Critical thinking skills in the Greek lyceum: Their promotion within the first class’s informatics textbook

Ioannis Oikonomidis 1*, Chryssa Sofianopoulou 1

1Department of Informatics & Telematics, Harokopio University, Athens, GREECE
*Corresponding Author: oikonom@hu.edu

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INTRODUCTION

Critical thinking plays an essential role in students’ study and life, and it is one of the educational goals of higher education in many countries (Fena & Xiaodong, 2023), it is considered as a key competency of university students (Vachova et al., 2023), it is essential to students in all educational levels (Dantas et al., 2023) and it a blend of skills and dispositions, which are closely related to collaboration, metacognition, motivation, creativity, and academic achievement (Ali & Awan, 2023). There is a correlation between critical thinking and communication skills (Wanah et al., 2023).

Critical thinking is vital for academic success or effectiveness and in the workplace (Li, 2023). Critical thinking skills are very useful in helping students enter the world of work (Sukra et al., 2023). Critical thinking is vital for academic success and effectiveness and in the workplace (Li, 2023), it is essential for developing a future workforce (Aydiner et al., 2023) and social work practice (Rogers & Allen, 2019) and it is very important in changing society in a way that can evaluate reasons, values, pluralism, and diversity (Rulyansah, 2023).

Critical thinking refers to thinking and making correct decisions independently (Rakhimova, 2023), it can be defined as the evidence-based ways in which people decide what to trust and what to do (Heim et al., 2023). Critical thinking is very fundamental in all aspects of life since “as an intellectual activity means developing an ever more accurate worldview and using it well in all aspects of your life” (Jason, 2022). Critical thinking consists of a tool for the interaction of information with thoughts (Erkinova, 2022). A critical thinker is open-minded and able to construct logical judgments and arguments in order to reach evidence-based conclusions (Ismail, 2023) and understands how to use knowledge in order to confront problems (Raj et al., 2022).
In is necessary to cultivate critical thinking skills in order to create effective individuals (Mihail, 2022). The influence of critical thinking can be seen in academic, professional and personal levels (Abasaid & Ferreira, 2022). In everyday life, everyone needs critical thinking skills to solve problems (Laabidi, 2022). Critical thinking is essential in teaching and learning process (Shamboul, 2022). Education has recognized the importance of developing students’ critical thinking skills (Nor & Sihes, 2022). Critical thinking lessons contributes to improving skills such as solving problems, gathering and analyzing information, drawing conclusions, communicating ideas with clarity and effectiveness (Bassham et al., 2011). Critical thinking is of immense importance in the twenty-first century for human beings (Akbar, 2023, Anggraeni et al., 2023) and comprises the key competency for economic survival in this century (Matthews & Lally, 2010).

The present study is one of the few studies exploring the extent to which the cultivation of critical thinking skills is promoted within the content of Informatics school textbooks. It provides useful insights to authors who write textbooks, where the cultivation of critical thinking skills will be adequately promoted. In addition, it provides a methodological tool that can be used to examine if the cultivation of critical thinking skills is promoted within a text.

Clarifying Critical Thinking

Critical thinking encompasses philosophical, psychological and pedagogical approaches to it (Lai, 2011; Lewis & Smith, 1993; Moon, 2008). As far as philosophical approach is concerned, there are definitions of critical thinking such as: “reflective and reasonable thinking that is focused on deciding what to believe or do” (Ennis, 1985, p. 85), “disciplined, self-directed thinking that exemplifies the perfections of thinking appropriate to a particular mode or domain of thought” (Paul 1992, p. 9). Psychological approach is related to definitions of critical thinking like “critical thinking comprises the mental strategies and representations people use to solve problems, make decisions and learn new concepts” (Sternberg, 1986, p. 3), “the use of those cognitive skills or strategies to increase the probability of a desirable outcome” (Halpern, 1998, p. 450). Regarding the educational approach, the critical thinking is often considered to be represented by the levels of analysis, synthesis and evaluation of the Bloom’s taxonomy (Kennedy et al., 1991). The critical thinking skills and sub-skills are the following (Facione, 1990):

