Original Article

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Perceptions of students and instructors towards relevance of physics in Mahidol Dental curriculum: A questionnaire survey

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

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

Objective: To explore the relevance of physics in Mahidol undergraduate dental curriculum based on perceptions of both instructors and students.

Materials and methods: The study employed a quantitative research method, using a paper-based questionnaire survey. The questionnaire contained questions regarding demographics, perceptions towards relevance of physics in dentistry, and self-perceived importance of physics in dental curriculum. The data were analyzed using descriptive statistics and Spearman's rho.

Results: There were 341 (57.1%) dental undergraduates and 74 (52.1%) instructors who responded to the questionnaire. The most three relevant physics topics for dental curriculum rated by students were Introduction (physical quantity and applications of physics), Fluid mechanics, and Dynamics, whilst those rated by instructors were Basic quantum mechanics, Fluid mechanics, and Introduction. Instructors and students considered Prosthodontics and Orthodontics as relevant subjects to physics, whilst only the instructor group valued Oral and maxillofacial radiology and Implantology as relevant subjects. In addition, 76% of the students believed that content of physics learned in high school was sufficient for dental curriculum, however over a half of the instructors disagreed. Respondents from both students and instructors also believed physics should be used as a part of the dental school admission. From students' view, the credits of physics courses should be deducted to three credits, and some topics should be excluded.

Conclusion: Physics is essential for dental curriculum. However, the current physics courses should be revised; a vertical integration and exclusions of irrelevant topics or topics overlapping with high school physics can be key factors for further curriculum improvements.

Keywords: Basic science, Dental curriculum, Dental education, Physics, School admission

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Introduction

Physics is the branch of science that studies laws of nature and explains matter and energy, which is the most fundamental of all other sciences. [1] Due to this concept, physics is considered as one of the most important subjects in education of science programs. It has been generally taught as a compulsory subject in high schools in order to construct essential knowledge, with an expectation for further application in university programs such as engineering, pharmacy, medicine, and dentistry.

Correspondence author: Kawin Sipiyaruk
Dental Hospital Faculty of Dentistry, Mahidol University, Bangkok, Thailand
Tel: 02-200-7643 Email: kawin.sipiyaruk@gmail.com
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There has been evidence that basic sciences including physics are helpful for medical students. The average grades of basic science courses achieved by medical undergraduates in the first year could influence the scores in subsequent years. [2] Knowledge of basic sciences is one of competences that medical students required to understand concepts of clinical practices. [3, 4] Therefore, basic sciences should be taught in a curriculum to comprehensively enhance knowledge and skills of medical students.

A point of physics application in dentistry has been discussed for a long time. In 1941, the role of physics in dentistry was introduced, which physics principles could be applied to better understand masticatory function or tooth restoration, either mechanical or esthetical aspects (color matching). [5] Later on, physics has been globally considered as an important subject in dental curricula. Dental schools generally set a criterion that their applicants have to successfully complete physics courses in high schools, and/or include physics subjects into entrance examinations. [6-10] Furthermore, dental undergraduates are required to study physics courses in pre-clinical years of dental curricula. [11-13] These requirements have also been applied to Thai dental school. [14]

According to the Doctor of Dental Surgery degree of Mahidol University, physics has been considered as an essential subject for all undergraduates. Not only physics has been required for the entrance examination, but also all first-year dental students are required to study three courses of physics. They are arranged in a total of six credits out of the total of 44 credits during the first year of all health science programs. Those three physic courses include one credit of 'General Physics Laboratory (SCPY110)', two lecture credits of 'Basic Physics for Medical Science (SCPY153)', and three lecture credits of 'Physics for Medical Science (SCPY154)'. In addition, these three subjects are set as prerequisites for 'Physical Principles in Life Science and Dentistry (DTBC235)' course of the second-year dental curriculum.

