Could Students' Attitudes towards Learning Physics Significantly Predict their Learning Outcomes: Implications for Innovative Methods in Teaching Physics

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Abstract

A modern educational process should approach students by taking into account all of their characteristics. A purely intellectual approach to teaching and learning should be replaced with a different approach that takes into account all of the other students' characteristics. Therefore, students' attitudes toward learning specific school subjects are very important determinants of their learning outcomes. Through examining student attitudes, very important implications for creating innovative teaching methods could be defined. Traditional classrooms should be replaced with those with standing desks and other innovative teaching methods that enhance learning applied physics. With the aim of postulating implications of specific innovative methods in teaching physics, students' attitudes toward learning physics are analysed as possible predictors of students' learning outcomes. The sample consisted of 557 eighth grade students from eight primary schools in Zagreb and Zagreb County. The collected data were analysed applying descriptive, correlation, and regression analysis. Overall, the study determined that students with more positive attitudes towards physics achieved better scores in knowledge tests. Eight specific students' attitudes toward learning physics were determined as significant predictors of their learning outcomes. The content analysis of the students' attitudes implied that applied physics would be the most understandable to students and that innovative teaching methods would improve their attitudes and learning outcomes in physics. In addition, some students' attitudes reflected gender differences and these differences should also be taken into account. Finally, some specific guidelines for implementing innovative teaching methods in physics education and future research have been postulated.

Keywords: Innovative teaching methods; physics; students' attitudes; learning outcomes.

Introduction

Unlike traditional teaching methods in which the teacher is mainly a knowledge carrier and students are passive listeners and recipients of that knowledge, modern teaching methods allow active inclusion of students into the learning process. In addition, these modern teaching methods assist students in revealing their creativity, which is one of the aims of modern teaching. Therefore, teaching methods that promote student activity, learning through experience, observing, and experimenting should be facilitated whenever possible.

Learning is promoted when learners are engaged in solving real-world problems and when new knowledge is applied by the learner (Merrill, 2002). Van Rossum and Schenk (1984) have demonstrated the relations between students' views about learning, their learning approaches, and the quality of their learning outcomes. Also, the influence of students' conceptions of learning and their approaches to learning has been established (Dart et al., 2000). The results of this study indicate that students who reported qualitative and experiential conceptions were likely to use deep approaches to learning, whereas students who had quantitative conceptions of learning tended to use surface approaches to learning.

According to students' conceptions, they prefer to learn in an active and constructive way and to participate in discussions. Also, high correlations were found between reported learning strategies among different learning contexts, indicating the existence of individual consistency in the use of a learning style (Könings et al., 2005).

A modern educational process should approach students by taking into account all of their characteristics. A purely intellectual approach to teaching and learning needs to be replaced by a new approach and this new approach should account for the fact that we learn with our mind, heart, and body (Jensen, 2003). The literature indicates that the psychological characteristics of students significantly correlated with their learning outcomes (Vizek Vidović et al., 2014; Tatalović Vorkapić, 2015) and some of these psychological characteristics include emotions associated with learning, motivation associated with learning, and personality characteristics. Further, the correlation of psychological characteristics of students and their learning outcomes may be observed in the context of applying innovative teaching methods. Students should be enabled to make personal choices whenever possible and students should be allowed to exercise their personal preferences. Finally, with respect to fostering student motivation, it would be advantageous if teaching was oriented toward stimulating students to learn and discover for themselves.

Students' characteristics and learning outcomes – theoretical background

Students' characteristics, such as attitudes, values, motivation, personality characteristics or cognitive styles, significantly correlate with the teaching and learning process. In addition, students' attitudes towards learning certain school subjects are significant factors of learning outcomes. Therefore, studying students' attitudes may have a large impact on enhancing students' learning outcomes and may have a large impact when defining and developing efficient and innovative teaching methods.

Student characteristics are not stable personality traits, but are the reflection of the students' learning experiences. Vermetten et al. (1999) has shown that students use different learning strategies in different learning contexts. Therefore, perceptions of a learning environment also influence students' learning-related characteristics.

In 2003, an extensive empirical study was undertaken with a representative sample of 121 Croatian primary schools financed by the Ministry of Science, Education and Sports of the Republic of Croatia, and the Open Society Institute – Croatia (Rister, 2007). The aim of the research was to improve the quality of obligatory education in Croatia and to provide researchers with an insight into the current state of the national curriculum from the perspective of teachers, headmasters, and students.

