Educación Médica 24 (2023) 100797

Educación Médica

www.elsevier.es/edumed

ORIGINAL ARTICLE

How do college courses and materials affect students' logical thinking of the Medical College at Al Baath University in Syria

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Received 12 July 2022; accepted 9 January 2023
Available online 26 February 2023

KEYWORDS
Logical thinking;
TOLT;
Education outcomes;
Academic achievements;
Problem-solving;
Medical students

Abstract
Background: Logical thinking is a mental process that helps individuals create sensible solutions and is associated with their academic performance. Although it is crucial in many fields like science and engineering, we have not found any papers on logical thinking in Syrian Medicine college students.
Methods: This study administered the TOLT[1] to assess logical thinking for medicine college students at Al Baath University. The sample was 188 participants from different years (N = 188). We analyzed the data using Python (a programming language).
Results: This study found that college courses and materials do not contribute to developing logical thinking abilities for Medical college's students at Al Baath University over the program years, where the sixth and last year scored the lowest Mean among all years. Most of the participants had better logical thinking at secondary school than now at college. Males scored higher Mean than females at TOLT.
Conclusion: This study expects no development of students' logical thinking in medical college at Al Baath University in all academic years. It suggests developing college courses and materials to enhance students' logical thinking abilities for their importance in clinical careers.

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[1] **TOLT**: Test Of Logical Thinking.

https://doi.org/10.1016/j.edumed.2023.100797

PALABRAS CLAVE
Pensamiento Lógico;
TOLT;
Resultados Educativos;
Logros Académicos;
Resolución de Problemas;
Estudiantes de Medicina

Cómo afectan los cursos y materiales universitarios al pensamiento lógico de los estudiantes de la Facultad de Medicina de la Universidad Al Baath de Siria

Resumen
Antecedentes: El pensamiento lógico es un proceso mental que ayuda a los individuos a crear soluciones sensatas y está asociado a su rendimiento académico. Aunque es crucial en muchos campos como la ciencia y la ingeniería, no hemos encontrado ningún trabajo sobre el pensamiento lógico en estudiantes universitarios de Medicina de Siria.
Métodos: Este estudio administró el TOLT para evaluar el pensamiento lógico de los estudiantes universitarios de medicina de la Universidad Al Baath. La muestra fue de 188 participantes de diferentes años (N = 188). Se analizaron los datos utilizando Python (un lenguaje de programación).
Resultados: Este estudio descubrió que los cursos y materiales universitarios no contribuyen a desarrollar las habilidades de pensamiento lógico de los estudiantes de la facultad de Medicina de la Universidad Al Baath a lo largo de los años del programa, donde el sexto y último año obtuvieron la media más baja de todos los años. La mayoría de los participantes tenían un mejor pensamiento lógico en la escuela secundaria que ahora en la universidad. Los hombres obtuvieron una media más alta que las mujeres en el TOLT.
Conclusiones: Este estudio no prevé el desarrollo del pensamiento lógico de los estudiantes en la facultad de medicina de la Universidad Al Baath en todos los años académicos. Sugiere que se desarrollen cursos y materiales universitarios para mejorar las habilidades de pensamiento lógico de los estudiantes por su importancia en las carreras clínicas.

Introduction

The diagnosis process needs several steps, involving patient examination, collecting and interpreting data, and extracting results. However, a doctor may make a mistake at any step, which leads to errors in the management of the healthcare process. Consequently, healthcare needs solutions to reduce diagnosis mistakes. Critical thinking alongside logical thinking is one of the solutions, where the doctors who use them both are more likely to make a correct diagnosis than other doctors.[1]

Logical thinking like critical thinking is a mental process that helps individuals identify ideas in a structured manner to present a problem in a better form, which leads to creating sensible solutions. Logical thinking uses deductive methods, while Critical thinking uses reasoning methods including logical thinking.[1–3]

Logical thinking skills are crucial for cognitive achievement since it includes different items. For example, proportional reasoning aids individuals with understanding tables and charts. As a result, they can conclude and formulate hypotheses while discovering correlations between variables. While controlling variables is essential in planning, executing, and interpretation, it requires probabilistic reasoning to investigate and observe interpreted data.[3–5]

Logical thinking and critical thinking are crucial and developable through university or school courses. So, developing them must be a top priority in education.[5–7]

Lots of medical college courses at Al Baath University use the spoon-feeding technique and lack methods or materials to develop logical thinking like charts and critical thinking problems, which raises a concern about how college courses affect students' logical thinking abilities and how they affect their ability to solve clinical problems and do research.

