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RESEARCH ARTICLE

Critical thinking among pharmacy students: Do age, sex and academic variants matter?

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Abstract

Background: Critical thinking (CT) is recognised as an essential component of higher education, and many academic institutions are working on improving their students' CT skills. To date, the complex relationships between students' ability to think critically and their age, sex, academic performance, major and prior experience taken all together have not been investigated. **Methods:** A cross-sectional study was designed to assess CT among undergraduate students from different health and non-health-related majors. **Results**: The results of this study show that the majority of students reported the ability to analyse data, employ formulas, and draw conclusions. However, integrating ideas from different disciplines and revising conclusions based on new findings remained most challenging for students. Moreover, age and academic performance were correlated with students' CT, while no correlation was found for sex and prior degree variables. **Conclusion**: This study contributes to a growing body of literature designed to improve CT among college and higher education students.

Introduction

The ability to think critically is frequently listed as a desirable outcome of undergraduate and professional education (Halpern, 2001), and critical thinking (CT) is identified as one of the most important learning outcomes of higher education (Cisneros, 2009; Schendel, 2017). In fact, a survey conducted by the Association of American Colleges and Universities in 2011 shows that 95% of the chief academic officers from 433 institutions rated CT as one of the most important intellectual skills for their students; likewise, 81% of the employers surveyed wanted CT to be more strongly emphasised in higher education (Rear, 2019).

One problem that impedes the study of CT is the widely divergent definitions of the term. Because of the complexity of defining and measuring CT (Miller, 2003), numerous definitions exist. In one reference, CT is described as students' practice of all previous knowledge on a specific topic and the evaluation of their own thinking skills (Norris, 1985). In another one, CT is a reasonable, reflective, responsible and skilled thinking process that focuses on what to believe or do (Ennis, 1989). In other references, CT is defined as reaching consequences based on observation and knowledge (Paul & Heaslip, 1995), or also as the use of cognitive skills or strategies, such as identifying central issues and assumptions, evaluating evidence and deducing conclusions, that would enhance the probability of desired behaviours (Halpern, 2001; Stupnisky *et al.*, 2008). Additionally, CT is defined as the ability to engage in purposeful, self-regulatory judgment (Abrami *et al.*, 2008) and also to think in the right way in the process of gaining relevant and reliable knowledge about the world (Emir, 2009).

Whatever definition is adopted, the ability to think critically is an important skill for self-directed and lifelong learning, particularly that nowadays, personal and professional success depends increasingly on continued learning and development throughout one's lifetime (Kreber, 1998). Furthermore, CT skills are necessary for active citizenship in any pluralistic and democratic society, where citizens are daily confronted with tremendous amounts of information and ill-defined problems with real uncertainty as to how they can be best solved (Angeli & Valanides, 2009).

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Moreover, CT is vital to a healthcare professional's competence to assess, diagnose and care for patients correctly and effectively (Pu *et al.*, 2019).

Therefore, CT has been identified as an essential component to provide safe, competent patient care (Paul, 2014). An American College of Clinical Pharmacy (ACCP) White Paper called for renewed attention to several outcomes, including CT and their integration into the training of future pharmacists (American College of Clinical Pharmacy, 2000). In addition, professional bodies in pharmacy are promoting the concept of pharmacists being analytical practitioners who are able to demonstrate CT in the clinical setting (American College of Clinical Pharmacy, 2000).

Consequently, higher education should provide not only professional skills but also general skills such as CT, which is nowadays considered the expression of the student's intellectual development (Erikson & Erikson, 2018). Furthermore, CT is believed to be a standard of intellectual excellence required for full and constructive participation in the academic, individual and social lives of students (Ghanizadeh, 2017). Therefore, CT should be an indispensable part of general education and not just another educational option. This is why educational accrediting bodies and policy documents across the world stress the need to develop CT in undergraduate students to ensure deliberate and constructive knowledge development in the future (Brodin, 2014). As an example, in the Centre for the Advancement of Pharmacy Education (CAPE) 2013 educational outcomes released at the American Association of Colleges of Pharmacy (AACP) July 2013 annual meeting, critically analysing scientific literature and emerging theories is considered at the base of foundational knowledge (Medina *et al.*, 2013). Moreover, the American Philosophical Association Delphi Panel characterized CT for educational purposes as an extensive concept including both cognitive skills and dispositions (Heijltjes *et al.*, 2014). A critical thinker must, for example, be skilled at reasoning, which refers to the cognitive process of drawing conclusions from given information (Facione, 2000). In addition, CT occurs when a student penetrates beyond the surface structure of a problem and recognizes how the problem can be solved, and in addition, possesses the content knowledge integral to solving the problem (Willingham, 2008).