1. Interpretation skill
   1.1. Categorization sub-skill
   1.2. Decoding significance sub-skill
   1.3. Clarifying meaning sub-skill
2. Analysis skill
   2.1. Examining ideas sub-skill
   2.2. Identifying arguments sub-skill
   2.3. Analyzing arguments sub-skill
3. Evaluation skill
   3.1. Assessing claims sub-skill
   3.2. Assessing arguments sub-skill
4. Inference skill
   4.1. Querying evidence sub-skill
   4.2. Conjecturing alternatives sub-skill
   4.3. Drawing conclusions sub-skill
5. Explanation skill
   5.1. Stating results sub-skill
   5.2. Justifying procedures sub-skill
   5.3. Presenting arguments sub-skill
6. Self-Regulation skill
   6.1. Self-examination sub-skill
   6.2. Self-correction sub-skill

Critical Thinking and Informatics

Some aspects of Informatics include understanding and promoting effective organization, analysis, management, and use of information; decision making relying on knowledge or evidence; integration of data, information and knowledge (Collins & Weiner, 2010). Hence, information management is essential in informatics. To develop information management skills, information literacy is needed. Information literacy is a set of skills for recognizing, evaluating and effectively using necessary information (American Library Association, 1989). Critical thinking can help develop information literacy (Yue et al., 2023). Students cannot cultivate Information literacy unless they have developed critical thinking skills (Paul & Elder, 2006). Therefore, critical thinking, Informatics and information literacy have a very strong relationship.

Informatics is a science of computers, algorithms, data structures, mechanical symbol, data processing, computer automation, computer simulation, and mechanization of thinking (Rechenberg, 1999) and thus it is related to computer science. Problem-solving is fundamental, both in informatics and critical thinking. In informatics, solving problems is linked to
computational thinking. Computational thinking is strongly related to computer science (Dagiene & Stupuriene, 2016), and therefore it is related to informatics. Computational thinking is a brain activity that facilitates problem-solving by applying deduction, deconstruction, algorithmic design, generalization, and evaluation to the production of automation that can be implemented by a human or by a computing device (Selby & Woollard, 2014). Computational thinking can support learners’ skills so that they become effective problem-solvers (de Jesus & Silveira, 2021). Computational thinking also facilitates the development of competencies related to problem-solving and decision-making (Cano et al., 2021). There are computational thinking skills and critical thinking skills, which are similar and computational thinking complements critical thinking with regard to problem-solving, decision making and interaction with the world (Kules, 2016). Critical thinking skills are essential for decision making and solving problems (Halpern, 1998). Critical thinking and computational thinking are necessary in solving complex technological problems (Voskolou & Buckley, 2012). The aforementioned imply that there is a strong linkage between critical thinking and Informatics.

The spectrum of critical thinking includes logic, informal logic, and systemic or analytic thinking (Scheuer, 2023). Logic is strongly related to many subjects of computer science (Martel, 2018) and therefore, it is related to Informatics. Critical thinking itself is a reasonable thinking (Ennis, 1985; Lipman, 1988) and logic constitutes an intellectual standard of critical thinking (Paul & Elder, 2013). Consequently, logic is a link between critical thinking and Informatics.

From all the above it becomes clear that critical thinking and Informatics have a very strong relationship. Due to this relationship within Informatics textbooks the cultivation of the critical thinking skills should be promoted.

**Critical Thinking and Informatics Curricula**

Education seeks to cultivate critical thinking (Kennedy et al., 2016). Due to the fact that critical thinking is strongly related to Informatics, the cultivation of the critical thinking skills should be promoted in Informatics curricula. In curricula of the primary, the secondary and the higher education, learning objectives underline the development of critical thinking (Thompson, 2011). Thinking skills or critical thinking programs have been incorporated into curricula of several countries (Matthews & Lally, 2010). As stated in analytical curriculum for information and computer technology in education, critical thinking is one of the skills that should be promoted (Weert & Anderson, 2002). According to the Hellenic Pedagogical Institute (2009), the cultivation of critical thinking is presented in the new curricula as a teaching objective. Consequently, in the school textbooks of Informatics the cultivation of the critical thinking skills should be promoted.

**Research Questions**

The purpose of the present research is to determine the extent to which the cultivation of the critical thinking skills is promoted within the examined text. In order to fulfill this purpose, the following research questions were posed.

Within the first-class Informatics textbook of the Greek lyceum:

1. Are there parts of the text, where cultivation of critical thinking skills is not promoted?
2. Which are the critical thinking skills, which are represented by all of their sub-skills, and which are the ones, which are not represented by all of their sub-skills?
3. Are there parts of the text, where the cultivation of critical thinking skills is promoted to their greatest extent?

