Original Article

pISSN, eISSN 0125-5614
M Dent J 2018; 38 (3) : 185-191

Relationship of students' performance in physics and related subjects in dental curriculum, Mahidol University

Kawin Sipiyaruk[1], Somkiat Koohawayrojanapakorn[2], Somsak Mitrirattanakul[3], Tawepong Arayapisit[4], Ratchapin L Srisatjaluk[5]

[1] *Dental Hospital, Faculty of Dentistry, Mahidol University*
[2] *Education and Academic Office, Faculty of Dentistry, Mahidol University*
[3] *Department of Masticatory Science, Faculty of Dentistry, Mahidol University*
[4] *Department of Anatomy, Faculty of Dentistry, Mahidol University*
[5] *Department of Oral Microbiology, Faculty of Dentistry, Mahidol University*

Objective: To examine the relationship between basic physics grades and dental students' academic performance in the subsequent physics-related subjects in Mahidol dental curriculum.

Materials and methods: This study employed a quantitative research approach using a retrospective study to examine the relationship between students' performance in basic physics courses (SCPY 153 and SCPY 154) taught in the first year of dental curriculum and physics-related subjects (DTBC 235, DTID 244, DTPS 241, DTPS 242, and DTRD 331) in the subsequent years of Mahidol dental curriculum. The data of a cohort of 322 undergraduates who were studying in the fourth to the final year in academic year 2017 were analyzed using descriptive statistical analysis, Pearson's correlation, and multiple linear regression, with a statistical significance taken at $p < 0.05$.

Results: There were statistically significant correlations between the grades of the two basic physics courses and all five physics-related subjects. However, weaker correlations for those physics-related subjects were found with SCPY 153 ($0.142 \leq r \leq 0.267$), compared to SCPY 154 ($0.300 \leq r \leq 0.444$). According to regression models, SCPY 154 grades significantly and positively influenced grades of all physics-related subjects ($p < 0.001$), whilst grades of SCPY 153 significantly affected only grades of DTID 244.

Conclusion: The two physics grades in the first year had influences on students' academic performance in physics-related courses in the subsequent years. The medical physics course was a predictor of all physics-related dentistry subjects, whist the basic physics course predicts only one dentistry subject.

Keywords: Basic science, Dental curriculum, Dental education, Learning performance, Physics

How to cite: Sipiyaruk K, Koohawayrojanapakorn S, Mitrirattanakul S, Arayapisit T, Srisatjaluk R L. Relationship of students' performance in physics and related subjects in dental curriculum, Mahidol University. M Dent J 2018; 38: 185-191.

Introduction

Basic sciences have been considered as fundamental subjects for healthcare profession education, including pharmacy, medicine, and dentistry. Several studies suggested that basic sciences were found as supportive in medical education. There appeared to be an influence of average grades of basic sciences in the first year on students' performance in the following years. [1] Medical undergraduates were also suggested to have basic science knowledge in order to understand concepts of clinical practices. [2, 3]

Correspondence author: Kawin Sipiyaruk
Dental Hospital Faculty of Dentistry, Mahidol University,
6 Yothi Road, Ratchathewi, Bangkok 10400
Tel: 02-200-7643 Email: kawin.sipiyaruk@gmail.com
Received : 19 July 2018 Accepted : 31 October 2018

Physics is one of the basic science subjects, which its concept is relevant to laws of nature as well as matter and energy. [4] Similar to other basic sciences, physics has been considered essential in dentistry. The application of physics principles in dentistry can comprehensively enhance understanding in physiology of human body including masticatory function, dental prosthesis, orthodontic treatment, as well as dental biomaterial properties and oral radiology. [5-15] This evidence demonstrated the need of physics in dentistry.

Whilst physics principles appear to be necessary for dentistry, there was an argument towards this point. One of our studies found that not all physics topics were perceived by Mahidol dental students as relevant to their curriculum. [16] Another research also reported that physics courses were perceived as not relevant to a dental curriculum by dental undergraduates. [17] However, it could be argued that those students might not realize a relationship between physics and dentistry due to insufficient experience in clinical practice.

Due to the importance of physics in dentistry, not only physics has been generally set as a criterion for a dental school admission, [18-22] but also dental schools, including in Thailand, required students to successfully complete their physics courses as a basic requirement in pre-clinical years. [17, 23-25] Based on our literature review, although there was evidence reporting that academic performance of medical students in basic sciences could affect how well they could perform in the following years, no research regarding a relationship between students' academic performance in physics and its subsequent courses in a dental curriculum was identified. This evidence would help clarify whether or not physics should be set as a criterion for a dental school admission.