Accordingly, schools and colleges across the world are revisiting their curricula, assessing their teaching and learning methods, and considering the use of the latest technologies and information to foster CT amongst students (Lee *et al.*, 2016). However, the education of CT at any age is only effective when it provides explicit instructions in CT (Marin & Halpern, 2011). Indeed, teaching students to think critically does include not only important problems within the disciplinary areas such as pharmacy, engineering or mathematics but also the social, political and ethical challenges of day-to-day life in the multifaceted and increasingly complex world (Abrami *et al.*, 2008). To help instructors with this endeavour, mind maps are tools that facilitate CT by helping students organize, integrate and retain information (D'Antoni *et al.*, 2010). Moreover, problem-based learning (PBL), self-directed learning (SDL), simulations and active learning techniques such as small discussion groups, class presentations, debates and independent studies positively affect students' development of CT skills (Tsui, 1999; Khoiriyah *et al.*, 2015; Lee *et al.*, 2016). Consequently, students will not only improve their CT and become better in higher education, but they will also have a better future as functional and contributing adults (Abrami *et al.*, 2008).

The Lebanese American University (LAU) School of Pharmacy has responded to the AACP White Paper and CAPE outcomes by applying changes in its curriculum content to better achieve desired outcomes. It has evaluated and implemented innovative methodologies to improve active learning in didactic, laboratory and experiential courses and thus enhance the CT ability of pharmacy students. One noteworthy example is the implementation of PBL and enquiry based learning (EBL) to actively engage students to participate in exploratory ways in their learning, to encourage new ideas, to assist students to attain the skills necessary to think critically and to become lifelong learners (Roberts & Ousey, 2004).

Purpose of the study

Previous studies mostly focus on instruments and tools used to measure CT, and over the years, many techniques and strategies for developing CT have been proposed. However, these techniques do not necessarily work equally well for all learners, and research on CT did not study these individual differences among learners thoroughly. In fact, there is little research, if any, discussing these factors separately or all together. Moreover, this literature is scarce when comparing CT of undergraduate students from different majors.

Therefore, the authors' study aims to assess CT among undergraduate students from different majors (pharmacy and other health and non-health majors), and identify factors associated with CT like age, sex, academic performance, and prior experience, work or training. This study is, therefore, necessary to measure desired student outcomes and assess the efficacy of the newly adopted learning techniques.

Methods

Study design and sample selection

A cross-sectional study was conducted at LAU - Byblos campus, Lebanon. The targeted population consisted of enrolled students from different health (medicine, nursing, nutrition and pharmacy) and non-health-related majors (arts, architecture, business, engineering, humanities etc.), through all academic years.

Data collection tool

Students were asked to voluntarily and anonymously fill out a survey addressing the following areas: 1) basic demographic and academic information (age, sex, major, grade-point average (GPA), prior degree, and prior work experience), 2) the professional year for pharmacy students, and 3) multiple-choice questions that elicit student's ability to analyse data, employ facts or formulas, integrate ideas and values from different disciplines, draw well-supported conclusions, and revise conclusions consistent with new observations. These questions were adopted from the "Measuring My Critical Thinking" survey based upon the Indicators for the Valencia Community College (Florida, USA) Core Competency THINK (Valencia Community College, 2006a). It is a reliable, validated, easy-to-use, rubric-based instrument intended for use in the assessment of student learning and the improvement of instruction at the institutional level within and across the many disciplines of human inquiry (Valencia Community College, 2006b). Based on their answer to each question/indicator, students can be then classified into one of four levels of achievements: beginning, developing, competent and accomplished. The survey was first pilot-tested on 20 students before administration to ensure clarity of included questions.

Sample size and power calculation

No quantitative data on the primary outcome is known to exist for Lebanese students from former studies, so the prevalence of adequate (competent and accomplished) CT was assumed to be around 50%. Since the number of students enrolled at LAU Byblos Campus is 3,942 students, and using Epi-Info Software (version 7; (Dean *et al.*, 1991)) a sample size of 700 participants is powered to provide 95% confidence interval with 5% confidence limit. Therefore, a total of 1,170 surveys were distributed to students across disciplines, expecting a response rate of 60% (Fincham, 2008).

Data management and statistical analysis

Comprehension scores obtained for all students together and for pharmacy students more specifically were described and tested to assess whether the increase of the percentage of competence correlates with the advancement through the curriculum (i.e. pre-pharmacy year 1 or Y1 to professional pharmacy year 4 or P4). Friedman tests were used for this purpose, where the response score is the relative percentage of students in each response category, the predictor is the year of advancement, and the blocking factor is the level of development.

A data matrix of dimension 805 (number of filled questionnaires, see below) by 10 variables was used for the analysis. Variables were grouped in two distinct groups: group A for descriptive variables, including age, sex, major, GPA score, and prior degree; and group B for explanatory variables consisting of the predefined questions. Descriptive variables were described by multiple modalities: variable age comprised four modalities (18-21 years old, 22-25 years old, 26-29 years old, and above 30 years old), sex comprised two modalities (male, female), major comprised three modalities (pharmacy major, other health-related majors, other non-health-related majors), GPA scores comprise seven modalities (GPA score 2 to 8), and prior degree comprised two modalities (yes or no). The age distribution into four categories follows the classification of QS Quacquarelli Symonds. QS is the world's leading provider of services, analytics, and insight to the global higher education sector, and the QS World University Rankings portfolio is the world's most popular source of comparative data about university performance (Top Universities, 2014).