**METHOD**

**Material**

In the present research the examined material is the content of the first-class Informatics textbook of the Greek lyceum. This book was selected for examination because it is the only one introductory Informatics textbook in Greek lyceum (senior high school). The aim of the examined textbook is for students to acquire knowledge, develop skills and shape attitudes related to the applications of Informatics (Aggelidakis et al., 2010). The textbook is divided into four thematic units: hardware-software and applications, programming environments-applications development, communication and the Internet and collaboration and security within the Internet. Each thematic unit is divided into chapters ranging from three to five. The pedagogical parts of the examined textbook are the teaching objectives, the teaching questions, the main text, the side text and the activities. In these parts the cultivation of critical thinking skills may take place and because of this, all these parts were examined.

**Research Design**

The method that was used in the present research is quantitative content analysis. Quantitative content analysis is a systematic, objective and quantitative analysis of the characteristics of a message (Neundorf, 2002). Quantitative content analysis has been applied since 1970 (Johnsen, 1993). The main idea of content analysis is the inclusion of elements of a text into categories (Creswell & Clark, 2007; Huntemann & Morgan, 2001; Krippendorff, 2004; Rustermeyer, 1992). The recording unit determines which parts of the text fall into the category system (Krippendorff, 2004). In the present research the recording unit is defined as any part of the examined text, which contains exactly one message promoting cultivation of a critical thinking skill.

Concerning the establishment of the category system, at the beginning of content analysis, an initial category system is used to help classify the parts of the text in the categories of this system. In the present research the initial category system that was used consists of the skills (categories) and sub-skills (sub-categories) of the critical thinking as referred in clarifying critical thinking section.
The content of the text was examined to see if there are categories that do not contain references promoting the cultivation of the critical thinking skills. Such empty categories were found and correspond to the decoding significance sub-skill, the detecting arguments sub-skill, the analyzing arguments sub-skill, the assessing arguments sub-skill, the justifying procedures sub-skill, the self-examination sub-skill and the self-correction sub-skill. However, in a final category system to be used in the Content Analysis, every category should be not empty (Berelson, 1952; Holsti, 1969; Rustermeyer, 1992). For this reason, the above empty sub-categories were removed from the initial category system and a final category system emerged. The categories and sub-categories of this final system are, as follows:

1. Interpretation skill
   1.1. Categorization sub-skill
   1.2. Clarifying meaning sub-skill
2. Analysis skill
   2.1. Examining ideas sub-skill
3. Evaluation skill
   3.1. Assessing claims sub-skill
4. Inference skill
   4.1. Querying evidence sub-skill
   4.2. Conjecturing alternatives sub-skill
   4.3. Drawing conclusions sub-skill
5. Explanation skill
   5.1. Stating results sub-skill
   5.2. Presenting arguments sub-skill

Data Collection and Analysis

The under study material is the content of the Informatics textbook of the first class of the Greek lyceum (Aggelidakis et al., 2010). In this under study text, its pedagogical parts are the teaching objectives, the teaching questions, the main text, the side text and the activities. These are the parts of the examined material, where the cultivation of critical thinking skills may take place. All these parts were examined. In the under study material, every text promoting the cultivation of a critical thinking sub-skill was noted and, according to its content, it was categorized into one of the sub-categories of the final category system. If the cultivation of a critical thinking skill or sub-skill is promoted within a text then this text is a categorized text, otherwise is a non-categorized text. In particular, a categorized subset of an examined part is its subset in which the cultivation of critical thinking skills is promoted.

In order to determine the extent to which the cultivation of a critical thinking is promoted within a text, the text should be measurable. To make a text measurable, the length of it was used. In the present research, the length of a text (categorized or non-categorized) is defined as the number of the lines that the text covers. The length of every examined part of the text (teaching objectives, teaching questions, main text, the side text and the activities) was computed. In addition, the length of the categorized subset of every examined part was computed as well. Then, for each examined part, the percentage of the length of its categorized subset to the length of the entire part was calculated.

RESULTS AND DISCUSSION

In the main text, which constitutes the greater part of the examined text, no references related to the promotion of the cultivation of critical thinking skills were found (Aggelidakis et al., 2010 p. 8-40, 43-70, 73-106, 109-141). On the contrary, in the other parts of the examined text references were found that promote the cultivation of critical thinking skills.

