Original Article

THE USE OF INVIGILATED EXAMS IMPROVED STUDENTS' ATTITUDES TOWARDS BIOPHYSICS: A QUASI-EXPERIMENTAL STUDY

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Abstract

Introduction: Negative attitudes and insufficient motivation to study can contribute to poor outcomes when teaching biophysics. Fear of failure can be alleviated by using invigilated exams. The aim of this study was to investigate whether invigilated exams impact students' self-reported effort to study, their attitudes, and the factors that promote academic performance.
Methods: A single-group post-test quasi-experimental study was conducted to explore the attitudes of a sample population. Data was collected using a questionnaire specifically developed for this study. The sample consisted of 472 students from four consecutive academic years (generations). Descriptive statistical methods were applied for data analysis, and average values were compared using the Student's t-test.
Results: Over 80% of students in the first generation reported a high level of fear of failure. After the introduction of new examination methods, this number decreased significantly by more than 20% ($p < 0.001$, $P = 1$). Concurrently, the time spent studying increased by over 40% ($p = 0.006$, $P = 88$). Furthermore, nearly all students (99%) believed that using information and communication technology (ICT) and social networks enhanced their academic success.
Conclusion: The findings indicate that information and communication technology have a positive, though limited, effect on students' motivation to learn biophysics and their attitudes toward the subject.

Keywords: learning, physics, academic performance, students, health, internet.

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Introduction

Physics provides fundamental knowledge across all scientific disciplines that involve matter and energy, including living systems. It is based on a model approach that enables the prediction of system behavior, which can then be manipulated. In health and medical sciences, understanding the mechanisms of diseases is crucial, making physics—particularly biophysics—a powerful tool. Ultimately, the goal of health and medical sciences is to understand the origins of physiological and pathophysiological processes. Additionally, biophysics helps explain the interactions of living beings with foreign objects and provides insight into the body's interior (e.g., various imaging techniques). As a result, biophysics is integral to diagnostics, therapy, and prevention[1].

Mastering fundamental approaches in physics enables students to develop a critical perspective on problem-solving. They learn to break down complex problems into manageable parts, cultivate patience, and estimate the effort required to solve the problem. Solving problems in health and medical sciences often requires collaboration and teamwork, necessitating assistance from other fields of knowledge [2]. This interdisciplinary and transdisciplinary teamwork proves effective, especially when individuals possess some knowledge of all the involved disciplines[3,4]. Given these factors, it is highly beneficial for health sciences students to study physics and biophysics.

However, motivation to learn and acquire new knowledge depends on various factors, including interest, curiosity, effort, time, financial resources, age, experiences, and the methods used in the educational process [5,6]. Students who are highly motivated to learn attain deeper knowledge with long-term retention[7]. There have been calls for better physics education for future health and life scientists, but students who do not major in physics are often insufficiently motivated to study it [8,9].

Invigilated examinations are considered a negative motivation factor by some students. The open-book examination format was first introduced in [10] to reduce fear and emotional blockages [11,12], but open-book exams can, on the other hand, lead to a decrease in study effort [13,14] and motivation for study. The use of information and communication technology (ICT)—such as computers, tablets, audio devices, cameras, mobile phones, software, educational materials (e.g., texts, movies, cartoons, animations), the internet, and social networks[15]present an opportunity to improve health science students' attitudes toward biophysics. Electronic devices have improved performance in many scientific fields and in everyday life. Including these methods seems to better simulate reality compared to situations where the student is isolated[16.]. However, lecturers often equate the use of electronic devices during exams with cheating [17]. Some educational institutions explicitly prohibit mobile phones and electronic devices during exams. We believe that the fear and outrage of lecturers could be overcome by finding effective ways to use new tools and methods in teaching physics. This work reports on our attempt to improve students' performance, motivation to learn biophysics, and attitudes toward biophysics by introducing information and communication technology into the study, particularly in examination activities.

The purpose of this study was to explore students' views on overall devotion and attitudes toward biophysics, as well as their perceptions of problem-solving. Specifically, we aimed to investigate whether invigilated exams influence students' self-reported study effort, attitudes, and factors that facilitate academic performance.