Despite the fact that physics is considered necessary, it is the subject that put in dispute on dental curriculum revision. In terms of dental school admission, one study has found no correlation between physics grade in high schools and the examination (physics/GPA) scores of the first year of dental curriculum. [15] Another study conducted in the University of Kentucky College of Dentistry in the USA revealed that dental students perceived physics courses as not relevant to dental curriculum and should not be required for admission in the dental school. [11] One possible problem is that students might not have an insight for the application of physics principles in clinical practice. Nevertheless, they did express that physics was essential for studying in pre-clinic classes. [16] For dental curriculum revision and course development, there is limited information in a relevance of physics in dental curricula. Therefore, this study was conducted to explore the relevance of physics in Mahidol undergraduate dental curriculum based on perceptions of both instructors and students in order to put the information into consideration for appropriate content of physics in the dental curriculum.

Materials and methods

Research design

This study employed quantitative research methods (a cross-sectional survey design), using a self-administered questionnaire as a data collection tool to explore perceptions towards physics amongst instructors and students from the Faculty of Dentistry, Mahidol University.

Setting and population

This research was conducted in the Faculty of Dentistry, Mahidol University. Research

population was 142 instructors from 11 departments and 597 dental undergraduates from the first year to sixth year during academic year of 2017. Due to a nature of a quantitative research approach, a large number of samples was expected to represent the population (Morse, 1991). Therefore, this study aimed to include as many as participants from the sample pool.

Data collection tool

The questionnaire was constructed in four parts, derived from relevant literatures, group discussion with educational experts, and physics course syllabi of SCPY153 and SCPY154. Part 1 was relevant to demographics, including sex and age, as well as year of studying and physics grades (from high school and university levels) for dental students, but specialty and work experience for instructors. According to Part 2, there were 27 questions exploring perceptions on relevance of physics topics towards dental curriculum. The questions include the topics arranged in the course syllabi of SCPY153 (13 questions) and SCPY154 (14 questions). The responses were collected using 'Physics Relevant Score (PRS)': 5-point scale ranging from strongly irrelevant to strongly relevant. The option 'Unmeasurable' was also available for respondents who might not be able to recall the information and could not answer a question. Part 3 consisted of 12 questions exploring relevance of physics towards dental specialties. Similar to Part 2, the information was gathered from respondents using PRS. Part 4 was about self-perceived importance of physics in dental curriculum, in accordance with sufficiency of high school' physics for studying dentistry, physics as one of the criteria for dental school admission, and suggested credits of physics courses in dental curriculum.

To test reliability and validity, the questionnaire was piloted in 22 instructors, 25 students from the first to third year classes, and 25 students from the fourth to sixth year classes. The quality of the questionnaire was accepted when Cronbach's Alpha Coefficient was greater than 0.8 for reliability, and index of Item-Objective Congruence of each question was equal to 0.5 point or higher for content validity.

Data collection procedures

The paper-based self-administered questionnaire (student version) was indirectly given to dental students by handing to a student representative of each class (first to sixth year). Students were then asked to complete the questionnaire and return it to a designated area in front of their classrooms. The instructor version of the questionnaire was handed to each instructor directly. When they completed the questionnaire, they were asked to return it to the department secretary. The data collection process was performed between October 2017 and February 2018.

Data analysis

Descriptive statistical analysis was employed to present demographics and opinions of respondents, as well as data regarding relevance of physics towards dentistry (dental curriculum and dental specialties), with mean PRS interpretations classified as follows:

$1.0 \leq PRS < 1.5$ refers to strongly irrelevant

$1.5 \leq PRS < 2.5$ refers to slightly irrelevant

$2.5 \leq PRS < 3.5$ refers to neither relevant or irrelevant

$3.5 \leq PRS < 4.5$ refers to slightly relevant

$4.5 \leq PRS < 5.0$ refers to strongly relevant

In addition, Spearman's rank order correlation (Spearman's rho) was used to analyze the correlation between the PRS level and the physics grades as well as preference towards physics to PRS level; this non-parametric test was required, as the data distributions of physics grades were not normal.

Ethical approval

Ethical approval for this research was granted by the Faculty of Dentistry and the Faculty of Pharmacy, Mahidol University, Institutional Review Board (MU-DT/PY-IRB), reference number: MU-DT/PY-IRB 2017/054.1610.