In total, the five variables of group A were described in eighteen modalities characterizing the dataset. Group B included explanatory variables elaborated specifically to describe the student's critical thinking. Each variable of group B represented a question having four possible predefined answers, thus constituting the four modalities per variable (i.e. per question). Group B consisted of five variables described in twenty modalities in total.

Data were analysed using a Multiple Correspondence Analysis (MCA) (Tenenhaus & Young, 1985). MCA allows one to analyse the pattern of relationships of several categorical dependent variables in a complex dataset. It is used to model the dataset in a cloud of points in a multidimensional Euclidean space, thus allowing the interpretation of results on the basis of the relative distribution of the points along selected dimensions. It is a particularly powerful tool to uncover groupings of modalities (i.e. variable categories) in a bi-dimensional space, thus providing key insights on relationships between variables. For the analysis, a distinction was made between the descriptive and the explanatory variables. Variables of group B were used as main categorical variables in the analysis, while variables of group A were used as supplementary categorical variables. This distinction was made to establish the dimensions based on the contribution of explanatory variables, while descriptive variables were simply projected on the predefined dimensions and did not contribute to the ordination of dimensions. Multivariate analyses were performed in RStudio using the statistical package FactoMineR (Lê *et al.*, 2008).

In order to assess whether differences exist between majors (pharmacy versus other majors in this study case), the authors decomposed the variance to establish to which extent the major variable structures the dataset of categorical variables. Students were grouped into two classes (pharmacy versus other majors), and between-class and within-class inertia analyses were performed. Variances were tested using a Monte Carlo randomization test with 999 random matchings. This analysis was performed using the package ADE4 (Dray & Dufour, 2007) for RStudio.

All these steps are summarised in Figure 1.

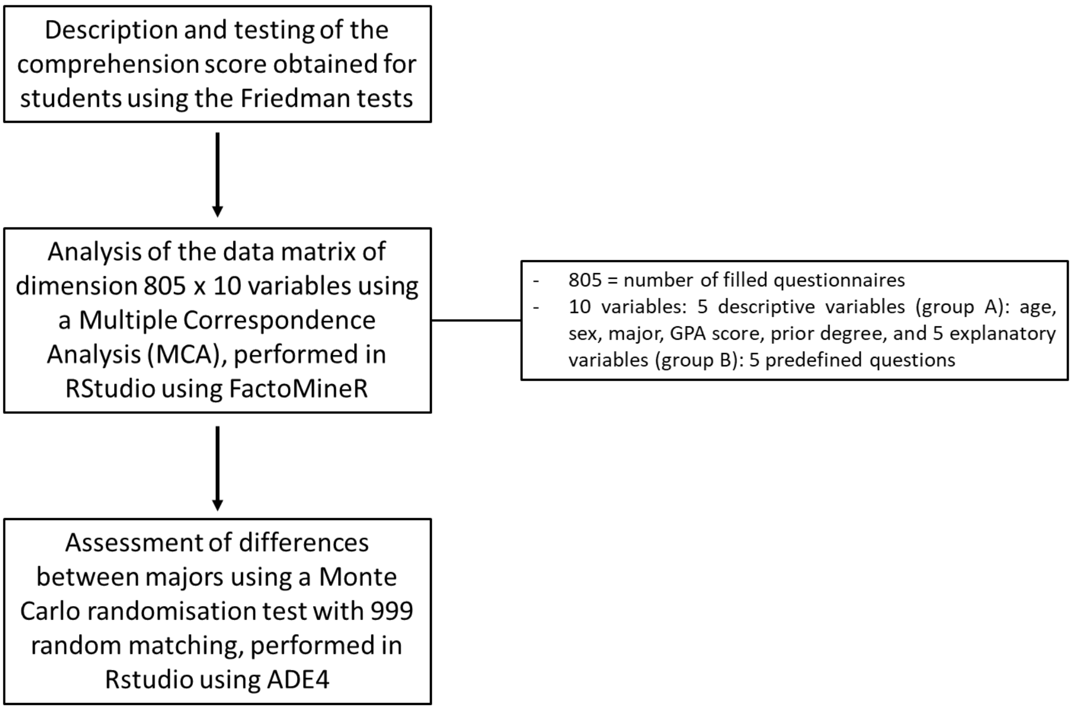


Figure 1: Schematic diagram summarising the data management and statistical analysis

Results

A total of 805 filled questionnaires were returned (response rate of 68.8%). The majority of the study participants were males (59.4%), aged between 18 and 21 years (67.0%), and had no previous training or work experience (61.6%). 41.4% of respondents were pharmacy students, 14.5% belonged to other health-related majors such as Nursing, Medicine, and Nutrition, and 43.7% belonged to non-health-related majors such as Engineering, Arts, Business, and Sciences. Student participants showed different levels of academic performance since they belonged to different GPA categories ranging from 2.0-2.5 (9.1%) up to 3.8-4.0 (9.3%) (Table I).