The 2003 study included the attitudes of eighth grade primary school students towards teaching physics and the research revealed that these students considered physics to be incomprehensible, difficult, and not particularly important for future life. The research also revealed that there were statistically significant differences between the responses of male and female students. The female students reported that physics was considerably more difficult, less understandable, less important, and not useful. However, the greatest difference between the female and male student responses was that the female students considered physics to be less interesting (Rister, 2007).

Innovative teaching methods – theoretical and practical background

Innovative teaching methods are defined as strategies for working with curriculum where teachers and students participate actively in the process and where learning through experience, observation, and experimentation is stimulated (Bonwell & Eison, 1991). In a classroom where active learning is fostered, students are not passive recipients of new information but students create their own knowledge. There are many pedagogical benefits that may result from fostering an active learning environment. An active learning environment is intellectually stimulating for students and it helps to maintain student motivation. Students engaged in active learning develop many learning capabilities necessary for organising activities and in strengthening social and communication competencies in cooperative activities. Students appear to accept active learning because it provides immediate feedback to students about their learning progress and active learning fosters positive student attitudes toward themselves and the subject.

In the learning process, students should be emotionally and thoughtfully invested in the subject of their learning and they should incorporate all of their senses into the learning process. When students use all of their senses in the learning process, the applicability and permanence of their knowledge increases since this knowledge is acquired through the efforts of their own mind. Active learning is important because it introduces new learning strategies, a new dimension to teaching, and develops a new system of values with students. As students form an interactive relationship with their learning, through a series of mental and work activities, students' learning becomes a challenge for them. Once students are challenged in this way, educators may expect that knowledge will be perceived as wealth by students and students may perceive the possibility of learning as privilege (Kovačević, 2005).

New and innovative approaches to teaching include the use of computers, the Internet, and modern multimedia (PEER Instruction, Just-in-time Teaching (JITT), Flipped classrooms, etc.). Through the use of such innovative teaching strategies, students become more motivated and the learning process is made more dynamic for them. The advantages of using computers in teaching and learning are numerous and may include (1) the ability for students to work at their own pace, (2) the ability for students to choose the degree of difficulty that suits their own needs, and (3) the ability for students to produce work that is not necessarily associated with school resulting in greater student learning independence and learning individualisation. Such innovative strategies have a motivating effect because they allow students to momentarily correct their mistakes and to decrease the frequency of such mistakes. As a result, students tend to answer all of the questions posed to them, they do not have to wait their turn during instruction, and students are engaged in constant activity.

Another innovative approach to teaching is based upon the physical activity of students. A significant amount of research indicates that physical activity is favourable to students in such a way that their learning improved. Koontz (2010) reports that students felt better and their ability to concentrate was improved when motion was a constituent part of their daily routine. In addition, recent research suggests that physical activity may have a beneficial effect on the cognitive abilities of students and on their academic success (Hillman et al., 2008).

Research suggests that teachers should facilitate increased student activity through promoting different body positions such as walking, leaning against a wall, kneeling, sitting or lying (Jensen, 2000). Jensen (2000) reports that physical activity during learning has a number of advantages as compared to learning while sitting. The research suggests that physical activity learning is more long-lasting, may be age adapted, students memorization skills increase, and students have more fun. Also, students can use their bodies to learn where they can stand up and demonstrate some concepts such as tall-short, small-big, or fast-slow. Finally, physical activity during learning promotes an environment where the class becomes more interesting (Jensen, 2000).

The final innovative approach to teaching is the standing desks method where students lean against their desk rather than sit at their desk. The goal of this innovative teaching method was to facilitate increased student concentration and to increase student intellectual engagement. With a view to improve student activity in class, student desks were modified allowing for higher energy consumption during class activities and during the carrying out of tasks (Benden et al., 2013). In this innovative approach to teaching, student desks were adjusted in height so that students could lean against them. The research reported that the continuous usage of standing desks was associated with significant improvements in executive function, significant improvements in the capacity of working memory were observed, and changes in the corresponding models of brain activation were also observed. Submitted findings of pilot research (Mehta et al., 2015) gave preliminary evidence to neurocognitive advantages of the standing desks method usage.

Research carried out in the USA (Dornhecker et al., 2015) referred to the very usage of standing desks, and as an answer to the ever growing educational and health demands which are put upon schools, with a view to, among other things, prevent the problem of obesity in children. The comparison of the engagement of students in a classroom in which they were sitting compared with standing students indicated a general improvement in their school activity over time with both groups. Standing desks did not result in negative effects on the engagement of students. The results indicate promising outcomes of using standing in primary school, with a view to enhancing energy consumption without influencing the educational engagement of students.

