Critical thinking in the first-class Informatics textbook of the Greek Lyceum: promoting the cultivation of its skills

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Abstract

There are problems societies and individuals have to deal with. To confront these problems, specific skills are needed. Critical thinking is indispensable in developing such skills. Critical thinking can contribute in improving problem solving skills and developing communication skills. Education of Informatics and critical thinking have a strong relationship since students cannot develop skills related to Informatics if they cannot think critically. Therefore, within the Informatics textbooks the cultivation of critical thinking skills should be promoted. The present paper aims to determine to what extent the cultivation of critical thinking skills is promoted in the Informatics textbook of the first class of the Greek Lyceum. The method that was used is the Quantitative Content Analysis. The present research revealed that within the examined textbook cultivating critical thinking skills is not promoted sufficiently.

Keywords: Critical thinking, critical thinking skills, Content Analysis, Informatics, textbooks

Introduction

Critical thinking develops an ever more accurate worldview and using it well in all aspects of life (Jason, 2022). Thus, Critical thinking is essential in of life. Critical thinking is a tool for the interaction of information with thoughts (Erkinovna, 2022). A critical thinker understands how to use knowledge to solve difficulties Raj et al., (2022). There is a need to cultivate critical thinking skills in order to create effective individuals (Mihail, 2022). There are impacts of critical thinking on academic, professional and personal levels (Abasaid & Ferreira, 2022). Every individual need critical thinking skill to solve problems in everyday life (Laabidi, 2022). Critical Thinking plays a great role in teaching and learning process (Shamboul, 2022). Education systems have recognized the importance of developing students' critical thinking skills (Nor & Sihes, 2022). The benefits of the critical thinking are many. Critical thinking lessons sought to improve skills such as solving problems, gathering and analyzing information, drawing conclusions, communicating ideas with clarity and effectiveness (Bassham et al., 2011). Critical thinking is the key competency for economic survival in the 21st century (Matthews & Lally, 2010). The present study is one of the few studies exploring the extent to which the cultivation of critical thinking is promoted within the content of Informatics textbooks. It provides useful insights to authors who write textbooks where the cultivation of critical thinking will be adequately promoted.

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, critical thinking is: a reflective and reasonable thinking which focus on what to believe or do (Ennis, 1985), a disciplined, self-directed thinking (Paul 1992). According to psychological approach, critical thinking comprises: the mental strategies and representations people use to solve problems and learn new concepts (Sternberg, 1986) or it is the use of cognitive skills

or strategies in order to increase the probability of an outcome (Halpern, 1998). Regarding the educational approach, the critical thinking is often considered to be represented by the levels of analysis, synthesis and evaluation of the Bloom taxonomy (Kennedy et al., 1991).

Critical Thinking and Informatics

Information management is essential in 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). 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). Students cannot cultivate Information literacy unless they have developed critical thinking skills (Paul & Elder, 2006). Therefore, critical thinking, Informatics and information literacy are strongly related.

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 has a very strong relationship with 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 (Voskoglou & Buckley, 2012). The aforementioned imply that there is a strong linkage between critical thinking and Informatics.

Logic is strongly related to many subjects of the 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

The current education system is becoming more and more aware of the importance of training students' ability to think critically (Balercă, 2022). Modern 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 the Analytical Curriculum for Information and Computer Technology in Education, critical thinking is one of the skills that should be promoted (Weert & Anderson, 2002). In Greece, the development of critical thinking is promoted in the new

curricula (Hellenic Pedagogical Institute, 2021). Consequently, in the Greek school textbooks of Informatics the cultivation of the critical thinking skills should be promoted.

Research questions

The purpose of the present research is to explore the extent to which the cultivation of the critical thinking skills is promoted within the Informatics textbook of the first class of the Greek Lyceum. 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 critical thinking skills whose cultivation is promoted?
2. If there are critical thinking skills whose cultivation is promoted, does this promotion occur to the same extent per skill?
3. Is there a critical thinking skill whose cultivation is promoted to the same extent per sub-skill?
4. To what extent the cultivation of the critical thinking skills is promoted in the whole text?

Method

Material

In this research the examined material is the content of the first-class Informatics textbook of the Greek Lyceum. 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 Internet and Collaboration and Security within Internet. Each thematic unit is divided into chapters ranging from three to five. In the present research the parts of the textbook that were examined are the teaching objectives, the teaching questions, the main text, the side text and the activities.

Research Design

The method that was used in the present research is the Quantitative Content Analysis. The 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 the 1970 (Johnsen, 1993). The main idea of Content Analysis is the inclusion of elements of a text into categories (Creswell & Clark, 2007; Krippendorff, 2004; Huntemann & Morgan, 2001; Rustermeyer, 1992). In order to encompass elements of the under-study text into a category system of categories should be established. This establishment was carried out as follows: firstly, an initial category system is used, secondly, it was defined the criterion that the parts of the under-study text must satisfy in order to fall into the category system and thirdly, it was examined whether the initial category system is suitable for the material of the present research and a final category system was emerged.