Materials and Methods

Study Design

A single-group post-test quasi-experimental study was conducted on a sample of 471 health sciences students. As part of this quasi-experiment, students participated in a 4-hour physics problem-solving session (PPSS), which involved solving problems related to orthopedic clinical conditions. The task was to produce (calculate) a biomechanical analysis using information and communication technology. After completing the PPSS, students were given a questionnaire to assess both extrinsic and intrinsic motivation factors for learning biophysics, to express their attitudes toward the problem-solving methods, and to evaluate the usefulness of these methods for their academic success.

The Instrument

A general questionnaire was developed based on a literature review[7,14,19]. The questionnaire covered three major themes: 1) questions related to students' overall devotion to biophysics, 2) students' perceptions of biophysics, and 3) self-assessed facilitators of academic performance. The questionnaire included 22 statements, with responses given in a simple yes/no format, a 1-5 Likert scale ranking, and a rating of the statements by importance (from 1 to 8). The questionnaire did not include demographic data as the sample consisted of first-year full-time students.

The Sample

First-year students from four study programs at the Faculty of Health Sciences, University of Ljubljana, were invited to participate in the study. Responses were collected from 472 students (2013: n=193, 100%; 2014: n=123, 100%; 2015: n=81, 100%; 2016: n=75, 100%) (Tables 1-3). Participation was voluntary, and anonymity was ensured as no personal data were collected.

Data Analysis

Average values and standard deviations were calculated for each parameter in each generation and overall. When applicable, the average values were compared using the t-test. The statistical significance of the differences was determined by the probability (p) and statistical power (P) of the difference at $\alpha = 0.05$.

Ethics

The institution granted approval to conduct this research.

Results

Students' view on overall devotion to the biophysics

The human body is subject to laws of physics, so in question 1 (Q1) in Table 1 we failed to reach 100% positive answers by 2%. Considering all four generations, the students studied on average 15 hours to prepare for the problem solving. Most satisfying was that the time spent for study during preparation for problem solving increased considerably after introduction of new methods in 2012/2013 and stayed about the same in 2014/2015, but decreased again in 2015/16 (Table 1, Q2). The difference between 2012/2013 and 2013/2014 generations' results was statistically significant with sufficient statistical power (p=0.006, P=0.88). 77% of students wished to study more (Table 1, Q3) while 64% were not satisfied with their knowledge of biophysics, regardless of their success at exam (Table 1, Q4).

Table 1: Students' view on overall devotion to the biophysics considering generations of academic years 2012/2013. 2013/2014. 2014/2015 and 2015/16.

	Study year	2012/2013		2013/2014		2014/2015		2015/16		Overall	
	Sample size	193		123		81		74		471	
	Portion of positive answers or numeric result	No.	%	No.	%	No.	%	No.	%	No.	%
1.	Human body is subjected to laws of physics.	184	95.3	116	94,3	79	97.5	74	100.0	454	96.4
2	How many hours aside of lectures did you study biophysics?	126	65.3	96	78.1	75	92.6	73	98.6	370	78.6
3	I could not study as much as I wished to.	173	89.6	115	93.5	79	97.5	74	100.0	441	93.6
4	Regardless of success at examination I am not satisfied with my knowledge on biophysics.	149	77.2	112	91.1	75	92.6	73	98.6	409	86.8

Continuation of Table 1.

5	I'm happy when I solve a physical problem.	188	97.4	121	98.4	80	98.8	74	100.0	464	98.5
6	It happened to me that I quit studying because I couldn't solve a problem.	187	96.7	118	95.9	78	96.3	74	100.0	457	97.0
7	It came to my mind that I will never pass the biophysics exam.	185	95.8	121	98.4	80	98.8	74	100.0	461	97.9
8	Fear of failure was positive as I studied more.	166	86.0	116	94.3	75	92.6	74	100.0	432	91.7
10	Grade the biophysics course on a scale from 1-5 according to how demanding it was (1-not demanding, 5-very demanding)	192	99.5	123	100.0	81	100.0	74	100,0	470	99.9

Table 2: **Students' perceptions toward biophysics considering generations of academic years 2012/2013. 2013/2014. 2014/2015 and 2015/16.**