In teaching physics, using one's own body to measure objects which surround us is one of the ways to promote physical activity during class. The existence of old units of measurement such as foot, span, or ell attests to the fact that in the past people have used parts of the body for measurement. Thus, students can, for example, measure the length of the classroom by using paced distances. Also, the physical activity of students is promoted when they perform experiments.

These experiments may include when students walk to measure time or when students climb stairs to measure their strength. In addition, students in the laboratory may be free to stand up while they prepare equipment for experiments, demonstrate or present their ideas in front of the class. Further, pairs of students may demonstrate the formation of waves on a spring while they stand and hold a vibrating spring. Finally, students may gather around the teacher's desk, observe the teacher while he/she conducts some experiment, and then provide comments and discussions.

Teaching physics – the contextual research frame

Physics introduces central concepts to students and provides fundamental and universal knowledge to them. As compared to other school subjects, physics is unique in that it promotes the development of student cognitive abilities, their formal scientific opinion, and promotes problem solving. As a result, physics is important because it promotes scientific literacy with students.

By learning physics, students acquire skills and abilities necessary for everyday life and these skills and abilities may include creative problem solving, cooperative work, modern technology usage, and lifelong learning evaluation. The goal of learning physics is acquiring physical literacy. Physics encompasses knowledge, skills, abilities, and attitudes which allow a person to observe occurrences, think about them, understand their explanations, and take action (Jakopović, 2003).

Physical literacy is determined by capability to (Jakopović, 2003):

- understand the natural world;
- use the acquired scientific processes and principles in making decisions; and,
- integrate into public discussion of problems concerning science, technology and ecology.

New approaches to teaching imposes the introduction of a new model, the so-called "discovery learning method" in which the assumption is that students want to learn, that learning can be fun, and that a true preparation of students for life is not in drill learning numerous facts and examination, but in learning how to study and love studying. By their nature, people are curious and thereby have an innate tendency to discover new things and learn about them (Jensen, 2003).

While organising the physics class, the teacher should take into account the following principles (Jakopović, 2003):

- Learning physics is an active process, meaning physical and mental activity by the students.
- Students learn more successfully while cooperating with other students.
- Learning is more successful through tasks that have meaning in everyday life.

It may be concluded that teaching and learning physics is an interactive and problem-oriented process based on experiments and examples from everyday life. By learning physics, students develop a scientific way of thinking, understand natural phenomena around them, and students may understand nature and its laws. Through teaching physics, students may be motivated to do research, perform experiments, perceive, observe, think, and conclude logically. Students are actively engaged by the use of a learning cycle which includes a written prediction of the results of an actual physical experiment, small group discussion, observation of the physical event, and comparison of observations with predictions (Sokoloff & Thornton, 1996). Students are taught to be critical and self-critical, their self-confidence is developed and they are presented with various problem situations, thus preparing them for their future lives. Therefore, physics instruction is important to stimulate the development of students' competence, to find their ways in situations that are new to them, as well as the development of cognitive abilities and formal and scientific thinking.

The aim, research problems and hypothesis

With the aim of postulating implications of specific innovative methods in teaching physics, students' attitudes toward learning physics were analysed as possible predictors of their learning outcomes. The research expected a significant positive correlation between students' attitudes toward learning physics and their learning outcomes, i.e. that students who have positive attitudes would have better learning outcomes in physics. Also, it was expected that students' attitudes toward learning physics would implicate certain modifications in applied teaching methods. The collected data were analysed applying descriptive, correlation, and regression analysis.

Methods

The research was carried out in eight primary schools in Zagreb and Zagreb County on a representative sample of eighth grade students. The headmasters' permission was requested before the research was carried out. The testing itself lasted for 45 minutes and was carried out by physics teachers during their classes. The students' participation in the survey was voluntary, the return of information was assured, and students were given codes to ensure anonymity. The sample included 557 eighth grade students, of which 295 were boys and 262 were girls. The following schools participated in the research: Tituš Brezovački Primary School with 104 students, Rudeš Primary School with 47 students, Brezovica Primary School with 146 students, Žuti Brijeg Primary School with 24 students, Sesvetska sela Primary School with 45 students, Brestje Primary School with 126 students, Mato Lovrak Primary School with 42 students, and Klinča Sela Primary School with 23 students.

A self-evaluated scale was used for measuring students' attitudes towards teaching and learning physics and the research instrument comprised of 25 items (Table 1) organised into five subscales (domains) that covered the following fields:

- Attitudes toward methods of teaching physics;
- Attitudes toward methods of learning physics;
- The perception of the role of mathematics in teaching physics;
- The perception of the importance of physics in everyday life; and,
- Motivation for learning physics in future.