Taking into account the research questions of the present paper, the initial category system that was used consists of the following skills (categories) and sub-skills (sub-categories) of the critical thinking as defined by the American Philosophical Association (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

The above system of categories gathers advantages that are also the reasons why it was chosen to be used in this work. First of all, this system refers to critical thinking skills and this paper examines the promotion of their cultivation. In addition, this system provides a set of distinct categories and subcategories of critical thinking that can be used in Content Analysis. Furthermore, this category system is a consensus of forty-six critical thinking experts.

Subsequently, it was defined the criterion that the parts of the under-study text must satisfy in order to fall into the category system. This criterion determines whether or not a part of the under-study text belongs to a category. The recording unit determines which parts of the text fall into the category system (Krippendorff, 2004). Definition of the recording unit. In the present research the recording unit is defined as any part of the under-study text which contains exactly one message promoting the cultivation of a critical thinking skill. Every category corresponds to exactly one critical thinking skill and vice versa. Similarly, every sub-category corresponds to exactly one critical thinking sub-skill and vice versa. In particular, a part of a text which contains exactly one message expressing a teaching goal or a question or a learning activity about categorization, significance, clarifying meaning, examining ideas, identifying arguments, analyzing arguments, assessing claims, assessing arguments, querying evidence, conjecturing alternatives, drawing conclusions, stating results, justifying procedures, presenting arguments, self-examination, self-correction, falls into the corresponding sub-category and thus promotes the cultivation of the corresponding critical thinking sub-skill. If a part of a text falls into a subcategory, then that part also belongs to the basic category which is a superset of the subcategory.

Next, it was examined whether the initial category system is suitable for the under-study text. This 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; Rustermeyer, 1992; Holsti, 1969). 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:

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

In the under-study material, every part of the text that promotes 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. The elements of a basic category are the elements of all its sub-categories. After the categorization, any part of the under-study text that belongs to a category is characterized as categorized text otherwise is a non-categorized text. A categorized part of the under-study text is an element of a category.

In order to determine the extent to which the cultivation of a critical thinking is promoted within a text, the text should become measurable. In the present research, it was used the length of it to make a text measurable. 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. If a part of the under-study text belongs to a specific category, then the length of this part expresses the extent to which this part promotes the cultivation of the corresponding critical thinking skill. statistical processing was performed on: the lengths of the members of the sub-categories, the lengths of the members of the categories, the length of the non-categorized text, the length of the categorized text and the length of the whole under-study text. The results of the statistical processes were presented using tables.

Results and discussion

Table 1 displays the percentages of the length of the text promoting the cultivation of each basic critical thinking skill within the categorized text.

Table 1. Distribution of promoting the cultivation of the critical thinking skills within the categorized text

Interpretation sub-skills	Length of the text %
Interpretation skill	7,2%
Analysis skill	33,6%
Evaluation skill	0,9%
Inference skill	32,1%
Explanation skill	26,2%
Total categorized text length	**100%**

The skill whose promotion of its cultivation covers the largest percentage of the text length in relation to the other skills is the analysis skill, followed in descending order by the inference skill, the explanation skill, the interpretation skill and the evaluation skill.

The interpretation skill is represented by the categorization sub-skill and the clarifying meaning sub-skill. Table 2 displays the different percentages of the length of the text promoting the cultivation of each of these sub-skills.

Table 2. Distribution of promoting the cultivation of interpretation skill, by sub-category

Interpretation sub-skills	Length of the text %
Categorization sub-skill	31,2%
Clarifying meaning sub-skill	68,8%
Total interpretation length	**100%**

The analysis skill is represented by the examining ideas sub-skill. The text which promotes the cultivation of the examining ideas sub-skill cover 149 lines.

The evaluation skill is represented by the assessing claims sub-skill and the text promoting the cultivation of this sub-skill cover 4 lines.

The inference skill is represented by the querying evidence sub-skill, the conjecturing alternatives sub-skill and the drawing conclusions sub-skill. Table 3 displays the different percentages of the length of the text promoting the cultivation of each of these sub-skills.

Table 3. Distribution of promoting the cultivation of inference skill, by sub-category

Inference sub-skills	Length of the text %
Querying evidence sub-skill	12,0%
Conjecturing alternatives sub-skill	7,7%
Drawing conclusions sub-skill	80,3%
Total inference length	**100,0%**

The explanation skill is represented by the stating results sub-skill and the presenting arguments sub-skill. Table 4 displays the different percentages of the length of the text promoting the cultivation of each of these sub-skills.

Table 4. Distribution of promoting the cultivation of explanation skill, by sub-category

Explanation sub-skills	Length of the text %
Stating results sub-skill	44,8%
Presenting arguments sub-skill	55,2%
Total explanation length	**100,0%**

Table 5 shows that within the whole examined text, a small percentage of the length of the text promotes the cultivation of critical thinking skills.