Results

Reliability and validity of the questionnaire

Following the reliability and validity tests, Cronbach's Alpha Coefficient of each construct was higher than 0.8 for internal consistency reliability, and index of Item-Objective Congruence of each item was between 0.8 and 1 for content validity. Therefore, the questionnaire was considered reliable and valid.

Demographic data

There were 341 dental undergraduates (respond rate 57.1%) and 74 instructors (respond rate 52.1%) who responded to the questionnaire. The numbers of students from each class and instructors from each department were listed in Table 1 and Table 2, respectively. A majority of them were female, 220 (64.5%) students and 43 (58.1%) instructors. The average ages were 21.2 years for students, and 42.3 years for instructors with 15.9 years of work experience. According to the physics grades of the students, the findings clearly showed that the average grade was higher in high schools, compared to grade achieved during the first year of dental school. These data were presented in Table 3.

Table 1 Number of instructors in each specialty

Specialty	n
Oral and Maxillofacial Surgery	17
Endodontics	12
Pediatric Dentistry	12
Prosthodontics	12
Orthodontics	11
Operative dentistry	10
Oral Medicine	9
Periodontology	9
Masticatory Science	7
Oral and Maxillofacial Radiology	8
Pre-clinic	35
Total	142

Table 2 Number of students in each year

Year	n
1st year	80
2nd year	84
3rd year	103
4th year	111
5th year	109
6th year	110
Total	597

Table 3 Demographic data of respondents

	Sex (n)		Age (year)	Physics grades		Work experience (year)
	Male	Female		High school	First year	
1st year	29	40	19.0	3.28	2.38	-
2nd year	22	23	19.7	3.36	1.95	-
3rd year	11	41	20.6	3.60	2.27	-
4th year	20	43	21.8	3.68	2.63	-
5th year	20	36	22.6	3.57	2.57	-
6th year	19	37	23.7	3.52	2.21	-
Total students	121	220	21.2	3.50	2.36	-
Instructors	31	43	42.3	-	-	15.9

Relevance of physics topics towards dental curriculum

Regarding to SCPY153 (Table 4), the findings demonstrated that 'Introduction (physical quantity and applications of physics)' was rated by students as the most relevant topic (PRS=3.5), followed by 'Fluid Mechanics' (PRS=3.2) and 'Dynamics' (PRS=3.0), and these three topics were also considered as relevant by instructors although 'Fluid mechanics' and 'Basic quantum mechanics' achieved the highest score (PRS=4.1). On the other hand, the most irrelevant topics rated by both students and instructors seemed to be 'Kinetics', 'Work and energy', 'Wave and sound', 'Electronics', 'Magnetism', and 'Nuclear physics'. Overall, perceived relevance of each topic was rated higher in the instructor group, compared to the student group. In addition, amongst the students, the final year undergraduates tended to consider most topics as more relevant.

According to results from SCPY154 (Table 5), students rated all topics irrelevant to dental curriculum, which the three most irrelevant topics were 'Special relativity theory', 'Wave function', and 'Schrödinger equation' (PRS=1.6). Although these topics were rated higher in the instructor group, they were considered as the three less relevant topics (PRS=2.4-2.5). Similar to SCPY153, the student group perceived all topics less relevant to dental curriculum, compared with the instructor group. In addition, PRS of SCPY154 rated by both students and instructors appeared to be lower than one of SCPY153.

Table 4 Mean of PRS rated by students and instructors in each topic of SCPY153

	Introduction	Kinetics	Dynamics	Work and energy	Fluid mechanics	Fluid dynamics	Thermal physics	Wave and sound	Optics	Electronics	Magnetism	Basic quantum	Nuclear physics
1st year	3.3	2.5	2.7	2.7	2.9	2.8	2.8	2.7	2.8	2.4	2.3	2.5	2.3
2nd year	3.9	2.8	3.1	2.9	3.4	3.0	3.1	3.0	3.0	2.2	2.0	2.2	1.8
3rd year	3.4	2.5	3.3	2.6	3.1	2.8	3.0	2.3	2.6	2.0	1.9	2.4	1.8
4th year	3.6	2.6	3.1	2.5	3.4	2.8	3.0	2.6	2.9	2.4	2.4	2.8	2.1
5th year	3.5	2.6	2.9	2.5	3.3	2.8	2.7	2.4	2.4	2.3	2.2	2.9	2.3
6th year	3.6	2.9	3.2	3.0	3.4	2.9	2.9	2.7	2.9	2.9	3.0	3.1	2.8
Total students	3.5	2.6	3.0	2.7	3.2	2.8	2.9	2.6	2.8	2.4	2.3	2.6	2.2
Instructors	4.0	3.2	3.8	3.3	4.1	3.8	3.7	3.6	3.7	3.3	3.4	4.1	3.3