Students gave their answers on the questionnaires by choosing a value on the Likert's scale from 1 (totally disagree) to 4 (totally agree). In addition to the questionnaire, the students took an energy test that included energy content from both the seventh and eighth grades.

The test consisted of six chapters, each divided into a different number of tasks. In total, there were 20 items with multiple choice questions. In the 1st part of the test, students were asked to recognize a situation that was different from the others from the point of view of physics. The 2nd part, had the goal to check students' knowledge of different forms of energy. In the 3rd part, students were asked about the dependence of different forms of energy on other physical quantities like mass, speed, and light. In the 4th part, students were expected to recognize forms of energy in the context of everyday situations. In the last two chapters of the test, students focused on two different problem situations. Students were asked to observe the same problem situation from different aspects and they had to calculate the gravitational potential energy for a body in different positions in relation to the ground.

Results and Discussion

Descriptive results on pupils' attitudes toward learning Physics. Overall, the research determined that students have mostly partially agreed with the presented items on the Attitude toward Learning Physics Scale. To be more exact, students partially agreed with 19 of 25 items, see Table 1.

Students indicated their highest agreement with the following three items:

- "New teaching material is much more easily understood to me if we make experiments and do measuring in the class."
- "In physics it's very important to understand the formulas before using them."
- "Knowledge of physics helps me understand the nature and the world around us."

Students indicated the lowest agreement with the following item:

"Physics classes are sometimes held out of school (nature outdoors, museums, different institutions)." The moderately high mean for the total Attitude toward Learning Physics Scale was *M* = 2.68 (*SD* = .53).

The research results indicated that active engagement and one's own model building based on making experiments, observing and measuring, are an appropriate approach to developing positive students attitudes, as well as better understanding of the world around us. Students are aware of the importance of mathematical modelling of physical problems, which shows that they have experience in learning physics.

Table 1: Means (*M*) and standard deviations (*SD*) of each item from attitudes toward Learning Physics Scale.

	Table 1: Items of Attitudes toward Learning Physics Scale	***M***	***SD***
1.	Physics is very interesting to me.	2.81	.95
2.	Teaching methods are interesting and motivating.	2.69	.92
3.	The atmosphere in class is working and relaxed.	2.72	1.06
4.	Physics' classes are generally dynamic and well exploited.	2.81	.98
5.	Students are generally actively involved in the conversation, doing assignments, practical work and student presentations.	2.74	1.00
6.	Through classes the purpose of learning physics and its connection with life is shown.	2.98	.97
7.	New teaching material is much more easily understood to me if we make experiments and do measuring in the class.	**3.32**	.94
8.	Physics classes are sometimes held out of school (nature outdoors, museums, different institutions).	**1.73**	.97
9.	Teaching materials such as models, computer, simulations, materials from conducting experiments, transparencies, posters etc. are regularly used in teaching Physics.	2.89	.99
10.	Grades show my actual knowledge of Physics.	2.83	1.08
11.	Detailed and careful reading of the text is a good way of learning physics.	2.73	1.03
12.	To understand physics better, I discuss it with friends.	2.32	1.06
13.	While solving physics problem I always try to predict the value I have to calculate.	2.31	.98
14.	Solving numerous tasks helps me in learning Physics.	2.88	1.00
15.	Usually there is only one correct way of dealing with a physical task.	2.40	.99
16.	After learning certain teaching material I have a feeling I understand it but I still have problems with solving problems.	2.52	1.07
17.	In physics it's very important to understand the formulas before using them	**3.28**	.91
18.	Physics can be explained without mathematical expressions (formulas).	2.38	1.08

19.	Learning physics develops my own capacity for scientific thinking.	2.91	.98
20.	Knowledge of Physics helps me understand the nature and world around us.	**3.03**	.96
21.	Physics can rarely be connected with my everyday situations and experience.	2.31	1.01
22.	I use my knowledge of Physics in other school subjects.	2.63	.97
23.	I learn Physics because it will be useful in everyday life.	2.84	1.03
24.	It's important for me to continue learning physics in a high school.	2.56	1.11
25.	For further learning Physics I am attracted by its application in new technologies.	2.71	1.10

The results of similar research on students' attitudes toward physics also indicate the importance of understanding nature, as well as putting the learning content in a real context, and thus providing guidelines on learning and teaching improvement. The Colorado Learning Attitudes about Science Survey (CLASS) probed students' beliefs about physics and learning physics, and distinguished the beliefs of experts from those of novices. A factor analysis indicated that statements involving the connection of physics with reality are separated into two distinguishable categories. The two categories distinguish between whether students think that physics describes the real world and whether they actually care or think about the physics they experience in their everyday life (Adams & al., 2006). Students who engage in model building, validation, and revision have authentic scientific experiences. These experiences promote certain attitudes about learning physics: that it is not simply about memorizing formulas, and that models in physics are coherent, constructed by students and subject to change (Brewe et al., 2013).