Table 5. Promoting cultivation of critical thinking skills in the whole text

Explanation sub-skills	Length of the text %
Promoting	9,1%
Not promoting	90,9%
Total examined text	**100,0%**

The findings of the present research are consistent with the results of other relevant researches. These researches were categorized according to their findings. There is a category of researches which examine the promotion of the cultivation of specific critical thinking components within textbooks. Concerning of this category, there is one in which, materials analysis, teacher interviews and lesson observations were used as methods to analyze the content of textbooks and it was found little opportunities for self-regulated strategy application (Bogaerds-Hazenberg et al., 2022), there is another research, in which the revised two-dimensional classification table (Anderson & Krathwohl 2001) was used to analyze the content of textbooks and it was revealed that the examined material does not promote High Order Thinking Skills and consequently does not sufficiently foster the development of the critical thinking (Peyró et al., 2020). There is one more research of the same category, in which document analysis and descriptive analysis were used and it was concluded that the activities in social studies textbooks do not meet sufficiently the critical thinking standards (Aybek & Aslan, 2016).

There is another category of researches which examine the level of emphasis on the critical thinking in books. Regarding this category, there is one of qualitative type, in which C2 level books were examined and it was revealed that not all aspects of the perspective of thinking

were found in the statement of questions in the examined books (Ilmiah, 2021), there is another research, in which content analysis was used, a textbook was examined and it was found that the textbook contained a few critical thinking elements (Hestrian et al., 2021). In another research of this category, descriptive method and content analysis were used, high school textbooks and the corresponding teacher's guidebooks were examined and it was concluded that emphasis on the critical thinking was at a very low level in the content of the examined books (Khademi, 2020). Concerning the same category, there is another research, in which the purpose was to determine the level of attention to the critical thinking components in a school textbook, it was used content analysis as method and it was revealed that low level of attention to the critical thinking has been paid in the components of the examined material (Samiee et al., 2020). Regarding the same category of researches, there is one research in which documents analysis, contents analysis and questionnaire were used and it was showed that in the content of accounting textbooks used in universities, little attention to the critical thinking is paid (Irafahmi et al., 2018). In another research of the same category, content analysis was used, it was examined the extent to which the critical thinking is promoted within language school textbooks and it was revealed that the examined textbooks do not contain many tasks promoting the critical thinking (Solihati & Hikmat, 2018).

There is another category of researches which examine teaching materials for their sufficiency in improving students' critical thinking skills. Research of this category, aimed to analyze the need for developing teaching materials to improve critical thinking skills, used qualitative method, and showed that the teaching materials used have not led to improve students' skills (Perdanasari & Sangka, 2021). Another research of this category, used content analysis, examined the extent to which University textbooks help in enhancing student's critical thinking skills and found that the examined material is insufficient in helping students develop high level of critical thinking skills (Al-Qahtani, 2019). There is another research of this category in which content analysis was used as method, English textbooks were examined and it was found that these books do not contain all the critical thinking elements and also do not contain many questions that encourage students' critical thinking (Siahaan, 2021). With regard to the same category, according to research which used content analysis, the English-as-a-foreign-language textbooks that were examined do not foster sufficiently students' critical thinking (Sobkowiak, 2016).

In the present research it was found that within the examined textbook, the cultivation of the critical thinking skills is promoted in a very small part of the whole text and therefore is insufficient. This insufficient promotion of the critical thinking within the examined text could be attributed to some of the reasons that are mentioned below. 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 (Yuan et al, 2022; Giacomazzi et al., 2022; Aliakbari & Sadeghdaghighi, 2013), the inefficiency of many adults to think critically in many cases (Halpern, 1998), the lack of fundamental reasoning skills from many adults (Kennedy et al., 1991; Gelder, 2005). 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 present research revealed that there are critical thinking skills whose cultivation is promoted within the examined text. These skills are: the interpretation skill, the analysis skill,

the evaluation skill, the inference skill and the explanation skill. On the contrary, it was found that within the examined text, there is a critical thinking skill whose cultivation is not promoted and this skill is the self-regulation skill. The critical thinking sub-skills whose cultivation is promoted are: the categorization sub-skill, the clarifying meaning sub-skill, the examining ideas sub-skill, the assessing claims sub-skill, the querying evidence sub-skill, the conjecturing alternatives sub-skill, the drawing conclusions, the stating results sub-skill and the presenting arguments sub-skill.

Regarding the skills whose cultivation is promoted, it was found that this promotion does not occur to the same extent per skill.

There is no critical thinking skill whose cultivation is promoted to the same extent per sub-skill.

The present research revealed that within the whole material, the cultivation of critical thinking skills is promoted in a small percentage of the text it covers. Consequently, within the examined textbook the cultivation of the critical thinking skills is not promoted sufficiently.

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, and also provide useful insights that may help the authors in compiling textbooks where the cultivation of the critical thinking skills is adequately promoted.

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