	Study year	2012/2013		2013/2014		2014/2015		2015/16		Overall	
	Sample size	193		123		81		75		472	
	Portion of positive answers	No.	%	No.	%	No.	%	No.	%	No.	%
1.	I believe that understanding physical phenomena would be useful in my future work.	163	84.5	111	90.2	76	93.8	75	100.0	425	90.0
2.	I don’t know how I could use physics in my future work.	165	85.5	113	91.9	77	95.1	74	98.7	429	90.9
3	I think I understand some physical phenomena.	175	90.7	117	95.1	80	98.8	75	100.0	447	94.7
4	I have learned of physical phenomenawhich I do not fully understand.	164	85.0	112	91.1	79	97.5	72	96.0	427	90.5

Almost all students (97%) are happy when they solve a physical problem (Table 1, Q5) while it happened to as many as 27% that the failure to solve the problem was so distressing that they stopped studying (Table 1, Q6). A very high percentage (76%) of students were presented with fear that they will never be able to pass the exam (Table 1, Q7). When the new methods were introduced, this percent was 84%. It dropped considerably and statistically significantly (for 20%, $p < 0.001$, $P = 1$) in the next year, possibly because the students learned from their seniors of high success in the previous year. Nevertheless, the percentage of students that feared that they would never pass the exam remained high (more than 60%, Table 2). Only 57% of students found fear stimulating to study more while 38% found it a cause of poor effectivity (Table 1, Q8 and Q9, respectively). Students rated biophysics a difficult subject (4.36 out of 5, Table 1, Q10), but some of them (23%) were positively surprised at their performance (Table 1, Q11).

Students' perceptions toward biophysics

Most students (86%) think that understanding physical phenomena would be useful in their future work, but only 35% have an idea how this will take shape (Table 2, Q1 and Q2, respectively). Most students (93%) thought that they understand some physical phenomena (Table 2, Q3) which is a fair result. But only 87% of students were critical and acknowledged that they learned of phenomena they did not understand (Table 2, Q4). Only 3% of students claimed that they were bored while almost all students (99%) have learned something new (Table 2, Q5 and Q6, respectively). These results indicate positive attitudes of students towards biophysics, as most of them believe that it will be useful to them and that they are able to understand at least some of it. As regards the contents of the course, it was new and interesting to almost all students, however, apparently not enough evidence was presented for them to see how physics and biophysics can be used in their profession and not enough knowledge was gathered for them to attain a critical point of view.

Assessed facilitators of academic performance

In can be seen from Table 3 that students of all four generations thought that perception ability it is the most important, followed by the impact of the lecturer. Persistence in study and positive attitudes towards biophysics turned out close in importance while classical disciplines literature, peer counseling, enough time and peaceful environment were counted lower. In preparing for the PPSS Internet was at the bottom of the list. However, students were unanimous (100%) that use of internet and electronic devices increased their success when they had to perform (Table 1, Q12).

Discussion

Pickens[18] defined attitude as a mindset or tendency to act in a particular way due to both an individual's experience and temperament. In science education, four areas of attitude objects have been identified[19] : attitudes toward the science subject itself, attitudes toward learning the science subject, attitudes toward the topics and themes covered in a particular course, and attitudes toward the methods of science. Attitudes are developed through experience and exert a directive and/or dynamic influence on behavior [6,19]. Moreover, attitudes tend to be relatively stable and often lead to consistent patterns of behavior [22], while negative attitudes can have potentially harmful effects at personal, social, or national levels[19] . Students' academic success is correlated with their attitudes toward physics [9],[22].

To improve students' attitudes toward biophysics, we introduced the use of information and communication technology (ICT) in problem-solving activities. We tracked the responses of students in four consecutive generations regarding their devotion to and attitudes toward biophysics. Our findings showed that most students found

biophysics useful and interesting, a sentiment that did not change with the introduction of new methods. However, students initially expressed a high level of fear of failure, which significantly decreased after the new methods were introduced (Table 1, Q7). This change was accompanied by an increase in the time spent studying (Table 1, Q2). Furthermore, allowing unlimited resources (thus eliminating cheating) did not automatically lead to successful problem-solving or high-quality presentations of solutions.