In conclusion, teaching should be based on experiments and measuring, putting physical problems into the real everyday context, and emphasizing understanding over memorizing.

Descriptive results on Physics test. The results achieved in the test showed that some items had the lowest score (Table 2).

Table 2: Frequency of right answers on the Physics Test (Learning outcomes).

Subtest of Test on Learning Outcomes		Frequency of right answers
I. recognize different physical situations	Task 1	145
	Task2	285
II. students' knowledge of different formations of energy	Task 3	355
	Task 4	455
	Task 5	379
	Task 6	440
III. the dependence of different forms of energy to other physical quantities	Task 7	447
	Task 8	385
	Task 9	239
IV. form of energy in a context of everyday students' situations	Task 10	222
V. the same problem situation with some different aspects	Task 11	407
	Task 12	321
	Task 13	81
	Task 14	113
	Task 15	413
	Task 16	296
VI. Calculus of gravitational potential energy of the body in different positions in relation to the ground.	Task 17	275
	Task 18	224
	Task 19	303
	Task 20	192
***M, SD* of total test score**		10.74; 3.84

Students generally do not distinguish the concept of force and the concept of energy. Students have problems with tasks in which they are expected to conclude in which position the body has the highest/lowest kinetic energy or to calculate the amount of gravitational potential energy of a certain body position. Items that showed the highest score were those in which students were asked to identify the forms of energy for different bodies in everyday situations and to connect the position of the body (height) with the corresponding gravitational potential energy or where it was required to recognize the dependence of the kinetic energy on the mass and velocity. It can be concluded that students have difficulties with mathematical expressions and calculations and do not always integrate what they have learned into real life situations.

Research conducted in the Republic of Croatia in 2008 on a sample of 114 high school students revealed a very low transfer of knowledge between mathematics and physics, the binding of knowledge, and the context in which the knowledge had been acquired (Katić et al., 2009). Similar results were confirmed by Beichner, R. J. (1994) and McDermott et al. (1987) and this research indicated that students had difficulties with graphs and their interpretation in physical contexts. The last aforementioned survey identified two categories of difficulty and these include difficulty in connecting graphs to physical concepts, and difficulty in connecting graphs to the real world.

Correlation analysis results. Students with more positive attitudes towards physics achieved better scores in knowledge tests. Some of the attitudes that grow according to better scores in a test are:

- "It's important to me to continue studying physics in high school."
- "Physics is interesting to me."
- "In physics it is very important to understand formulas before I use them."

As it could be observed in Table 3.In the same table it could be seen that attitudes which are less noticeable with better results in tests are:

- "Physics classes are sometimes held out of school (nature, museum, different objects and institutions)".
- "After learning certain teaching material I have a feeling I understand it but I still have problems with solving problems."

The determined correlation analysis results indicated that students' attitudes are linked to their knowledge test achievements. The more positive students' attitudes are, the better the results gained.

Research on correlation between students' attitudes and their achievements are relatively few in number and the gained results differ. For example, Wilson (1983) indicated that causal ordering results support achievement causing attitude in lower grades and levels of education. The research indicated that attitude changes may result from science achievement for primary school students, but these results also indicated that for older students (high school and college), there was evidence that their attitude modestly predicted later achievement, but not the reverse.

The results of more recent research (Willson et al., 2000) supported an interactive model of conceptual understanding and achievement, but with attitude largely irrelevant to the process for a population of college freshman students. Attitudes did not predict later physics achievement or concept development. A possible explanation for the complex behaviour of attitude that the authors provide was integration of knowledge and attitude over time.

Table 3: Correlation coefficients between attitudes toward learning physics and learning outcomes from physics test.