Consequently, this study was conducted in order to examine whether there were any influences of physics grades on the subsequent physics-related courses in Mahidol undergraduate dental curriculum. To achieve the aim, specific objectives were set as follows:

1. To explore relationships between physics courses and the subsequent physics-related subjects.

2. To examine whether physics grades could have predicted students' academic performance in the subsequent physics-related courses.

Materials and Methods

Physics and physics-related courses in Mahidol dental curriculum

The structure of the six-year undergraduate dental curriculum of Mahidol University was firstly reviewed by the researchers with discussion with an expert panel to explore whether there were any physics courses as well as their subsequent related subjects to be included in the analysis of this study (Table 1). The selection of the physics-related subjects was decided, based on how physics content as well as its applications are relevant to the subsequent subjects. Finally, two physics didactic courses were found, including 'Basic physics for Medical Science (SCPY 153)' and 'Physics for Medical Science (SCPY 154)', which all first-year dental students were required to register and succeed. When conducting a content review of the second and third years, five subsequent physics-related courses were selected, included 'Physical Principles in Life Science and Dentistry (DTBC 235)', 'Fundamental of Dental Biomaterial Science (DTID 244)', 'Physiology I (DTPS 241)', 'Physiology II (DTPS 242)', and 'Radiology (DTRD 331)'. However, although physics principles could be applied to comprehensively understand content of these courses, only SCPY 154 was a prerequisite for DTBC 235.

Table 1 Physics and related subjects in dental curriculum

Course code	Course name	Credit(s)
Physics courses in the first year		
SCPY 153	Basic Physics for Medical Science	2
SCPY 154	Physics for Medical Science	3
Physics-related courses in the second and third years		
DTBC 235	Physical Principles in Life Science and Dentistry	1
DTID 244	Fundamental of Dental Biomaterial Science	1
DTPS 241	Physiology I	1
DTPS 242	Physiology II	3
DTRD 331	Radiology I	1

Grading systems used to measure students' academic performance

Students' academic performance of each course in Mahidol dental curriculum was measured as a grade, ranging from 'grade A (the best)' to 'grade F (the worst)'. These alphabetical grades were then transformed into a numerical grading system (a 4.0 scale), as follows: 'A' = 4.0; 'B^+' = 3.5; 'B' = 3.0; 'C^+' = 2.5; 'C' = 2.0; 'D^+'= 1.5; 'D' = 1.0; and 'F' = 0.0. However, there was a condition of the grading system in Mahidol dental curriculum, where a 'D' was considered as the lowest passing grade of both first-year physics courses, whilst a 'C' was required for students to pass any subjects in the second year to the final years. In other words, a 'C' was the lowest passing grade for the five physics-related subjects.

Research design

This study employed a quantitative research approach, using a retrospective cohort study to examine the relationship between students' academic performance in the two physics courses arranged in the first year and the five physics-related subjects in the subsequent years of Mahidol dental curriculum. The data analyzed in this study included official students' grades of the seven courses mentioned previously, which were retrieved from the Education and Academic Office, Faculty of Dentistry, Mahidol University. These grades were presented in official student transcripts. The data were retrieved from a record of 322 undergraduates, which were all students who were studying in Year 4 to Year 6 of the six-year dental curriculum in academic year 2017.

Data analysis

The data in this study were analyzed using IBM SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp). Descriptive statistical analysis was employed to present overview of students' grades achieved in each physics and physics-related course, including means and standard deviations. All data were checked for normal distribution. As all variables were normally distributed, Pearson's correlation was computed to explore relationships between the grade of each physics course and the grade of each physics-related subject, with the strength of the correlations was determined by considering a correlation coefficient as follows: [26]

$0.00 \leq$ Correlation coefficient ≤ 0.19 was determined as "Very weak"

$0.20 \leq$ Correlation coefficient ≤ 0.39 was determined as "Weak"

$0.40 \leq$ Correlation coefficient ≤ 0.59 was determined as "Moderate"

0.60 ≤ Correlation coefficient ≤ 0.79 was determined as "Strong"

0.80 ≤ Correlation coefficient ≤ 1.00 was determined as "Very Strong"

Furthermore, multiple linear regression was performed to examine whether physics grades could predict students' academic performance in physics-related courses. Statistical significance was taken at $p < 0.05$.