Participating pharmacy students belonged to the following academic years: 25.8% from pre-pharmacy year 1, 24.6% from pre-pharmacy year 2, 10.8% from professional pharmacy year 1 or P1, 14.1% from P2, 16.2% from P3, and 8.4% from P4 (Table II).

The study results show that 53.8% of pharmacy students are competent and accomplished in analysing data (against 40.2% and 51.4% for other health-related majors and non-health-related majors, respectively). Moreover, 53.5% of pharmacy students utilised facts or formulas (against 43.6% and 48.6% for other health-related majors and non-health-related majors, respectively).

Table I: Student demographic

Student demographic	Total (100%) (N=805) (%=n/N*100)
Age	
< 18 years	5 (0.6%)
18 – 21 years	539 (67.0%)
22 – 25 years	244 (30.3%)
26 – 29 years	11 (1.4%)
≥ 30 years	3 (0.4%)
Not declared	3 (0.4%)
Sex	
Male	478 (59.4%)
Female	273 (33.9%)
Not declared	54 (6.7%)
Major	
Pharmacy major	333 (41.4%)
Other health-related majors[1]	117 (14.5%)
Non-health-related majors[2]	352 (43.7%)
Not declared	3 (0.4%)
GPA	
< 2.00	0 (0%)
2.00 – 2.50	73 (9.1%)
2.51 – 2.75	87 (10.8%)
2.76 – 3.00	128 (15.9%)
3.01 – 3.19	118 (14.7%)
3.20 – 3.49	168 (20.9%)
3.50 – 3.79	125 (15.5%)
3.80 – 4.00	75 (9.3%)
Not declared	31 (3.9%)
Prior training/work	
Yes	272 (33.8%)
No	496 (61.6%)
Not declared	37 (4.6%)

[1] Other health-related majors include Medicine, Nutrition, and Nursing.

[2] Nonhealth-related majors include Arts, Architecture, Business, Engineering, Humanities, etc.

Table II: Pharmacy students' distribution

Pharmacy academic year	Total (100%) (N=333) (%=n/N*100)
Pre-Pharmacy Year 1 (Y1)	86 (25.8%)
Pre-Pharmacy Year 2 (Y2)	82 (24.6%)
Professional Pharmacy Year 1 (P1)	36 (10.8%)
Professional Pharmacy Year 2 (P2)	47 (14.1%)
Professional Pharmacy Year 3 (P3)	54 (16.2%)
Professional Pharmacy Year 4 (P4)	28 (8.4%)

Furthermore, 27.3% of pharmacy students reported the ability to integrate ideas and values from different disciplines (against 25.6% and 27.8% for other health-related majors and non-health-related majors, respectively). Additionally, 82.3% of pharmacy students reported the ability to draw well-supported conclusions (against 85.5% and 82.1% for other health-related majors and non-health-related majors, respectively). Finally, 29.7% of pharmacy students reported the ability to revise conclusions consistent with new observations (against 22.2% and 28.7% for other health-related majors and non-health-related majors, respectively) (Table III).

Scores are calculated for each result category (beginning, developing, competent, and accomplished). These scores show that most of the pharmacy students (98%) are competent or accomplished (scoring above 11), as is the case for non-health-related majors. Students from other health-related majors are slightly better (100% competent or accomplished) (Table IV).

Table III: Students' responses to "Measuring My Critical Thinking" survey

Students (n)	Pharmacy (%=n/N*100)	Other health-related majors (%=n/N*100)	Non-health-related majors (%=n/N*100)
Analyse data			
Beginning	84 (25.2%)	44 (37.6%)	101 (28.7%)
Developing	70 (21.0%)	26 (22.2%)	70 (19.9%)
Competent	177 (53.2%)	46 (39.3%)	177 (50.3%)
Accomplished	2 (0.6%)	1 (0.9%)	4 (1.1%)
Employ facts or formulas			
Beginning	133 (39.9%)	62 (53.0%)	143 (40.6%)
Developing	22 (6.6%)	4 (3.4%)	38 (10.8%)
Competent	12 (3.6%)	4 (3.4%)	12 (3.4%)
Accomplished	166 (49.8%)	47 (40.2%)	159 (45.2%)
Integrate ideas and values from different disciplines			
Beginning	135 (40.5%)	40 (34.2%)	119 (33.8%)
Developing	107 (32.1%)	47 (40.2%)	135 (38.4%)
Competent	8 (2.4%)	3 (2.6%)	16 (4.5%)
Accomplished	83 (24.9%)	27 (23.1%)	82 (23.3%)
Draw well-supported conclusions			
Beginning	46 (13.8%)	13 (11.1%)	48 (13.6%)
Developing	13 (3.9%)	4 (3.4%)	15 (4.3%)
Competent	212 (63.7%)	81 (69.2%)	245 (69.6%)
Accomplished	62 (18.6%)	19 (16.2%)	44 (12.5%)