Table 5 Mean of PRS rated by students and instructors in each topic of SCPY154

	Rigid body and moment of inertia	Oscillation	Thermodynamics	Diffraction	Gauss's law	Ampere's law	Inductor and capacitor	Special relativity	Blackbody radiation	Wave function	Schrödinger equation	Angular momentum	Atomic nucleus	Nuclear reaction
1st year	2.1	2.2	2.3	2.3	2.2	2.2	2.2	2.0	2.0	2.0	2.1	2.2	2.1	2.0
2nd year	1.7	1.8	2.3	2.0	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.6	1.5
3rd year	1.9	1.8	2.3	2.1	1.6	1.7	1.7	1.4	1.7	1.5	1.4	1.8	1.9	1.5
4th year	1.8	1.7	2.3	1.9	1.5	1.7	1.6	1.4	1.5	1.4	1.5	1.6	1.6	1.4
5th year	2.0	1.7	1.9	1.8	1.4	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5
6th year	2.4	2.3	2.5	2.5	2.2	2.4	2.4	2.0	2.1	2.0	2.0	2.3	2.4	2.3
Total students	2.0	1.9	2.3	2.1	1.8	1.8	1.8	1.6	1.7	1.6	1.6	1.8	1.8	1.7
Instructors	3.0	2.8	2.9	2.9	2.6	2.7	2.7	2.5	2.6	2.4	2.5	2.9	3.0	2.7

Overall, the most five relevant topics rated by students were 'Introduction' (PRS=3.5), 'Fluid mechanics' (PRS=3.2), 'Dynamics' (PRS=3.0), 'Thermal physics' (PRS=2.9), and 'Fluid dynamics' (PRS=2.8), whilst ones valued by instructors were 'Basic quantum mechanics' (PRS=4.1), 'Fluid mechanics' (PRS=4.1), 'Introduction' (PRS=4.0), 'Fluid dynamics' (PRS=3.8), and 'Dynamics' (PRS=3.8). None of the SCPY154 topics achieved these top five rankings. These findings were presented in Table 6.

Relevance of physics towards dental specialties

When considering relevance of physics towards 12 dental specialties (Table 7), both instructors and students considered that physics was relevant to 'Prosthodontics' and 'Orthodontics' ($3.5 \leq PRS < 4.5$), whilst only the instructor group valued 'Oral and maxillofacial radiology' and 'Implantology' as relevant ($3.5 \leq PRS < 4.5$). The findings also presented that 'Community dentistry' and 'Oral medicine' were rated irrelevant by both instructors and students ($1.5 \leq PRS < 2.5$); only the student group considered 'Pedodontics' as irrelevant ($1.5 \leq PRS < 2.5$). The rest were rated by both groups as neither relevant nor irrelevant.

Table 6 The five most relevant physics topics rated by students and instructors

Rank	Students		Instructors	
	Topic	PSR	Topic	PSR
1	Introduction	3.5	Basic quantum mechanics	4.1
2	Fluid mechanics	3.2	Fluid mechanics	4.1
3	Dynamics	3.0	Introduction	4.0
4	Thermal physics	2.9	Fluid Dynamics	3.8
5	Fluid dynamics	2.8	Dynamics	3.8

Table 7 Relevance of physics towards dental specialties (PRS)