Ethical approval

Exemption of the ethical review for this study was granted by the Faculty of Dentistry and the Faculty of Pharmacy, Mahidol University, Institutional Review Board (MU-DT/PY-IRB), reference number: COE.No.MU-DT/PY-IRB 2017/023.1708.

Results

Average grades of physics and physics-related courses

The average grades of the two physics courses achieved in the first year were approximately equal, 2.62 for SCPY 153 and 2.68 for SCPY 154. According to the physics-related courses in the subsequent years, the average grades were generally higher than the physics grades, ranging from 2.96 to 3.32, as presented in Table 2.

Correlations between grades of physics and physics-related courses

There were significant correlations ($p < 0.05$) between the average grades of the two physics courses and all of the five physics-related subjects. However, weaker correlations of those physics-related subjects were found in SCPY 153, compared to SCPY 154 (Table 3). To illustrate, correlation coefficients of the correlations between SCPY 153 and its related-subjects ranged from "Very weak" to "Weak", whilst those of SCPY 154 and its related-subjects ranged from "Weak" to "Moderate".

Multiple regression analysis for grades of the physics-related courses as dependent variables

Multiple regression analyses were computed in five models for grades of DTBC 235, DTID 244, DTPS 241, DTPS 242 and DTRD 331 as dependent variables, and those of SCPY 153 and SCPY 154 as independent variables.

According to Table 4, the SCPY 154 grade significantly and positively influenced grades of DTBC 225 ($\beta = 0.355$, $p < 0.001$), DTID 244 ($\beta = 0.311$, $p < 0.001$), DTPS 241 ($\beta = 0.223$, $p < 0.001$), DTPS 242 ($\beta = 0.278$, $p < 0.001$) and DTRD 331 ($\beta = 0.210$, $p < 0.001$). In addition, the grade of SCPY 153 significantly affected the grade of DTID 244 ($\beta = -0.136$, $p < 0.05$). However, no significant effects were found on grades of DTBC 235, DTPS 241, DTPS 242, and DTRD 331. Overall, average grades of physics courses in the first year partly influenced physics-related courses in the second and third years.

Regarding the fit of the regression models, the coefficients of determination or R-squared values for grades of DTBC 235, DTID 244, DTPS 241, DTPS 242 and DTRD 331 were 0.198, 0.186, 0.094, 0.181 and 0.098 respectively. This indicated that the grades of SCPY153 and SCPY154 accounted for 19.8%, 18.6%, 9.4%, 18.1% and 9.8% of the grades of these physics-related courses. In addition, regarding the multicollinearity of the models, the tolerance statistics were 0.601, indicating that there were no highly correlated predictors to be concerned in the models, as the values were more than 0.2. [27]

Table 2 Average grades of physics and physics-related courses

Course	Mean	SD
Physics courses		
SCPY 153	2.62	0.56
SCPY 154	2.68	0.88
Physics-related courses		
DTBC 235	2.96	0.67
DTID 244	3.11	0.54
DTPS 241	3.32	0.56
DTPS 242	3.25	0.57
DTRD 331	3.25	0.57

Table 3 Correlation coefficients between grades of physics and physics-related courses

	DTBC 235	DTID 244	DTPS 241	DTPS 242	DTRD 331
SCPY 153	0.259**	0.180**	0.142*	0.267**	0.186**
SCPY 154	0.444**	0.418**	0.300**	0.425**	0.312**

*Significant at $p < 0.05$, **Significant at $p < 0.01$

Table 4 Multiple regression analyses for grades of the physics-related courses as dependent variables

	DTBC 235		DTID 244		DTPS 241		DTPS 242		DTRD 331	
	β	R^2	β	R^2	β	R^2	β	R^2	β	R^2
SCPY 153	-0.043	0.198	-0.136*	0.186	-0.080	0.094	-0.002	0.181	-0.020	0.098
SCPY 154	0.355***		0.311***		0.223***		0.278***		0.210***	

*Significant at $p < 0.05$, **Significant at $p < 0.01$, ***Significant at $p < 0.001$

Discussion

Based on our findings, average grades of physics courses (SCPY 153 and SCPY 154) students achieved in the first year appeared to be lower than those of the subsequent physics-related subjects (DTBC 235, DTID 244, DTPS 241, DTPS 242, and DTRD 331) in the second and third years. One major reason was that the lowest passing grade was higher in the physics-related subjects (C), compared to the physics courses (D). Therefore, they needed to concentrate on their studies, causing that average grades of the physics-related subjects were higher. In addition, students might prioritize their study in the latter pre-clinical years, as they felt that those subjects were more relevant to their career after graduation.