Students (n)	Pharmacy (%=n/N*100)	Other health-related majors (%=n/N*100)	Non-health-related majors (%=n/N*100)
Revise conclusions consistent with new observations			
Beginning	46 (13.8%)	41 (35.0%)	95 (27.0%)
Developing	188 (56.5%)	50 (42.7%)	156 (44.3%)
Competent	82 (24.6%)	24 (20.5%)	80 (22.7%)
Accomplished	17 (5.1%)	2 (1.7%)	21 (6.0%)

Table IV: Students' scores on "Measuring My Critical Thinking" survey

Results category (score average)	Number of students (%)	Average survey score	Average GPA	Average age
Pharmacy (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	8 (2.4%)	10.0	2.76 - 3.00	18 - 21 years
Competent (11 – 15)	143 (42.9%)	13.9	3.01 - 3.19	18 - 21 years
Accomplished (16 – 20)	182 (54.7%)	17.0	3.20 - 3.49	22 - 25 years
Other health-related majors (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	0 (0.0%)	-	-	-
Competent (11 – 15)	43 (36.8%)	13.9	3.01 - 3.19	22 - 25 years
Accomplished (16 – 20)	74 (63.2%)	17.6	3.01 - 3.19	22 - 25 years
Non-health-related majors (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	8 (2.3%)	9.4	3.01 - 3.19	18 - 21 years
Competent (11 – 15)	136 (38.6%)	13.8	3.01 - 3.19	18 - 21 years
Accomplished (16 – 20)	208 (59.1%)	17.3	3.01 - 3.19	18 - 21 years

Moreover, scores of accomplished pharmacy students significantly increase through the academic years, from pre-pharmacy year 1 to the professional year 4 (Friedman test; $p = 0.009$) (Table V). This increase is also observed in all majors (Friedman test; $p = 0.03$), but not as significant as in the pharmacy major.

Table V: Scores of pharmacy students on "Measuring My Critical Thinking" survey

Results category (score average)	Number of students (%)	Average survey score	Average GPA	Average age
Pre-Pharmacy Year 1 (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	4 (4.7%)	10.0	2.51 - 2.75	18 - 21 years
Competent (11 – 15)	49 (57.0%)	13.8	3.01 - 3.19	18 - 21 years
Accomplished (16 – 20)	33 (38.4%)	16.8	3.01 - 3.19	18 - 21 years
Pre-Pharmacy Year 2 (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	3 (3.7%)	10.0	2.76 - 3.00	18 - 21 years
Competent (11 – 15)	45 (54.9%)	13.8	3.20 - 3.49	18 - 21 years
Accomplished (16 – 20)	34 (41.5%)	16.8	3.01 - 3.19	18 - 21 years
Professional Pharmacy Year 1 (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	1 (2.8%)	10.0	2.76 - 3.00	22 - 25 years
Competent (11 – 15)	14 (38.9%)	14.1	3.20 - 3.49	18 - 21 years
Accomplished (16 – 20)	21 (58.3%)	17.3	3.20 - 3.49	18 - 21 years
Professional Pharmacy Year 2 (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	0 (0.0%)	-	-	-
Competent (11 – 15)	16 (34.0%)	13.9	3.01 - 3.19	22 - 25 years
Accomplished (16 – 20)	31 (66.0%)	16.9	3.01 - 3.19	22 - 25 years
Professional Pharmacy Year 3 (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	0 (0.0%)	-	-	-
ompetent (11 – 15)	13 (24.1%)	13.7	3.01 - 3.19	22 - 25 years
Accomplished (16 – 20)	41 (75.9%)	17.0	3.20 - 3.49	22 - 25 years

Results category (score average)	Number of students (%)	Average survey score	Average GPA	Average age
Professional Pharmacy Year 4 (%=n/N*100)				
Beginning (1 – 5)	0 (0.0%)	-	-	-
Developing (6 – 10)	0 (0.0%)	-	-	-
Competent (11 – 15)	6 (21.4%)	14.8	3.50 - 3.79	22 - 25 years
Accomplished (16 – 20)	22 (78.6%)	17.4	3.50 - 3.79	22 - 25 years

The scatterplot displaying the distribution of modalities of explanatory variables in the first two dimensions summarizes 19.4% of the variance (Figure 2A). The first dimension (Dim1, Figure 2A) displays a gradient of answers expressing the level of achievement of students. Answers expressing the lowest level of achievement (beginner) are clustered on the positive side of Dim 1 (question 1 - answer D, or Q1.D, Q2.C, Q4.C, Q5.D), opposed to answers expressing the highest level of achievements (accomplished) located on the negative side of Dim 1 (Q1.C, Q2.A, Q5.C). Intermediate accomplishment levels (developing and competent) are distributed between the two extremes along the same dimension. Such distribution of answers allows the authors to establish a gradient of achievements along with Dim 1 (Figure 2A), ranging from the lowest achievement indicators to the highest achievement indicators.

In addition, the supplementary variables (GPA scores and age categories) are highly correlated to the achievement gradient (Figure 2B). The lowest GPA scores are distributed on the positive side of Dim 1, in opposite to the highest GPA scores located on the negative side of the dimension. A similar distribution is found for age categories: the highest age categories being correlated with high achievement indicators. No distinct distribution along the achievement gradient is found for sex and prior degree variables.