	Oral & maxillofacial surgery	Periodontology	Pedodontics	Prosthodontics	Community dentistry	Masticatory Science	Oral medicine	Oral & maxillofacial radiology	Endodontics	Orthodontics	Operative dentistry	Implantology
1st year	3.2	3.0	2.9	3.4	2.8	3.4	3.0	3.4	3.3	3.6	3.1	3.2
2nd year	2.6	2.2	2.3	3.0	2.0	2.8	2.2	3.1	2.5	3.2	2.7	2.5
3rd year	2.8	2.3	2.0	3.5	1.6	2.9	1.9	2.9	2.3	3.7	2.4	2.7
4th year	3.7	2.5	1.9	3.8	1.5	3.1	1.7	3.5	2.6	4.1	2.8	3.6
5th year	3.6	2.5	2.1	3.7	1.5	3.0	1.8	3.5	2.5	3.8	2.6	3.3
6th year	3.6	2.7	2.2	3.9	2.0	3.2	2.0	3.7	2.8	4.2	2.9	3.8
Total students	3.4	2.6	2.2	3.6	1.9	3.1	2.0	3.4	2.7	3.8	2.8	3.3
Instructors	3.3	2.9	2.6	4.1	2.1	3.4	2.3	4.2	3.2	4.0	3.3	3.8

Self-perceived importance of physics in dental curriculum

When considering sufficiency of physics content learned during high school for dental education, a majority of the students (76%) believed that it was sufficient, however marginally more than half of the instructors (52.7%) disagreed. Both students and instructors were asked whether physics should be used as a part of the dental school admission. Only 13.5% of the students and 4.1% of the instructors did not agree with keeping physics as a subject for the dental school admission. In addition, most of the respondents believed physics to be used as an admission subject, with the suggested proportion of 40% of total basic science admission score (Table 8).

Regarding to the suggested number of physics credits in dental curriculum, responses were varied. Whilst over two-thirds of respondents suggested physics credits to be reduced, approximately 20% of students and instructors believed that the amount of six credits was appropriate. Among those who agreed with the credit reduction, a majority of the students (27%) and the instructors (24.3%) suggested that the physics credits should be deducted to only three credits. Most of them (61.9% of students and 75.7% of instructors) further suggested that some topics of the physics should be excluded.

Correlations amongst PRSs and physics grades

The analysis found that PRS of SCPY153 significantly correlated with PRS of SCPY154 ($p<0.01$). In addition, there was a significant correlation between the high school physics grade and the first-year physics grade in dental school ($p<0.01$). PRSs of both subjects also significantly correlated with the first-year physics grade ($p<0.01$). However, no significant correlations between the two PRSs and the high school physics grade were found. These results are presented in Table 9.

Table 8 Physics as a criterion for the dental school admission (%)

	Not used as a criterion	Used as a criterion (as a part of basic science subject score)			
		<40%	04%	>40%	100%
1st year	17.4	17.4	50.7	7.3	7.3
2nd year	13.3	15.6	37.8	8.9	24.4
3rd year	9.6	23.1	38.5	11.5	17.3
4th year	14.3	25.4	34.9	7.9	17.5
5th year	8.9	23.2	42.9	14.3	10.7
6th year	16.1	10.7	48.2	8.9	16.1
Total students	13.5	19.4	42.5	9.7	15.0
Instructors	4.1	9.5	40.5	28.4	17.6

Table 9 Correlations amongst PRSs and physics grades

	High school physics grade	First-year physics grade	PRS in SCPY153	PRS in SCPY154
High school physics grade		0.25**	0.08	0.05
First-year physics grade			0.16**	0.16**
PRS in SCPY153				0.67**
PRS in SCPY154				

** Significant at $p<0.01$

Discussion

Relevance of physics in dentistry

The findings of this study demonstrated that not all of the physics topics in SCPY153 and SCPY154 were relevant to dental curriculum. The topics rated most relevant by both students and instructors appeared to be 'Introduction' and 'Fluid mechanics'. Interestingly, as the 'Introduction' topic provided information on how physics could be applied for other fields including medicine and dentistry, respondents clearly considered it as relevant. According to the 'Fluid mechanics' topic, Pascal's law (fluid pressure), Archimedes' principle, and surface tension were introduced; these could be used to describe physiology of cardiovascular system and dental biomaterial properties, [17-19] thus respondents rated this topic as relevant.