Our study also found significant correlations between average grades of both physics courses and those of all physics-related subjects. In other words, students who achieved higher grades in the two physics courses in the first year tended to perform well in the five physics-related subjects in the following years. Our findings were consistent with a previous study in undergraduate medical education, which there were correlations between

academic performance of basic sciences in the first year and grade point averages of the following years. [1] However, that study did not identify a relationship between academic performance in physics and subsequent physics-related courses.

When considering the strength of these relationships, SCPY 154 was likely to have greater correlation coefficients, compared to SCPY 153. The stronger relationship of SCPY 154 comparing to SCPY 153 for the academic performance in following dental courses may not due to the content relationship. However, previous study had shown that the content of SCPY 153 was more relevant to dental courses than SCPY 154, [16] which could be explained by the fact that academic performance depends on several factors such as course instructors, course content, and student's background in each subject. To illustrate, surface tension and fluid pressure could be considered as background knowledge for dental biomaterial properties and a cardiovascular system. [8, 13] Another interesting topic of SCPY 153 was 'basic quantum mechanics', which could be applied for x-ray imaging, and computed tomography system. [10, 28] In addition, students might not be familiar with learning styles in the university. There was research informing that learning styles could affect a learning quality. [29, 30] As students were required to study SCPY 153 followed by SCPY 154, they possibly adapted their learning styles and performed better in the latter one.

Our regression models were consistent with the findings of the correlation analysis. SCPY 154 grade could predict students' academic performance in all physics-related courses, whilst the SCPY 153 grade was a predictor for only DTID 244 with a reverse effect. When considering the overall fit and collinearity statistics, the regression models were considered valid; however, the coefficients of determination demonstrated that there were other predictors, in addition to the two physics grades, for students' academic performance in all physics-related courses. This could be considered as a limitation of this research, as only the physics grades were included as predictors. There was evidence that not only physics but also other subjects in the first year could predict grade point averages of the following years. [1] Therefore, further studies should consider other variables in order to explore whether or not they could predict the grades of the physics-related courses. For example, grades of biology and chemistry should also be entered into the regression models.

Conclusions

Based on our findings, there appeared to be relationships between the two physics grades in the first year and the grades of physics-related courses in the following years. In addition, our regression analysis found that the physics grades were considered as predictors for students' academic performance in the subsequent physics-related courses; one of them was a predictor of all physics-related courses, whist the other physics course could predict only one subsequent subject. Apart from the two physics courses, other influencing factors, such as additional subjects, should also be included in the analysis.

References

1. Lynch C, Grant T, McLoughlin P, & Last J. The relevance of basic sciences in undergraduate medical education. *Ir J Med Sci*. 2016; 185(1): 195-201.
2. Woods NN, Brooks LR, & Norman GR. The value of basic science in clinical diagnosis: creating coherence among signs and symptoms. *Med Educ*. 2005; 39(1): 107-12.
3. Pangaro LN. The Role and Value of the Basic Sciences in Medical Education: The perspective of clinical education-students' progress from