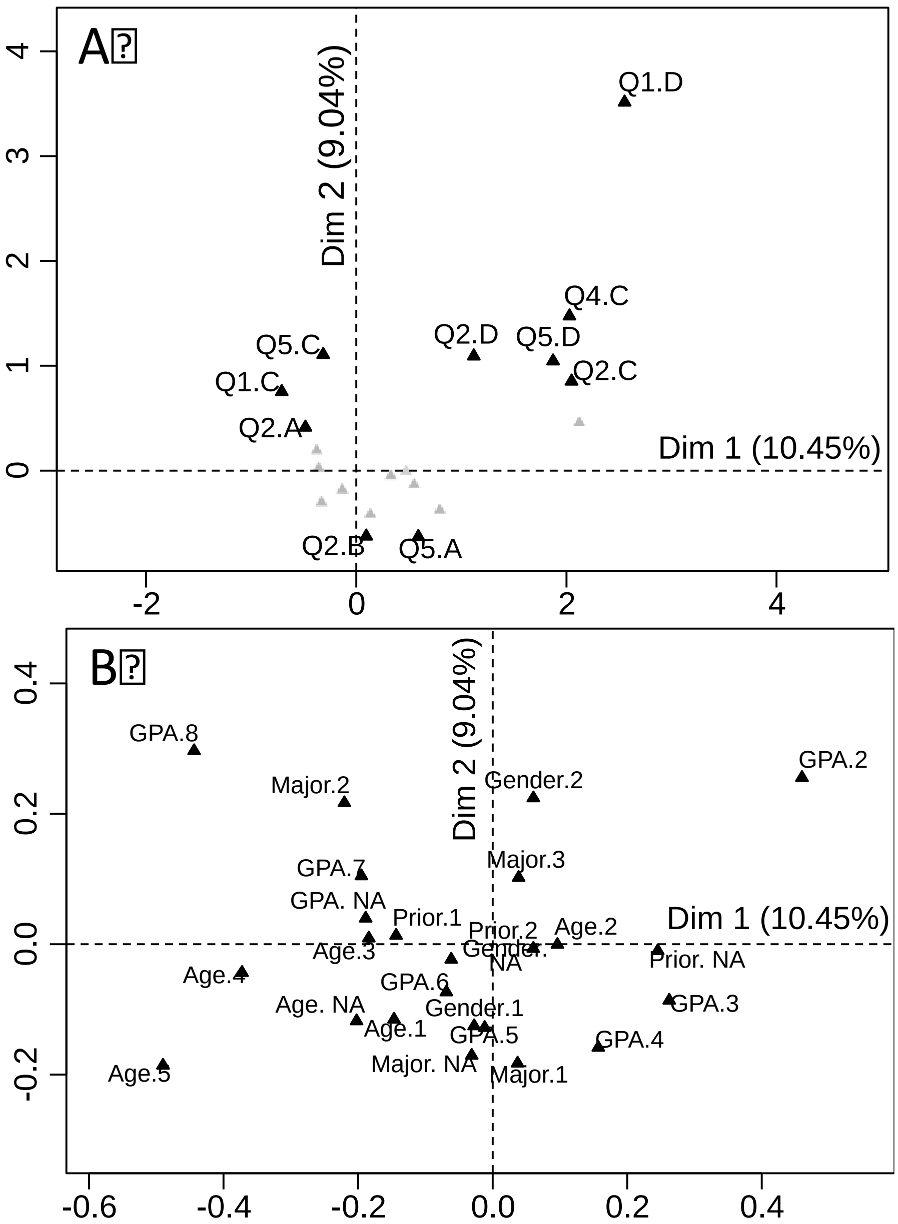
The between-class inertia explains less than 10 % of the variance, while the within-class inertia explains 90% of the total variance. Thus, the results suggest that within-class variance is much higher when compared to between-class variance, and the criterion major (pharmacy versus other majors) does not constitute a structuring element of the dataset. Both between-class and within-class inertia value are significant (p < 0.01, number of random matching = 999).

Discussion

A considerable number of publications focus on the development of CT ability in higher education, such as the efficacy of CT courses, the pedagogical tools used and the usefulness of electronic discussions in the development of CT (Macpherson & Owen, 2010). But based on the proposed importance of CT, it is surprising that there is limited research on the assessment of students' CT. This study explores the extent to which students' ability to think critically could be explained by their age, sex, academic performance, major and prior experience.