To the best of our knowledge, this study is the first of it is kind to assess medical college students' logical thinking in Syria and Al Baath University. It will provide indicators of the current college courses' ability to develop logical thinking, so it will help to decide whether current courses and materials require improvement. This study aims to assess the logical thinking of medical college students at Al Baath University in Syria. We investigated whether college courses and materials affect students' logical thinking abilities and whether there was a difference between females' and males' abilities.

Methods

This study depends on the descriptive analysis method, where statistics indicate whether college courses develop students' logical thinking or not.

Our sample consisted of 188 participating students at Al Baath University medical college, where 57.45% are females. We obtained it from the cohort of academic years 2 to 6 and excluded first-year students, because the first year is preparatory and includes medicine, dentistry, and pharmacy students.

The Test Of Logical Thinking -TOLT-, which does not require any prior knowledge, was administered.[4,8] TOLT measures logical thinking with a validity of 0.80 and item-difficulty of 0.55.[4] It consists of 10 items (the maximum

possible score is 10 Points), including: Proportional Reasoning (2 Items), Controlling Variables (2 Items), Probabilistic Reasoning (2 Items), Correlational Reasoning (2 Items), and Combinational Reasoning (2 Items), the first 8 items are multiple-choice questions, where each of them has multiple answers and reasons. A participant receives credit for an item only if they choose the correct answer-reason pair. The last two items require the participants to write the answers themselves.[4] We asked the participants to answer the test following its rules which included answering the questions individually, not using calculators, and finishing the test within 45 minutes with 7 of them for revision.[9]

We translated and modified the test to best suit the targeted cohort while maintaining the main ideas of the original test and aimed to administer the modified test two times, one at the beginning of the academic year and the other at the end of it. We announced that we would invite students to a paper-based test on specific dates through social media groups. The announcement reached almost the whole cohort of 3531 students. We invited students in-person to voluntarily participate in the test and told them the general aim of the test without mentioning any details on the specific aim to avoid bias and maintain blindness. The general aim is assessing the learning outcomes, while the specific one is studying the effect of college courses on logical thinking. Only 196 students accepted participation in the test at the beginning of the 2020-2021 academic year. By the end of the second semester of the same academic year, we invited early-participated students to participate in the test again on three possible dates. However, only 40 students accepted the invitation due to the partial lockdown as a precaution against COVID-19. The test was administered during free time when there were no lectures to avoid pressure and coercion on participants.

We automated and cleaned the data from May to August 2021, which resulted in a sample size of 188 (N = 188), 5.32% of the cohort, for the first test, but only 40 participants, 1.13% of the cohort, participated in the second test. Therefore, we excluded the second test from the study and then collected students' results in the secondary school final exam, which are available online on the ministry of education website in September 2021, using students' full names. As a result, we collected grades in math, physics, chemistry, and biology of 150 students ($N_{Secondary} = 150$)[2] (Table 1) (Fig. 1).

We analyzed the data using Python (a programming language) in October and November 2021. We used the following statistical methods: Sum, Mean, Standard Deviation, Cronbach's Alpha, Skewness, Kurtosis, T-test, Levene's test, and Welch's test.

Research ethics and informed consent

The medical college council at Al Baath University granted permission to conduct this study in June 2020. All participants agreed to take the test and provided the required personal information. We assured all potential participants that participating in the test is voluntary and their personal information will only be used for research purposes. Participants were free to withdraw from the test and delete their personal information without giving any reason.

Results

The results of 188 participants showed a Mean of 6.43 (Sd.= 2.91) in the TOLT, where they had the lowest number of correct answers in the ninth and tenth questions. Cronbach's alpha value was satisfactory, indicating that the modified version of the test is reliable (Table 2).[10]

Skewness and kurtosis values ranged between −2 and + 2 when stratified by sex or year, which are enough to consider the data to be normally distributed.[11]

Participants' scores ranged from 0 to 10. There were score of 10 in each year, but 0 was only in the third, fifth, and sixth years. In terms of sex, 73.00% of females scored 4 or higher while the corresponding males' percentage was 89.00%. In contrast to females who had 0 as an inlier, males had 0 score as an outlier.

The Means of years two to five varied around the overall Mean, but the sixth year had the lowest Mean ($Mean_{Y2}$ = 6.25, $Mean_{Y3}$ = 6.79, $Mean_{Y4}$ = 6.43, $Mean_{Y5}$ = 7.03, $Mean_{Y6}$ = 4.70). The sixth year scored the lowest Means in all reasoning modes except for combinational reasoning. Student's t-test values indicated a significant difference between the sixth year overall TOLT score compared to each of the third and fifth years scores (T-values > 1.99, P-values < 0.05).