understanding to action. ***Med Sci Educ***. 2010; 20: 307-13.
4. Bueche FJ, & Jerde DA. ***Principles of Physics***. 5th edition ed. New York: McGraw-Hill; 1988.
5. Gabel AB. The Role of Physics in Dentistry. ***J Appl Phys***. 1941; 12(10): 712-7.
6. Bidez MW, & Misch CE. Force Transfer in Implant Dentistry: Basic concepts and principles. ***J Oral Implantol***. 1992; 18(3): 264-74.
7. Wiskott HW, Nicholls JI, & Belser UC. Stress Fatigue: Basic principles and prosthodontic implications. ***Int J Prosthodont***. 1995; 8(2): 105-16.
8. Wootton DM, & Ku DN. Fluid Mechanics of Vascular Systems, Diseases, and Thrombosis. ***Annu Rev Biomed Eng***. 1999; 1(1): 299-329.
9. Şahin S, Çehreli MC, & Yalçın E. The Influence of Functional Forces on the Biomechanics of Implant-Supported Prostheses-A review. ***J Dent***. 2002; 30(7): 271-82.
10. Rowlands JA. The physics of computed radiography. ***Phys Med Biol***. 2002; 47(23): R123.
11. Ren Y, Maltha JC, & Kuijpers-Jagtman AM. Optimum Force Magnitude for Orthodontic Tooth Movement: A systematic literature review. ***Angle Orthod***. 2003; 73(1): 86-92.
12. Taylor TD, Wiens J, & Carr A. Evidence-based considerations for removable prosthodontic and dental implant occlusion: A literature review. ***J Prosthet Dent***. 2005; 94(6): 555-60.
13. Baier RE. Surface Behaviour of Biomaterials: The theta surface for biocompatibility. ***J Mater Sci Mater Med***. 2006; 17(11): 1057.
14. Vignon-Clementel IE, Alberto Figueroa C, Jansen KE, & Taylor CA. Outflow boundary conditions for three-dimensional finite element modeling of blood flow and pressure in arteries. ***Comput Methods Appl Mech Eng***. 2006; 195(29): 3776-96.
15. Badawi HM, Toogood RW, Carey JPR, Heo G, & Major PW. Three-Dimensional Orthodontic Force Measurements. ***Am J Orthod Dentofacial Orthop***. 2009; 136(4): 518-28.
16. Koohawayrojanapakorn S, Arayapisit T, Mitrirattanakul S, Srisatjaluk RL, & Sipiyaruk K. Perceptions of Students and Instructors towards Relevance of Physics in Mahidol Dental Curriculum: A questionnaire survey. ***M Dent J***. 2018; 38: 79-90.
17. Humphrey SP, Mathews RE, Kaplan AL, & Beeman CS. Undergraduate basic science preparation for dental school. ***J Dent Educ***. 2002; 66(11): 1252-9.
18. Komabayashi T, Raghuraman K, Raghuraman R, Toda S, Kawamura M, Levine SM, & Bird WF. Dental Education in India and Japan: Implications for U.S. Dental Programs for Foreign-Trained Dentists. ***J Dent Educ***. 2005; 69(4): 461-9.
19. Jedrychowski J, & Lindemann R. Comparing Standardized Measures of Diligence and Achievement with Dental Student Academic Performance. ***J Dent Educ***. 2005; 69(4): 434-9.
20. Komabayashi T, & Åstrom A. Dental education in Norway. ***Eur J Dent Educ***. 2007; 11(4): 245-50.
21. Elangovan S, Allareddy V, Singh F, Taneja P, & Karimbux N. Indian Dental Education in the New Millennium: Challenges and Opportunities. ***J Dent Educ***. 2010; 74(9): 1011-6.
22. Ihm J-J, Lee G, Kim K-K, Jang K-T, & Jin B-H. Who Succeeds at Dental School? Factors Predicting Students' Academic Performance in a Dental School in Republic of Korea. ***J Dent Educ***. 2013; 77(12): 1616-23.
23. Bucur MV, Shanley DB, & Claffey N. Contents of stomatological curricula in Europe. ***Eur J Dent Educ***. 2006; 10(2): 61-6.
24. Komabayashi T, Srisilapanan P, Korwanich N, & Bird WF. Education of dentists in Thailand. ***Int Dent J***. 2007; 57(4): 274-8.
25. Wu ZY, Zhang ZY, Jiang XQ, & Guo L. Comparison of dental education and professional development between mainland China and North America. ***Eur J Dent Educ***. 2010; 14(2): 106-12.
26. Evans JD. ***Straightforward statistics for the behavioral science***: Brooks/Cole Publishing Company; 1996.
27. Field A. ***Discovering statistics using IBM SPSS statistics***. 3rd ed. London: Sage; 2013.
28. Harpen MD. Positronium: Review of symmetry, conserved quantities and decay for the radiological physicist. ***Med Phys***. 2004; 31(1): 57-61.
29. Entwistle N. Teaching and learning in diverse university settings: Analytic frameworks for integrating different data sources. 5th Annual Conference on Teaching and Learning Research Programme; 22-24 November 2004; Cardiff2004.
30. Arevalo CR, Bayne SC, Beeley JA, Brayshaw CJ, Cox MJ, Donaldson NH, Elson BS, Grayden SK, Hatzipanagos S, Johnson LA, Reynolds PA, & Schonwetter DJ. Framework for e-learning assessment in dental education: A global model for the future. ***J Dent Educ***. 2013; 77(5): 564-75.