Scale items and average results	Total results on all 20 tests on learning outcomes
Attitude 1	**.222****
Attitude 2	**.126****
Attitude 3	.005
Attitude 4	.038
Attitude 5	.062
Attitude 6	**.183****
Attitude 7	**.168****
Attitude 8	**-.151****
Attitude 9	.014
Attitude 10	.064
Attitude 11	**.175****
Attitude 12	.072
Attitude 13	**.126****
Attitude 14	**.121****
Attitude 15	-.028
Attitude 16	**-.171****
Attitude 17	**.207****
Attitude 18	-.038
Attitude 19	**.166****
Attitude 20	**.184****
Attitude 21	-.052
Attitude 22	.083
Attitude 23	**.190****
Attitude 24	**.225****
Attitude 25	**.192****
Attitude Mean	**.169****

$^*p<0.05$, $^{**}p<0.01$

Attitudes and achievements research are also linked to some other aspects of teaching physics such as teaching methods. For example, according to Kalu (2008), students' development of positive attitudes towards physics and achievement in low academic tasks significantly increased with the teachers' indirect influence through classroom activities. However, the link between attitudes and achievements was not observed.

Regression analysis results. All 25 attitudes together significantly predict students' learning outcomes and their contribution is 46% of the explained variance in the criterion variable, i.e. results on all tests. The research determined that gender is not a significant predictor of learning outcomes in physics. Regression analysis results are shown in Table 4.

Even though 15 attitudes indicated a significant correlation with the total results on the tests, only 8 specific students' attitudes toward learning physics were determined as significant predictors of their learning outcomes. These attitudes are:

- "Physics is interesting to me."
- "New teaching material is much more easily understood to me if we make experiments and measuring in the class."
- "Teaching physics sometimes takes place outside the classroom (nature, museums, various structures and institutions in the city)."
- "Detailed and careful reading of the text is a good way of learning physics."

- "After learning certain teaching material I have a feeling I understand it but I still have problems with solving problems."
- "In physics it's very important to understand the formulas before using them."
- "Physics can be explained without mathematical expressions (formulas)."
- "I use my knowledge of physics in other school subjects."

Table 4: Regression analysis results with attitudes toward learning physics as predictors and learning outcomes (results from physics test) as criterion variable.

Items	Learning outcomes			
	B	Beta	R^2	*F*(df)
Constant	**8.076****		.245	**5.446** **(25.420)****
Attitude 1	.585	**.146***		
Attitude 2	-.115	-.028		
Attitude 3	-.271	-.075		
Attitude 4	-.076	-.019		
Attitude 5	-.035	-.009		
Attitude 6	.292	.073		
Attitude 7	.497	**.118***		
Attitude 8	-.786	**-.196****		
Attitude 9	-.243	-.062		
Attitude 10	-.104	-.029		
Attitude 11	.519	**.140****		
Attitude 12	.079	.022		
Attitude 13	.231	.059		
Attitude 14	.021	.005		
Attitude 15	-.038	-.010		
Attitude 16	-.630	**-.178****		
Attitude 17	.574	**.133****		
Attitude 18	-.362	**-.102***		
Attitude 19	-.127	-.032		
Attitude 20	.463	.116		
Attitude 21	-.235	-.062		
Attitude 22	-.544	**-.137****		
Attitude 23	.342	.093		
Attitude 24	-.040	-.012		
Attitude 25	.306	.087		

The gained results indicate that students' attitudes toward learning physics and teaching performance, as well as opinions on physics and its importance in everyday life, are connected with their achievement on a test.

In their study, Perkins et al. (2004) observed positive correlations between student beliefs and conceptual learning gains. Also, students who come into a course with more favourable beliefs are more likely to achieve high learning gains. The survey by Harper et al. (2003) indicated that it is possible to make some prediction about student achievement on conceptual tests purely based on the types of questions they ask in their reports. In particular, encouragement of high-level questions about how the content knowledge of the course is structured is related to better conceptual understanding.

Additional difference analyses. Significant gender differences have been determined in some students' attitudes and should be additionally taken into account. These results are presented in Table 5 and in Figure 1.

Table 5: Gender differences in six attitudes toward learning physics.

Attitudes toward learning physics	Boys *M*	Girls *M*	ANOVA *F* (*p*)
Attitude 1	2.95	2.65	*F*(1,554) = 14.286 (*p* =.000)
Attitude 8	1.82	1.63	*F*(1,5543 = 5.366 (*p* =.021)
Attitude 13	2.44	2.15	*F*(1,550) = 12.352 (*p* =.000)
Attitude 15	2.53	2.26	*F*(1,539) = 10.280 (*p* =.001)
Attitude 24	2.70	2.40	*F*(1,551) = 10.650 (*p* =.001)
Attitude 25	2.87	2.53	*F*(1,549) = 13.903 (*p* =.000)