There are a number of standardised tests of CT currently available for use: the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980), the Cornell Critical Thinking Tests (Ennis *et al.*, 1985), the Ennis-Weir Critical Thinking Essay Test (Ennis & Weir, 1985), the California Critical Thinking Skills Test (Facione, 1990), the California Critical Thinking Disposition Inventory (Facione & Facione, 1992), the Halpern Critical Thinking Assessment (Halpern, 2007), and the ETS HEIghten Critical Thinking Assessment (Liu *et al.*, 2016). Nonetheless, the Valencia Community College Core Competency THINK is an easy test to administer and an objective mean of evaluating key skills students are expected to have. In fact, in the light of various classifications, five broad skills are identified as being particularly important in effective thinking and CT (Ennis, 1987; Garratt *et al.*, 2000): analyse data, employ facts or formulas, integrate ideas and values from different disciplines, draw well-supported conclusions, and revise conclusions consistent with new observations. This can also be explained by the fact that the test chosen offers an effective and appropriate measure of evaluation of these skills required in the tasks students typically carry out during their studies at LAU. In addition, the rubric options provided in this test stimulate a more productive discussion than that which occurs with a more open-ended task. In fact, students do not respond well when presented with a short passage and are asked to comment or argue (Garratt *et al.*, 2000).

The findings of this study show that more than 50% of the student population in this study from different disciplines demonstrate competent and accomplished levels in analysing data, employing facts and formulas, and developing well-supported conclusions. The majority of respondents, however (more than 70%), show a beginning or developing level in integrating ideas and values from different disciplines and in revising conclusions based on new observations. In fact, there are various complex problems and concepts that resist resolution when approached from a single discipline. Interdisciplinary education must supplement disciplinary teaching so students can learn how to develop more complete pictures than would be possible from any one disciplinary perspective. This should enable them to respond to challenges that surpass disciplines and to develop trajectories that do not conform to standard disciplinary paths (Gardner, 2009; Golding, 2009).



Note: Dim 1 and Dim 2 correspond to the first two dimensions of the MCA analysis, cumulatively summarising 19.49% of the total variance. The codes for the different modalities are explained in the method section

Figure 2. Scatterplots displaying the distribution of the 10 most contributive modalities of explanatory variables (Plot A) and the distribution of modalities of descriptive variables (Plot B)

In an attempt to improve interdisciplinary education, LAU launched an Inter-Professional Education (IPE) programme where all students enrolled in Medicine, Nursing, Nutrition, Pharmacy and Social Sciences are invited to participate in several learning activities over the course of their enrolment. This type of interdisciplinary education remains challenging to implement and embed CT in students and requires continuous assessment and improvement.

Moreover, the research findings indicate that age and academic performance are correlated with the students' CT ability. In fact, people begin developing CT abilities at a very young age and may continue to develop them throughout the years, especially if they are enrolled in instructional programmes that encourage idea exchange, metacognitive skills, and critical thinking (Sternberg, 1986; Lai, 2011). Therefore, students' CT scores are expected to steadily improve through the academic years, as an affirmation to the curriculum (cumulative) efficiency, their maturation and the college experience (Keeley *et al.*, 1982; Miller, 2003; Cisneros, 2009; Macpherson & Owen, 2010). Additionally, the correlation between academic performance and CT skills is similarly reported in the literature (Lun *et al.*, 2010; Marin & Halpern, 2011; Burbach *et al.*, 2012; Ghazivakili *et al.*, 2014; Nordin, 2015). In fact, the student's problem-solving skills, evaluative skills, deductive reasoning, and ability to employ formulas naturally enable them to score higher GPA, especially in accredited programmes that adopt new educative techniques and novel students' assessment and evaluation tools.

On the other hand, the study population did not show any difference between males and females in the assessed dimensions. In fact, there are conflicting results in the literature regarding the correlation of sex with CT competencies (Walsh & Hardy, 1999; Aliakbari & Sadeghdaghighi, 2011; Leach & Good, 2011; Piaw, 2014; Nordin, 2015; Salahshoor & Rafiee, 2016). This reported variability can be explained by the type of instrument used to assess CT, the dimension of CT under investigation (i.e. analysis, deduction, creativity, open-mindedness and maturity) and the major/field of study. While females' scores are reported to be higher than males on open-mindedness and maturity (Walsh & Hardy, 1999), male students are reported to be better in elaborating creative ideas than female students (Piaw, 2014) and to have higher gains in CT skills (Li *et al.*, 1999). Hence, the sex-related research in CT has failed to confirm an actual difference in overall cognitive performance between males and females. With acknowledgement of the sex differences in verbal and quantitative abilities (Verawati *et al.*, 2010), the results highlight the importance of creating classrooms that engage students and enhance their CT skills regardless of their sex difference.

Another area of divergence is the extent to which CT skills are domain-specific versus domain-general (Lai, 2011). Considering CT as a state of applied intelligence, it can be deduced that CT includes both general and domain-specific elements (Ennis, 1989; Facione, 2000). In this study, the student's major is not significantly correlated with their CT ability. This comes at a time after LAU is granted a 10-year re-accreditation by the New England Commission of Higher Education (NECHE). This accreditation status is a confirmation that the university meets the specific standards set by the accrediting agency, one of which assures academic quality and that students demonstrate critical analysis and logical thinking skills. Moreover, the LAU School of Pharmacy is a member of AACP, and its Doctor of Pharmacy (Pharm.D) programme is accredited by the Accreditation Council for Pharmacy Education (ACPE). It currently remains the only ACPE-accredited Pharm.D programme outside of the United States. In addition, the different Engineering programmes are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), the Computer Science programme is accredited by the Computing Accreditation Commission of the ABET, the Nursing programme is accredited by the Commission on Collegiate Nursing Education (CCNE), and the different Business programmes are accredited by the Association to Advance Collegiate Schools of Business (AACSB). Thus, the similarity in survey scores between Pharmacy students, other health-related majors and non-health-related majors can be attributed to the fact that most LAU schools are accredited by international bodies, which are recognised by the Council for Higher Education Accreditation (CHEA). These accreditations are only granted for programmes that meet pre-specified educational standards, promoting academic quality and excellence.

