difficulties, 9th & 11th graders, Physics, Teachers

Introduction

In many parts of the world, there have been a notable decline in the interest among young people towards careers in science and technology for over a decade (Department of Education and Science, Ireland, 2002; OECD, 2006). This decline is particularly concerning in the field of physics (Institute of Physics, 2001), which holds a pivotal role in the realms of science and technology. Consequently, various initiatives have been launched in several countries to address this issue (Department of Education and Science, Ireland, 2002; Institute of Physics, 1999; Main, 2011), aiming to enhance the teaching of physics and render it more appealing and effective. The perceptions students hold regarding the context of their courses significantly influence their learning experiences. Students and teachers perceive the context of courses differently, influenced by their unique experiences, knowledge, goals, needs, and motivations (Carter and Brickhouse, 1989). Consequently, studies have investigated questions such as "What aspects make physics challenging?", "Which topics do students struggle with?", "How do students perceive the difficulty of physics?", or "Why do students lack interest in physics?" (Erinosha, 2013; Ornek, Robinson & Haugan, 2007; Şahin & Yağbasan, 2012; Williams, Stanisstreet, Spall, Boyes & Dickson, 2003) [18, 26]. Our primary concern is to identify the core reasons behind the perception that "physics is a difficult course" or that it is something learners are reluctant to engage with. Educators with experience in teaching physics possess valuable insights in this regard. Thus, understanding learners' perceptions of physics courses is crucial for addressing teaching challenges. To achieve this, we investigated students' difficulties in learning physics and prompted them to articulate their thoughts on the question of "Why is the physics course difficult?"

Literature Review

Physics is widely acknowledged as a challenging subject to both learn and teach (Angell, Guttersrud, Henriksen & Isnes, 2004; Mualem & Eylon, 2007; Mulhall & Gunstone, 2008) [7, 4, 14]. Senior high school students perceive physics as both "difficult" yet "interesting" (Angell *et al*., 2004) [7], with teachers highlighting the significance of mathematical competency for grasping physics concepts—a factor often overlooked by students (Williams, Stanisstreet, Spall, & Boyes, 2003) [26]. Studies suggest that as students' progress through senior high school, physics becomes increasingly complex and mathematical, contributing to its perceived difficulty (Owen *et al*., 2008) [17]. Redish (1994) [21] emphasizes the disparity in perspectives between faculty members, teaching assistants, and students regarding physics learning, underscoring the importance of educators understanding students' views. This awareness can inform curriculum decisions and address classroom challenges (Carter & Brickhouse, 1989). Additionally, researchers stress the role of motivation, goals, and learning environment in academic success (Hidi & Harackiewicz, 2000; Nolen, 2003) [15]. Teachers often perceive students to hold misconceptions about the difficulty and abstract nature of physics concepts, emphasizing the necessity of strong mathematical skills for comprehension (Oon & Subramaniam, 2011) [16]. Negative attitudes towards physics courses and struggles with mathematical formulas further compound student challenges (Aycan & Yumuşak, 2002; Karakuyu, 2008) [8]. "Electromagnetic induction" emerges as a particularly challenging topic, contrasting with the relative ease of understanding "substance and its features" (Aycan & Yumuşak, 2002; Karakuyu, 2008) [8]. Preservice physics teachers identify various reasons for the difficulty of physics subjects, including the complexity of content, students' preconceptions and lack of background knowledge, challenges in applying concepts to daily life, and shortcomings in teaching methodologies (Şahin & Yağbasan, 2012). These findings underscore the multifaceted nature of challenges in learning and teaching physics, emphasizing the need for targeted interventions and pedagogical strategies to enhance comprehension and engagement.

Methodology

Survey model was adopted in this research (Fraenkel & Wallen, 2006). Survey model is a research approach aims to describe an existing case (Karasar, 1984). Survey model serves to two purposes (Yıldırım, 1966). These are a) to be acquainted with existing case, b) to gather information and to summarize them for the aim of solving or explaining the problem.

313 students who are studying in five high schools at the center of Denizli were included in this study. Approximately 80% of students are 9th and 10th grade students. Nearly half of the participating students stated that their physics course grade average are between 65 and 80. Mother of 20% of students are university graduates and 34% are high school graduates while father of 33% are university graduate and 25% are high school graduate. 82% of students stated that they have a computer with internet access while half of them stated that they have the regular reading habit. The following table (Table 1) summarizes the characteristics of the Participating students.