There was no significant difference in the scores between pre-clinical stage's students (second and third years) and clinical stage's students (years four to six). (T-value = 0.66, P-value > 0.50)

Males scored higher Means than females in all years and in all reasoning modes, where there was 55.00% of males and 38.89% of females in rigorous formal cognitive level because they scored 8 or higher at TOLT (Table 3).[12]

Males and females of the sixth year had the lowest Means compared to other years. Student's t-test values indicated a significant difference between males and females, and the second year's males and females (Table 4).

The collected secondary school grades of participants in subjects related to logical thinking (Math, Physics, Chemistry, and Biology) were higher than the TOLT scores in post-Secondary education (Table 5).

Discussion

This study showed no development of logical thinking between any two consecutive years and no difference between pre-clinical and clinical stages, which might indicate that the university courses are not contributing enough to developing logical thinking for the students. All years fall in the cognitive stage of formal reasoning with an overall Mean of 6.43 and a standard deviation of 2.91 in TOLT scores, whereas another study on students of different colleges reported a 4.40 Mean and a 2.80 standard deviation in TOLT scores.[4,12] Although the grades of subjects in secondary education point to a high level of logical thinking for most students, students of the last clinical years' stage,

[2] We scaled all grades at secondary school final exams to be in the range 0-1 using MinMax scaling and multiplied them by 10. As a result, subjects have the same theoretical Mean of TOLT which is 5.

Table 1 Number and percentage of participants and their available secondary school grades stratified by year and sex.

	Number (%)				Number (%)		
Year	First test	Second test	Secondary school	Sex	First test	Second test	Secondary school
2	36 (19.15)	7 (17.50)	29 (19.33)	Female	21 (58.33)	4 (57.14)	15 (51.72)
				Male	15 (41.67)	3 (42.86)	14 (48.28)
3	53 (28.19)	14 (35.00)	37 (24.67)	Female	27 (50.94)	10 (71.43)	20 (54.05)
				Male	26 (49.06)	4 (28.57)	17 (49.59)
4	44 (23.40)	12 (30.00)	40 (26.67)	Female	26 (59.09)	4 (66.67)	24 (60.00)
				Male	18 (40.91)	8 (33.33)	16 (40.00)
5	35 (18.62)	7 (17.50)	31 (20.67)	Female	18 (51.43)	7 (100.00)	16 (51.61)
				Male	17 (48.57)	0.00 (0.00)	15 (48.39)
6	20 (10.64)	0.00 (0.00)	13 (8.67)	Female	16 (80.00)	0.00 (0.00)	11 (84.62)
				Male	4 (20.00)	0.00 (0.00)	2 (15.38)
Total	188 (100.00)	40 (100.00)	150 (100.00)	Female	108 (57.45)	25 (62.50)	86 (57.33)
				Male	80 (42.55)	15 (37.50)	64 (42.67)

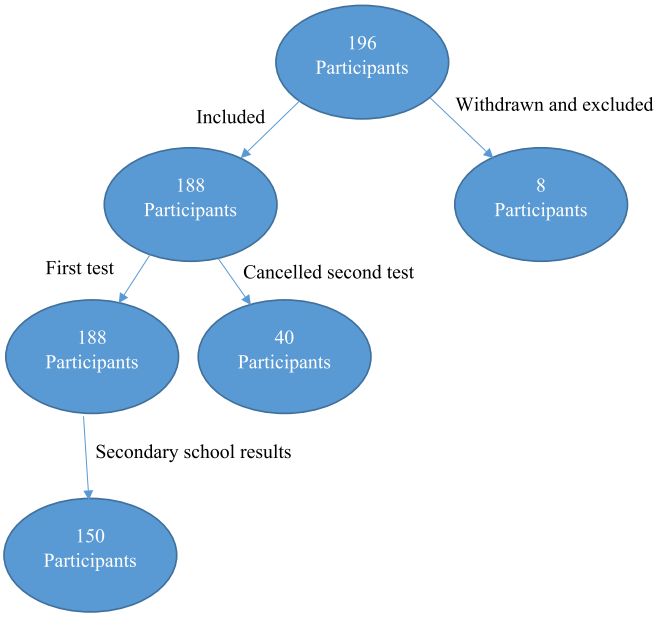

Fig. 1 Flow chart for study participants.

Table 2 Cronbach's Alpha values in the modified test compared to the original one stratified by reasoning mode.

Question Number	Sum	Mean	Sd.	Cronbach's Alpha (this study)	Cronbach's Alpha (Tobin & Capie, 1981)
Q1	118	0.63	0.48	0.73	0.82
Q2	107	0.57	0.50		
Q3	136	0.72	0.45	0.88	0.82
Q4	133	0.71	0.46		
Q5	128	0.68	0.47	0.67	0.61
Q6	134	0.71	0.45		
Q7	128	0.68	0.47	0.63	0.56
Q8	144	0.77	0.42		
Q9	91	0.48	0.50	0.60	0.71
Q10	89	0.47	0.50		
Total	1208	6.43	2.91	0.82	0.85

who took almost all of the college's courses, scored the lowest Mean compared to all years.