While fear of failure had some short-term positive effects—students claimed they studied more to avoid failure—we believe that the positive impact of fear is only temporary. In the long term, it does not outweigh the negative effect of turning students away from biophysics. We argue that motivation driven by genuine interest in the subject, rather than fear of failure, will yield long-term benefits. This type of motivation encourages students to engage with the methods and continue expanding their knowledge throughout their professional lives.

It is during early high school or even primary school years that students tend to develop negative attitudes toward physics [6.] We believe that the high degree of fear in our students results from values imposed by teaching processes in primary and secondary schools. In these systems, students must solve problems with known solutions without mistakes to achieve high scores. Furthermore, "understanding" the phenomena is often emphasized, which sets physics apart from subjects that primarily require rote memorization[23]. Teaching non-physicists at the university level presents additional challenges. For health sciences students, biophysics should be integrated into the respective fields and address relevant, often complex problems. These problems are usually not well-understood by anyone, and the conventional approach of manipulating already known solutions is of little help. Additionally, insisting on complete understanding at every stage of the problem-solving process is counterproductive; not understanding the phenomena is often the driving force behind scientific inquiry.

A lecturer who practices science in both physics and health sciences can present students with original and relevant problems. These problems may not yet have solutions, and the lecturer must be willing to set aside their pride and use cutting-edge methods to invite students to propose potential solutions. Students will learn that accepting the frustration of not understanding a problem is an essential part of contributing to the process.

Previous studies have indicated that physics lecturers can play a crucial role in increasing students' interest, motivation, and satisfaction as well as in fostering motivation through personal approaches, appropriate teaching methods, and assessments[26,27]. Our results show that students also found the lecturer's impact to be an important factor (Tables 3 and 4), which aligns with previous findings. The introduction of ICT into physics teaching further enhances the lecturer’s role. To encourage the necessary skills for problem-solving—such as using existing knowledge, developing original approaches, improving communication skills, and fostering persistence—the lecturer can provide students with a variety of problems: some with known solutions, others that can be solved by combining existing solutions, and original ones with no known solution. These problems often stem from the lecturer’s own scientific work, establishing a natural connection between science, profession, and teaching Therefore, it is crucial that physics lecturers in health sciences courses (including medicine) are active scientists engaged in both biophysics and health sciences professions.

Table 3: Assessed facilitators of academic performance at PPSS considering the sample of academic years 2012/2013. 2013/2014. 2014/2015 and 2015/16.

	Study year	2012/2013	2013/2014	2014/2015	2015/16	Overall
	Sample size	193	114	76	75	458
	Rank	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1.	Perception ability	3.12 (1.78)	3.33 (1.78)	3.37 (2.10)	3.73 (2.20)	3.32 (2.01)
2.	Lectures and lecturers' guidance	3.31 (2.01)	3.44 (1.86)	3.87 (1.93)	3.77 (1.92)	3.51 (2.44)
3.	Persistence in learning	3.89 (2.03)	4.14 (2.11)	4.24 (2.28)	4.28 (1.84)	4.07 (2.05)
4.	Positive attitudes towards physics	4.20 (2.52)	4.04 (2.65)	4.64 (2.40)	4.03 (2.57)	4.20 (2.56)
5.	Good notebook and other support	4.39 (1.96)	4.12 (2.04)	4.69 (2.04)	4.40 (1.92)	4.38 (2.01)
6.	Peer counselling	5.96 (1.77)	5.09 (2.18)	4.34 (2.44)	4.35 (2.52)	5.21 (2.14)
7.	Enough time and peaceful environment for learning	4.79 (1.85)	5.46 (1.76)	5.57 (1.95)	5.55 (1.76)	5.21 (1.81)
8.	Internet access	6.31 (2.17)	6.26 (2.17)	5.33 (2.38)	5.65 (2.67)	6.03 (2.55)

Conclusion

Our results have shown that information and communication technology can positively affect students' motivation for learning biophysics and their attitudes toward biophysics. However, the internet as a facilitator of academic performance was reported as the least important factor. Students reported that traditional methods, such as lectures and lecturers' guidance, are of great value. This study indicates that invigilated exams might be considered useful in improving the methods of teaching biophysics in health sciences and enhancing students' academic success. Students reported that traditional methods, such as lectures and lecturers' guidance, are of great value.

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Conflict of interest

The authors declare no conflict of ineterest.

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