However, there is an inconsistency in the literature regarding the correlation between CT and the major of study. Some manuscripts show that CT is affected by the major (Davison *et al.*, 1981; Welfel & Davison, 1986; Terenzini *et al.*, 1995); others indicate that the major is not a factor related to gains in CT skills (King *et al.*, 1990; Astin, 1992; Li *et al.*, 1999). Furthermore, educators agree that thinking skills are important in almost every discipline and occupation and are constantly required to meet all academic objectives (Ghanizadeh, 2017). On the other hand, curriculum design, learning styles and personal characteristics have a key influence in promoting the development of CT (Ghazivakili *et al.*, 2014; Perry, 2014), which might dilute the effect of the field of study or major. Almost all employers surveyed (93%) in a national American survey of business and non-profit leaders believe that "a demonstrated capacity to think critically, communicate clearly, and solve complex problems is more important than [a candidate's] undergraduate major" (Hart Research Associates, 2013).

Study limitations

This study examines students' CT scores at one point in time and does not examine potential score improvement as students proceed through the curriculum/academic years, which could provide a better picture of the curriculum effectiveness. In addition, all data presented is self-reported, which introduces potential self-presentation bias.

Study strengths

This is the first journal paper to address and assess CT among Lebanese, Middle-Eastern and North-African students. Power has been set and met, and a good response rate of around 70% was obtained. This could be partially attributed to the short time needed to complete the survey (compared to lengthier surveys such as the 75-questions California Critical Thinking instruments that require 45-50 minutes) and to the convenient time of administration (at the beginning of the class session).

Implications for research

CT is not dependent on individual traits alone. However, these do condition the critical and creative process and outcome. That being said, there may be other individual factors not considered in this study, which could influence how students engage in CT, such as cultural background, student involvement in organizations and clubs, student employment, students living on campus, etc. In addition, a replication of this study using a more diverse sample from a variety of colleges and universities may reveal more results on the association between CT and students' individual factors.

Implications for practice

The results from the current study can be generalised to higher education settings with similar cultural contexts because the findings do provide insights into ways in which practices in higher education can condition students' CT development. Moreover, instructors must be cognisant that they can and should play an influential role in structuring activities and techniques which foster CT. Therefore, they should use appropriate instructional methods and curriculum materials, and they should put some effort into the professional development and elaboration of course design and implementation in order to improve students' CT. Nonetheless, an instructor should not use the same techniques for different classes and students of different ages. Moreover, single-sex education, which is not only present in the Arab world as one would presume, but is also being revived in developed countries like the United States or even China (Wong *et al.*, 2018), should not rely on different programmes or different approaches, since CT skills are not sex-related.

These recommendations, when applied, will lead to a better critical thinking environment in classroom settings which in turn will lead to better people who are more analytical in their professions, citizens who are more discerning, and parents who can think carefully through the variety of choices facing them while raising a family in a complex and challenging world (Abrami *et al.*, 2008).

Conclusion

The ability to think critically is considered an important cognitive competency for our century (Wechsler *et al.*, 2018). Moreover, pharmacy, like most professions, involves problem-solving situations in which CT is required, thus indicating the importance to understand the role of CT in order to educate students on the use of this ability in different contexts (Baker *et al.*, 2001; Seymour *et al.*, 2003).

LAU students in general, and pharmacy students in particular, use their CT ability to analyse data, employ facts and formulas, and develop supported conclusions. Efforts should be made in the different curricula to improve students' ability to revise conclusions based on new observations and mostly to integrate ideas and values from different disciplines.

Moreover, CT is influenced by many factors, in particular, students' age and academic performance. However, the students' CT ability is not associated with their sex nor the major in which they are enrolled.

Considering the growing importance of CT skills in enhancing the professional competence of individuals, the results of this study should serve as a platform for the subject institution and for other academic institutions in Lebanon and abroad to assume their responsibilities in spurring interschool collaboration, foster research, feeding into policymaking, and accelerating the pace of academic innovation. Initiatives could include launching inter-school undergraduate and graduate degree programmes and considering new frameworks for course delivery that will hopefully be integrated and not discipline-bound.

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Conflict of Interest

The authors declare no conflict of interest.

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Ethics approval

The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. It was also approved by the Institutional Review Board (IRB).

Consent to participate

An informed consent form, in the form of a brief cover letter, was provided to participants introducing the purpose of the questionnaire and re-assuring confidentiality. Students willing to participate were asked to write the date.

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