The interpretation skill is represented by categorization sub-skill and clarifying meaning sub-skill (Aggelidakis et al., 2010, p. 8, 19, 20, 44, 49, 74, 124). The analysis skill is represented by the examining ideas sub-skill (Aggelidakis et al., 2010, p. 8, 11, 16, 20, 25, 26, 36, 40, 47, 49, 53, 72, 77, 82, 87, 92, 103, 105, 118, 119, 122, 124, 133). The examination skill is represented by the assessing claims sub-skill (Aggelidakis et al., 2010, p. 42). The inference skill is represented by querying evidence sub-skill, conjecturing alternatives sub-skill and drawing conclusions sub-skill (Aggelidakis et al., 2010, p. 11, 14, 22, 25, 26, 42, 47, 54, 65, 79, 82, 110, 122, 130, 133, 143). The explanation skill is represented by stating results sub-skill and presenting arguments sub-skill (Aggelidakis et al., 2010, p. 22, 42, 92, 114, 126, 143). Inference is the only critical thinking skill represented by all of its sub-skills. The interpretation skill, the analysis skill and the explanation skill are not represented by all of their sub-skills.

The parts of the text, where the cultivation of critical thinking skills is promoted to their greatest extent are the teaching objectives and the activities. The parts of the text that contain the teaching objectives are located on pages 8, 20, 26, 44, 49, 54, 74, 80, 87, 93, 103, 110, 119, 124, and 133 in the examined textbook. The parts of the text that contain the activities, are located on pages 11, 14, 16, 19, 22, 24, 25, 29, 33, 35, 39, 40, 41, 42, 47, 48, 52, 53, 65, 70-72, 77, 79, 82, 84, 86, 92, 97, 100, 102. 105-108, 111, 114, 118, 122, 123, 126, 130, 132, 136, 138, and 140-143 in the examined textbook.

Figure 1 shows an example of teaching objectives related to promotion of cultivating critical thinking skills, which is located on page 26 in the examined textbook.
Figure 1. Example of teaching objectives in the examined textbook (Aggelidakis et al., 2010)

<table>
<thead>
<tr>
<th>Teaching objectives</th>
<th>Teaching questions</th>
<th>Side text</th>
<th>Activities</th>
<th>Main text</th>
</tr>
</thead>
<tbody>
<tr>
<td>59.6%</td>
<td>96.4%</td>
<td>89.8%</td>
<td>59.4%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 2. Example of activities in the examined textbook (Aggelidakis et al., 2010)

Figure 3. Promoting cultivation of critical thinking skills in the examined parts of the text (Source: Authors’ own elaboration)

Figure 2 shows an example of activities related to promotion of cultivating critical thinking skills, which is located on page 33 in the examined textbook.

Figure 3 shows percent’s of the extent of every examined part in which the cultivation of critical thinking skills is promoted or is not promoted.