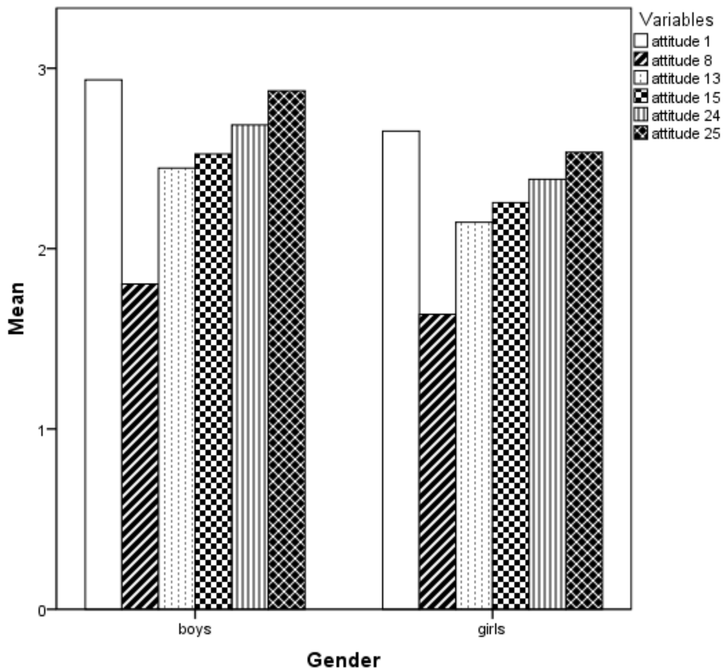

Figure 1: Gender differences in six attitudes toward learning physics.

All differences are in favour of boys; i.e., boys demonstrated more positive 6 attitudes toward learning physics than girls:

- "Physics is interesting to me."
- "Teaching physics sometimes takes place outside the classroom (nature, museums, various structures and institutions in the city)."
- "While solving physics problem I always try to predict the value I have to calculate."
- "There is usually only one correct way of dealing with a physical task."
- "It's important to me to continue studying physics in high school."
- "For further learning physics attracts me because of its application in new technologies."

Two interaction effects of learning outcomes and gender were determined, as indicated in Figures 2 and 3. Boys who have a low score on the test significantly show higher agreement with attitudes 18 and 21 than those with higher scores:

- "18. Physics can be explained without mathematical expressions (formulas)."
- "21. Physics can rarely be connected with my everyday situations and experience."

For girls, the result is completely the opposite. The girls who have a low score on the test, significantly show lower agreement with these two attitudes.

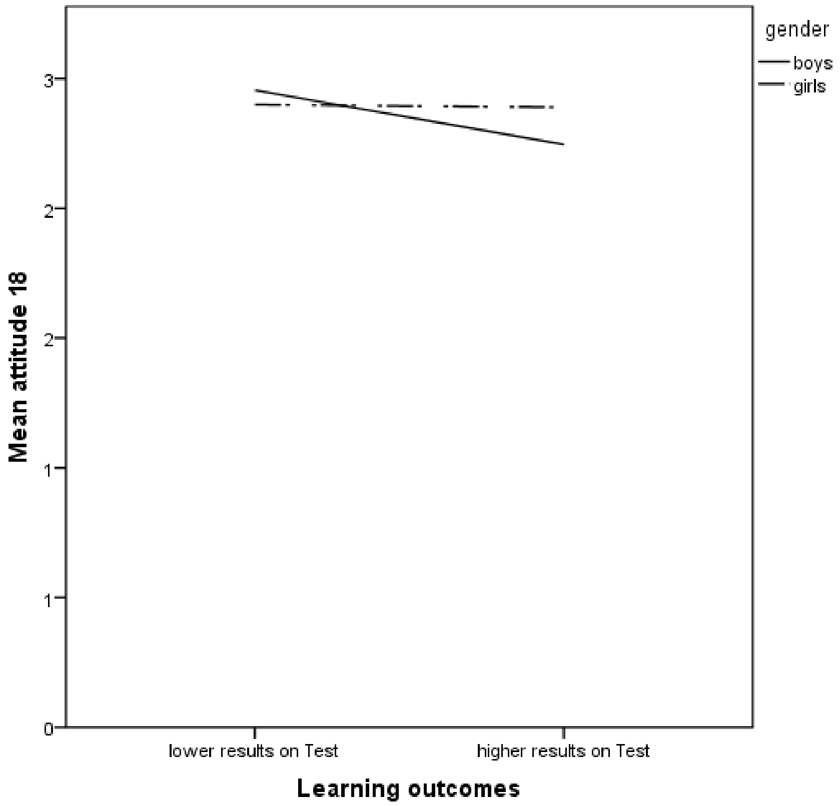

Figure 2: Significant interaction effect of gender and learning outcomes regarding the 18th attitude toward learning physics.