Table 1: Characteristics of the participants

	Category	**N**	**%**	**Category**	**n**	**%**
Grade Level	9. Grade	179	57,2	11. Grade	61	19,5
	10. Grade	73	23,3	Total	313	100
Achievement	Poor (<50)	14	4,5	Good (65-80)	138	44,1
	Middle (50-65)	80	25,6	Better (>80)	81	25,9
Mother Education						
Level	Illiterate	2	0,6	High School	105	33,5
	Literate	46	14,7	Associate Degree	8	2,6
	Primary School	2	0,6	University	62	19,8
	Middle School	72	23	M.S. or Doctorate	4	1,3
				Not Known	12	3,8
Father						
Educational Level	Illiterate	2	0,6	High School	77	24,6
	Literate	9	2,9	Associate Degree	21	6,7
	Primary School	37	11,8	University	103	32,9
	Middle School	40	12,8	M.S. or Doctorate	12	3,8
				Not Known	12	3,8

		n	%		n	%		n	%
Computer Ownership	**Yes**	257	82,1	**No**	44	14,1	**Not Known**	12	3,8
Book Reading Habit	**Yes**	158	50,5	**No**	143	45,7	**Not Known**	12	3,8

Table 2: Distribution of the Participants for Pilot Application

	category	n	%	category	N	%
Gender	Male	196	49.1	female	203	50.9
Class level	9 Grade	179	41.9	11 Grade	77	19.3
	10 Grade	125	31.3	12 Grade	18	4.5
age	14	14	3.5	17	85	21.3
	15	157	39.3	18	2	0.5
	16	141	35.3			

Physics course achievement	Bad	12	3.0	Good	192	48.1
	middle	89	22.3	better	106	26.6
	Total	399	100			

Factor analysis phase

Before the factor analysis, normality of data was investigated. A Shapiro-Wilk's test (p> .05) (Oztuna, Elhan, Tuccar, 2006; Shapiro & Wilk, 1965; Razali & Wah, 2011) [22, 20] and a visual examination of the histograms, normal Q-Q plots and box plots showed that the instrument scores were approximately normally distributed, with a skewness of -0.195 (SE=0.122) and a kurtosis of 0.229 (SE=0.244) (Cramer, 1998; Cramer & Howitt, 2004; Doane & Seward, 2011). Exploratory Factor Analysis was executed on the data acquired to determine the structure validity of the draft scale consisting of 30 items. Exploratory Factor Analysis is a technique used to group the items that measure the same structure or attribute among the items determined by the researchers and to clarify the scale through those limited number of substructures (the factors) (Buyukozturk, 2010). Before this analysis, several criteria have been offered by researchers for the competent sample size for factor analysis (Kline, 2005; Bryman & Cramer, 2001). In terms of sample size, another criterion to investigate the competency of a data set for the factor analysis is the Kaiser-Meyer-Olkin (KMO) test (Leech, Barrett & Morgan, 2005). As shown in Table 3, the KMO was calculated as 0.927 which demonstrates that the size of the sample is perfect. When we examined the result of Bartlett's Test of Sphericity (chi-square = 5544.36; df = 435; p<.000), we observed that the data were appropriate for the factor analysis.

Table 3: Kaiser-Meyer-Olkin and Bartlett's Test of Sphericity

KMO Measure of Sampling Adequacy		0.927
Bartlett's Test of Sphericity	Approx. Chi-Square	5544.36
	Df	435
	Sig.	0.000

Table 4: Principle Component Analysis

DiLP Scale	Factor 1	Factor 2	Factor 3
Eigenvalue	9.967	2.992	1.779
Explained Variance %	33.223	9.974	5.928
Cumulative Variance %	33.223	43.198	49.126

At the end of the last analysis, there were not any items left to be excluded. Among the three factors determined, there were 25 items, which meant that five items were excluded from the 30-item scale. The three factors were determined as a result of the last analysis explaining 52.372% of the total variance. While the first component had an eigenvalue of 8.763 and explained 35.051% of total variance, the second component had an eigenvalue of 2.690 and explained 10.758% of the total variance and the third and the last component of the scale had an eigenvalue of 1.641 and explained 6.563% of the total variance.

Table 5: The relation among the dimensions of the scale (Pearson Correlation Analysis)

Relations	r
1. Teacher*Content	0.541(**)
2. Teacher*Student	0.409(**)
3. Content*Student	0.617(**)

Correlation is significant at the 0.01 level (2-tailed)

Following the evaluation of the data with regard to why physics courses are difficult; it is observed that there is a low positive significant relation between teacher and student dimensions (r=0.409(**); p≤0.001), there is moderate positive relation between teacher and content dimensions (r=0.541(**); p≤0.001) and between student and content dimension (r=0.617(**); p≤0.001). This relation indicates that the teacher factor has a low but effective impact on the students' perception of physics as a difficult course. Furthermore, the moderate relation between the dimension of content and the student indicates that content factor has an effective impact on students' perception of physics as difficult course. There is also moderate positive and statistically significant relation between the teacher and content factors.

Results and Discussion

Results

When the mean scores for sub dimensions were compared, as it was summarized in *table* 3, it is seen that the students mostly emphasized the course content as the reason of having difficulty in learning physics. The student and the teacher factors follow this respectively. According to this result, mean scores of the content factor were investigated. The mean scores and the standard deviations of these items were given in the Appendix.