Surprisingly, 'Basic quantum mechanics' achieved the highest PRS amongst instructors but lower in the student group. This topic provided knowledge regarding atomic physics, x-ray imaging, and computed tomography system. Dental radiography was commonly used as diagnostic aids, e.g. proximal carious detection. However, dental undergraduates might lack of clinical experience, and therefore they consider this topic less relevant than instructors. This was consistent to the findings that instructors rated physics as more relevant to 'Oral and maxillofacial radiology', compared to the students. Other physics topics were considered by respondents as less relevant, because they seemed beyond the use in dental curriculum, such as 'Magnetism' and 'Wave function' as well as all topics contained in SCPY154.

In terms of dental specialties, in addition to 'Oral and maxillofacial radiology' discussed above, 'Prosthodontics' and 'Orthodontics' were rated as most relevant to physics in both groups of respondents, whilst the relevance of 'Implantology' was agreed by only among instructors. Adding to this, the six-year dental students showed the higher PRS in 'Oral and maxillofacial radiology' and 'Implantology' than other years and comparable to the instructors. These four specialties required knowledge and understanding in the principle of forces, [20-25] which was introduced in the 'Kinetics' topic. However, it was not considered as the most relevant, as this topic in SCPY153 might contain other knowledge that was beyond the application in dentistry.

Physics as a criterion for dental school admission

This study revealed that most respondents agreed with a physics subject as a part of dental school admission. In other words, respondents in our research believed that basic knowledge learned in high schools could affect learning performance in dental curriculum. This argument was supported by the evidence that a significant correlation between the high school physics grade and the first-year physics grade was found. However, our findings were not consistent with the results from a research in University of Kentucky College of Dentistry, which dental students

perceived that physics should not be required for the dental school admission. [11] In addition, another research found that the physics grade in high schools did not correlate with the natural science performance arranged after the first year in the dental school, [15] which could be argued that the natural science course did not contain only physics but also chemistry and biology.

Potential changes of physic in dental curriculum

Most of the respondents suggested physics credits to be deducted, ranging from six to three credits. They also suggested that some physics topics should be excluded. Together with the fact that several physics topics were considered as not relevant to dentistry, some of them might be removed from the physics courses, especially in SCPY154.

Should not only the irreverent topics be concerned, but also the content that has already been studied should be revised. Following the curriculum changes of Chinese dental schools in the 1990s, where the proportion of basic science was reduced from 20% to 18%, by deleting the content that was already taught in high schools. [26] Based on our findings, most students agreed that physics studied in high school is sufficient for studying in dental schools although 52.7% of teachers disagreed with that. Although students and instructors had opposing opinions towards sufficiency of high school physics for studying in dental curriculum, there seemed to be the content in dental curriculum that requiring revision, as some had already been taught in high schools. In this case, the proportion and the scores of physics in dental admission should be considered.

In addition to the content removal, physics can be modified as an applied course to enhance its application in real situations. It should be illustrated how physics could be applied for the use in biological systems and medical instruments. This will improve understanding of fundamental physics concepts through biomedicine. [27] In addition, there were some relevant topics students rated as irrelevant, possibly due to the lack of dental experience. This suggests that certain physics courses should be incorporated in the later years of dental curriculum, rather than only during the first or second year. This vertical integration will support students to recognize relevance of physics in dentistry, as they have more experience from other subjects in the curriculum.

Limitations

This research employed a quantitative research method, using a paper-based questionnaire as a survey tool; one strength of this technique was an ability to collect information from a large number of respondents in a short period. However, there was limitation in exploring in-depth information from research participants. Further studies should be conducted using a qualitative research approach to enhance understanding in order to fulfil this gap. In addition, this research was conducted in only Mahidol dental school; multi-site research in other dental schools should be performed, as there may be any other factors that can affect physics education in dental curricula.

Conclusions

Based on the perceptions from both instructors and students, physics was important for dental curriculum although certain topics of the physics courses in Mahidol University were considered irrelevant by both students and instructors. Due to time constraints of the dental curriculum, irrelevant topics or topics overlapping with high school physics may be excluded for the deduction of the physics credits. In addition, a vertical integration can also be considered for further curriculum improvements.

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