Although there are conflicting data on the correlation of mathematics with logical thinking, multiple studies correlated logical thinking with solving mathematics and chemistry problems.[5,7,13,14]

Considering mathematics and chemistry grades in secondary education, most students could think logically before admitting to college. However, logical thinking abilities decreased for some students compared to their presumed TOLT scores when they were in secondary school. Second-year students had taken the fewest number of college courses when this study was conducted, but their scores ranged from 1 to 10 with a Mean of 6.25 and a standard

Table 3 Number and percentage of students at different stages of cognitive development stratified by sex.

Sex	Females (%)	Males (%)	Total (%)
Cognitive Level			
0–1 (concrete)	9 (8.33)	2 (2.50)	11 (5.85)
2–3 (transitional)	20 (18.52)	7 (8.75)	27 (14.36)
4–7 (formal)	37 (34.26)	27 (33.75)	64 (34.04)
8–10 (rigorous formal)	42 (38.89)	44 (55.00)	86 (45.74)
Total	108 (100.00)	80 (100.00)	188 (100.00)

Table 4 Means of TOLT scores of each year stratified by sex, and T-test values between TOLT scores of females and males stratified by year.

Sex	Females	Males	T-value	P-value
Year				
2	5.33	7.53	2.57^{*}	<0.05
3	6.63	6.96	0.42^{**}	0.67
4	6.27	6.67	0.49^{***}	0.63
5	6.33	7.76	1.55^{*}	0.13
6	4.44	5.75	0.56^{****}	0.60
Total	5.92	7.11	2.84^{******}	<0.01

Critical-T: *2.03, **2.01, ***2.02, *****2.10, *****1.97

Table 5 T-test values between TOLT scores and secondary school results stratified by cognitive level.

Subjects Cognitive Level	Math	Physics	Biology	Chemistry	
	T-value	T-value	T-value	T-value	Critical-T
0-1 (concrete)	15.87*	39.86*	16.78*	21.47*	2.23
2-3 (transitional)	36.27*	44.67*	29.10*	36.36*	2.04
4-7 (formal)	24.68*	26.80*	17.88*	22.92*	1.98
8-10 (rigorous formal)	6.03*	7.61*	-0.03**	5.95*	1.98

* P-value < 0.0001
** P-value > 0.05

deviation of 2.77, and 11 out of 36 scored below 5. Another study on first-year pharmacy students' showed that TOLT scores ranged from 5 to 9 with a Mean of 7.70, the authors explained the elimination of students with scores of 0 to 4 by the admission process and perhaps maturity.[8]

Our study found that males performed better than females overall, which is not the case in the study that was conducted at Lake Erie's college which found no significant difference between males and females.[8] However, the second year had the only significant difference between males and females among all years, which might foretell a later stage, where males perform better in all years. On the other hand, the only difference in the second year could be due to a flaw.

Based on the lack of development in students' logical thinking during college years, and other studies, we encourage more thinking about studies program, education methods' effectiveness, and the extent to which they develop logical thinking at the medical college of Al Baath University in Syria. Also, we suggest reconsidering the number of courses' weekly hours to focus on quality instead of quantity. On the other hand, students may not be putting as much effort at college as in the secondary school final exams. Both of the previous points of view may be wrong, so the reason behind no logical thinking development is due to factors that this study did not discuss, or at least affecting with the studied factors, which requires deep studying of how the college courses affect students' logical thinking.

The main strength of our study is that participants were blind to the aim behind the test and what it measures. However, this study has a limitation, which is the small number of participants. There are few empirical studies conducted across Syria and Al Baath University, making students not fully aware of research importance or interested in participating in a study.

Recommendations

This study recommends Investigating why males performed better than females, especially in the second year. It also encourages more use of charts and illustrations in college courses to develop students' logical thinking.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

Michel Samaan is an orthopedic professor at Al Baath University, faculty of medicine. Basel Soufan, Basel Bairkdar, and Eiad Soufan are students at the same University. We did not receive any financial aid from the university.

Authors' Contributions

Basel Soufan: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project administration, Funding acquisition. Basel Bairkdar: Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project administration, Funding acquisition. Michel Samaan: Methodology, Validation, Investigation, Resources, Writing – Review & Editing, Supervision. Eiad Soufan: Software, Validation, Investigation, Formal analysis, Data Curation, Visualization, Supervision.

Acknowledgments

The authors would like to thank Professor Fahd Shribati the Dean of the Medicine faculty at Al Baath University for his support, Assad Suliman, a student at the faculty, for his help in inviting students to the test, and all participants.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.edumed.2023.100797.

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