Table 6: Mean scores and Standard Deviations for Items of Content Factor

Item No	Content Factor	Mean	SD
C1	There are too many subjects and concepts in physics course.	3,79*	1,069
C2	Physics subjects have too many formulas.	3,43	1,142
C3	Physics subjects have complicated formulas.	3,60	1,156
C4	Physics courses have formulas based on memorization.	3,59	1,152
C5	I am lacking background knowledge about physics.	3,29	1,147
C6	Physics is considered as a difficult subject in my environment.	3,84*	1,050
C7	Physics is a memorization-based course.	2,80	1,221
C8	I cannot allocate time for physics course	2,87	1,068
C9	Physics course books are boring for me.	3,63*	1,250
C10	Most of the subjects in physics course are abstract concepts	3,02	1,210

There are 10 items in the scale related to course content. Among the items under this factor, "Physics is considered as a difficult subject in my environment" has the highest mean (M=3.84, sd=1.05) and respectively the item of "There are too many subjects and concepts in physics course" (M=3.79, sd=1.07) and the item of "Physics course books are boring for me" (M=3.63, sd=1.25). According to these results, it can be said that the students have a prejudice towards the physics course that originates from their environment (friends, parents, etc.) and they perceive this prejudice as a reason for having difficulty in the course. Moreover, the students think that the physics course has too many subjects and concepts. The students see the course content's intensity as a reason for having difficulty in learning physics. Another important emphasis is students' seeing the course books as boring, and it can be said that this also causes them to have difficulty in learning the physics course. Besides the demographic information in the scale, the students were asked to indicate their grade point averages as "Poor (Below 50)", "Middle (between 50 and 65)", "Good (between 66 and 80)" and "Better (81 and above)". This information was used in comparison the mean scores by student success. Comparison of the Mean Scores According to Students' Physics Course Achievement According the results, students mostly emphasized the course content as the reason for having difficulty in learning physics. When the factor scores were compared by the success of students, all students put forward the course content as the reason of having difficulty in learning physics. The mean scores of DiLP Scale were compared by the grade levels of the students. It was found out that 9th grade (X=75.48) and 11th grade (X=71.25) students have more difficulty when compared with the 10th grade students (X=62.64) (table7).

Table 7: Mean scores by grade levels

Grade Levels	N	X	SD
9	179	75,48	19,227
10	73	62,64	13,544
11	61	71,25	13,366

When it was examined whether this difference appeared by sub-dimensions of the scale, in teacher subdimension, 9th (X=25.59) and 11th (X=23.77) grade level students emphasizes teachers as the reason of having difficulties in learning physics more than 10th (X=18.90) grade students. Similarly, in content sub-dimension, 9th (X=34.68) grade level students emphasizes curse content as the reason of having difficulties in learning physics more than 10th (X=32.03) grade students. In student sub-dimensions, 9th grade (X=15.21) and 11th grade (X=13.89) students consider themselves as the reason of having difficulty in learning physics more than
10th grade (X=11.71) students.

Discussion

The findings from this review study indicated that students primarily attribute the difficulty of learning physics to the course content and syllabus, follow by student teacher factors. While there is a common belief that teachers bear the sole responsibility for students' success or failure, our results challenge this notion. Contrary to popular belief, teachers exert minimal influence on students' difficulties in learning physics. Regardless of their level of success in the course, students consistently identify course content as the primary challenge, followed by personal factors and then teacher-related aspects. Students perceive the content of physics courses as overly extensive, abstract, and disconnected from their daily lives, leading to a perception of the course as boring and difficult. This suggests that course materials may not be sufficiently tailored to students' real-life experiences. Furthermore, differences in perceptions of difficulty between 9th, 10th, and 11th-grade students may be attributed to variations in teaching programs and students' prior exposure to physics concepts. The sub-dimensions of the scale offer insights into the underlying reasons for students' difficulties in understanding physics topics. Higher scores in the teacher sub-dimension indicate that students view teachers as significant influencers of their understanding and enjoyment of physics, particularly among 9th and 11th-grade students. Additionally, differences in the student sub-dimension scores suggest that 9th and 11th-grade students perceive themselves as more responsible for their difficulties in understanding physics compared to 10th-grade students.

Conclusion

Despite variations in students' academic success levels, there was no significant difference in their perceptions of the difficulty of physics courses. This underscores the pervasive perception among students that physics is inherently challenging, regardless of their performance in the subject. The Difficulty in Learning Physics Scale provides valuable insights into the conditions and sources of students' difficulties in learning physics, guiding educators, researchers, and administrators in developing measures to enhance student success in the subject. By understanding students' perspectives, educators can tailor teaching methodologies and course materials to better meet students' needs and enhance their engagement and comprehension of physics concepts. This scale is expected to contribute significantly to future research on the subject, facilitating a deeper understanding of students' challenges in learning physics.

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