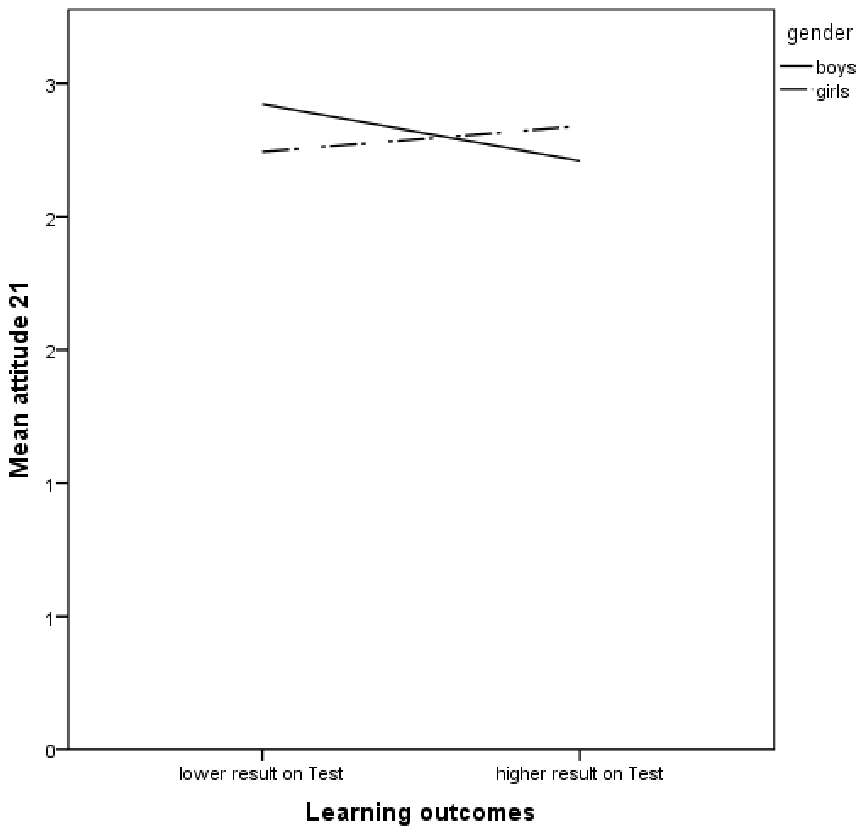

Figure 3: Significant interaction effect of gender and learning outcomes regarding the 21st attitude toward learning physics.

The research concluded that boys and girls have different perceptions of physics as a subject. These results may also be explained by the fact that the sample is random. The study by van Rossum and Schenk indicated that student gender is very strongly related to the study strategy. Also, female students have a significantly increased reproductive approach to learning.

The CLASS showed that the responses to nearly half the statements indicate significant gender differences. Comparing male and female students' responses in the same classes, female students are generally less compliant in the "real world connections", "personal interest", "problem solving confidence", and "problem solving sophistication" categories statements. On the other hand, the results are minimally more compliant in some "sense-making/effort" type statements. The calculus-based course results indicate minor gender differences, but there are still significant differences, particularly in the "real world connections" and "personal interest" categories (Adams et al., 2006).

Conclusion

The conducted research indicated that student attitudes toward learning physics may be a possible predictor of their achievements (outcomes). Students with more positive attitudes towards physics achieved improved scores in the knowledge tests. In addition, the research also established that there is a positive correlation between student attitudes and their achievements. Significant gender differences have been determined in some students' attitudes, which may be attributed to a different female or male students' approach to learning and teaching.

According to these research results, innovative teaching methods in physics education should be implemented through problem oriented education based on experiments, by putting the physics content in a real context, by collaborating studying through the students' projects, including more outdoor/indoor classes with physical activities in order to increase intellectual engagement, and by using different methods of teaching.

Finally, some specific guidelines for future research have been postulated. Future research should investigate the influence and possible implementation of innovative teaching methods in physics education and to determine methods of stimulating students by physical and mental activities or by making experiments and demonstrations using modern technology.

The content analysis of students' attitudes implied that applied physics would be the most understandable to students and that innovative teaching methods would improve their attitudes and learning outcomes in physics. Students with more positive attitudes towards physics achieve better scores in knowledge tests. All 25 attitudes taken together significantly predict students' learning outcomes. Finally, the research determined that students' attitudes toward learning physics implied that certain modifications in applied teaching methods are necessary.

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