DISCUSSION

The findings of the present research are consistent with the results of another relevant research. The self-regulation is a critical thinking skill. In the research of Bogaards-Hazenberg et al. (2022), the content of Dutch textbooks for reading comprehension instruction was analyzed using material analysis and teachers’ evaluation and use of these books was analyzed using semi-structured teacher interviews and it was found little opportunities for self-regulated strategy application. The research of Siahaan (2021) examined English textbooks and revealed that these books do not contain all the critical thinking elements and also do not contain many questions that encourage students’ critical thinking. The research carried out by Ilmiiah (2021) examined C2 level books and revealed that not all aspects of the perspective of thinking were found in the statement of questions in the examined books. In the research of Hestrian et al. (2021), the content of a textbook was examined, and it was revealed that the textbook contained a few critical thinking elements. The research of Din (2021) examined the role of textbooks in developing critical thinking skills and revealed that the examined textbooks help develop lower order thinking skills, but they remain unable to hone and develop students’ higher order thinking and there is a need to integrate activities that help the students develop their critical thinking skills. The research of Perdanasari and Sangka (2021) aimed to analyze the need for developing teaching materials to improve critical thinking skills and showed that the teaching materials used have not led to improve students’ skills. High school textbooks and the corresponding teacher’s guidebooks were examined in the research of Khademi (2020), and it was found that emphasis on the critical thinking was at a very low level in the content of the examined books. The research of Peyró et al. (2020) analyzed the content of textbooks and showed that the examined material does not promote higher order thinking skills and consequently does not sufficiently foster the development of the critical thinking.
The purpose of the research of Samiee et al. (2020) was to determine the level of attention to the critical thinking components in a school textbook and it was concluded that low level of attention to the critical thinking has been paid in the components of the examined material. The research conducted by Al-Qahtani (2019), examined the extent to which university textbooks help in enhancing student’s critical thinking skills and showed that the examined material is insufficient in helping students develop high level of critical thinking skills. The research of Es-Salhi and Elfathii (2019) aimed to evaluate the promotion of the critical thinking skills in English textbooks and concluded that the examined textbooks do not foster the critical thinking skills of learners adequately. The research carried out by Irafahmi et al. (2018) showed that in the content of accounting textbooks used in universities, little attention to the critical thinking is paid. The research of Maki and Horita (2018), revealed that within school textbooks used in elementary schools, junior high schools and high schools, problems focusing on the critical thinking rarely appear. Solihati and Hikmat (2018) undertook research in order to determine the extent to which the critical thinking is promoted within language school textbooks and the findings showed that the examined textbooks do not contain many tasks promoting the critical thinking. In the research of Aybek and Aslan (2016) it was concluded that the activities in social studies textbooks do not meet sufficiently the critical thinking standards. According to the research of Sobkowiak (2016), the English-as-a-foreign-language textbooks that were examined do not foster sufficiently students’ critical thinking. The research carried out by Errington and Bubna-Litic (2015) examined popular management textbooks and showed that the majority of the examined textbooks potentially inhibit or support insufficiently the development of students’ critical thinking. In the doctoral dissertation of Ilyas (2015), it was examined, among other things, whether high school textbooks in English as a foreign language facilitate the teaching of the critical thinking skills and it was revealed that the examined textbooks do not sufficiently facilitate the teaching of the critical thinking skills. The doctoral dissertation of Permatasari (2012) showed that the reading tasks in senior high school textbooks do not involve high critical thinking level.

In the present research it was found that promotion of the cultivation of the critical thinking skills is insufficient. This insufficient promotion could be attributed to various reasons. Some reasons are the difficulties of the cultivation of the critical thinking (Brookfield, 2013; Willingham, 2007), the lack of training in the methodology of the critical thinking, the lack of information about educational material that promotes the critical thinking, the personal beliefs and prejudices of educators about the content of the curriculum and the way they teach it (Snyder & Snyder, 2008) and the fact that typical school teaching does not encourage high-level thinking skills (Paul, 1992).

Some other reasons are the teaching inefficiency and lack of knowledge about what is critical thinking and how it could be promoted (Aliakbari & Sadeghdaghighi, 2013; Giacomazzi et al., 2022; Yuan et al, 2022), the inefficiency of many adults to think critically in many cases (Halpern, 1998), the lack of fundamental reasoning skills from many adults (Gelder, 2005; Kennedy et al., 1991). Furthermore, there are the barriers to critical thinking such as egocentrism, sociocentrism, unwarranted assumptions, stereotypes, relativistic thinking and wishful thinking (Bassham et al., 2011).

CONCLUSIONS

The main text is the only part of the under study text, where cultivation of critical thinking skills is not promoted. Inference skill is represented by all of its sub-skills and interpretation, analysis, evaluation explanation skills are not represented by all of their sub-skills. The teaching objectives and the activities are the only examined parts, where the cultivation of critical thinking skills is promoted in the largest percentage of the text they cover. The present research showed that within the examined textbook the cultivation of critical thinking skills is not promoted sufficiently.

The present study is one of the few studies exploring the extent to which the cultivation of critical thinking skills is promoted within the content of an Informatics textbook. It can contribute to providing useful insights that may help the authors in compiling textbooks, where the cultivation of the critical thinking skills is adequately promoted. Furthermore, it provides a method, which can be used to examine if cultivation of critical thinking skills is promoted within a text.

A limitation of the present research is that the findings cannot be generalized to refer to other textbooks. It is suggested that research be conducted, where the content of the textbooks and a range of cognitive subjects are studied, with regard to the cultivation of the critical thinking skills within them. These types of research may shed light on the quality of the existing textbooks and how they can potentially be used concerning the critical thinking and the promotion of its cultivation.

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