Reading literacy and technological and engineering literacy in the context of their links to critical thinking

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Abstract

This paper examines the interdisciplinary issue of the role of various forms of literacy in the development of critical thinking in contemporary primary education. Drawing on findings from cognitive psychology and the didactic sciences, we put forward the thesis that reading, technological and engineering literacy are not merely independent competences, but that their didactic integration can make a significant contribution to fostering critical thinking. Using a narrative literature review across three mutually complementary fields – the didactics of technology, reading literacy and critical thinking – we identify theoretical intersections and conclude that the current didactic separation of these two forms of literacy in school practice diminishes the quality of higher-order cognitive processes in pupils. Technological and engineering literacy provide a contextual framework and a substantive basis for understanding the contemporary technology-mediated world, whilst reading literacy constitutes the fundamental ability to interpret, evaluate and critically reflect upon texts, data and information. We conceptualise critical thinking as a cognitive competence that can be fostered and developed through coherent and high-quality didactic integration of both forms of literacy.

Keywords

reading literacy, technological and engineering literacy, critical thinking, higher-order skills

1 Introduction

1.1 Reading literacy and the development of critical thinking

In the specialist literature, reading literacy is defined as the ability to understand, use, evaluate and reflect on texts, with a view to achieving one's own goals, developing knowledge and participating in society [25]. Literacy, understood in this way, goes beyond the mere decoding of graphic symbols and encompasses interpretation, evaluation and reflection – processes that are linked to certain important dimensions of critical thinking. The relevance of this conceptualisation is also confirmed by the results of the PISA 2022 survey, which indicate a marked decline in reading achievement **Error! Reference source not found.**, thereby highlighting the need for the systematic development of reading literacy within the school system.

From a cognitive-psychological perspective, reading comprehension is not a linear process of decoding, but rather a constructive activity in which the reader forms a mental representation of the text at multiple levels, ranging from the surface code to the situational model [14]. At the level of the situational model, the reader integrates textual information with prior knowledge and assesses its coherence and reliability, with some processes of reading comprehension being linked to critical thinking. This ability to link textual information with prior knowledge can make the transition from mere reproduction of information to reasoned judgement more difficult [21]. [16] discusses related processes from a text-linguistic perspective within the framework of the seventh component of reading literacy, which defines text comprehension as the recognition of linguistic and non-linguistic elements of context, on the basis of which the reader distinguishes the essential from the non-essential.

Recent empirical studies also suggest a link between reading comprehension and specific aspects of critical thinking, although these were conducted on older populations. Among secondary school pupils, a link was found between deeper reading comprehension and a greater ability to critically evaluate texts [23], whilst among university students, it was found that reading with the aim of critical evaluation is associated with a greater ability to detect inconsistencies [20]. As both studies examine a population older than the target group of this paper, we use their findings as indirect empirical support, rather than as evidence of the relationship among pupils in the second and third three-year cycles of primary school.

In Slovenia, critical reading is classified as one of the nine components of reading literacy [10], specifically the ninth component – critical reading – which [18] define as the ability to assess and evaluate the message, facts and viewpoints in a text, and to form a well-reasoned opinion. In this model, critical reading is treated as an integral part of reading literacy.

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There is a conceptual and functional link between reading literacy and critical thinking, as reading literacy involves the ability to understand, evaluate and reflect on information. [9] defines critical thinking as the purposeful use of cognitive skills in problem-solving and decision-making, whereby the quality of one's understanding of the available information can significantly influence judgement. A superficial understanding of a text can make it difficult for a learner to construct arguments and identify logical inconsistencies, thereby reducing the quality of their reasoned judgement. Reading literacy can therefore significantly support the understanding of problem situations presented in text form, as well as the analysis and evaluation of information, including in the fields of technology and engineering.

1.2 Technological and engineering literacy and the development of critical thinking

Technological and engineering literacy is one of the fundamental, yet conceptually more challenging, concepts in modern technical education. Its complexity stems from the fact that it encompasses a broad and constantly evolving field of human activity, which is closely intertwined with the natural sciences, mathematics and other disciplines [27]. In this context, the concept of literacy does not merely refer to the functional ability to handle technological tools, but to a deeper cognitive understanding of technology as a phenomenon, a process and a system [12]. For brevity, the term 'technological literacy' is used interchangeably with 'technological and engineering literacy' throughout this paper.

The most important international reference framework in this field is the Standards for Technological and Engineering Literacy (STEL), published in 2020 by the International Society for Technology and Engineering Education [13]. The aim of STEL is not to train technologists or engineers, but to broaden the technological and engineering literacy of all learners to such an extent that they are able to make informed decisions regarding the technologies they encounter in the world. In Slovenia, this literacy has long been reduced to the use of information and communication technology (ICT), whilst its deeper significance has remained of peripheral importance [15]. [33] notes that the level of technological literacy among trainee teachers in the Slovenian higher education sector is unsatisfactory, which indirectly affects the quality of teaching technical subjects in primary schools.

In the Slovenian primary school curriculum, the subject of 'Technology' plays a central role in the development of this literacy. The new curriculum [24] directly links it to the development of technical thinking, creativity and innovation, and emphasises that the subject is one of the few that enables the implementation of higher cognitive levels of knowledge according to Bloom's taxonomy – particularly analysis, synthesis and evaluation. Primary schools play a key role, as they are the only institutions in the education system that offer technical content to the entire pupil population [15].

The relationship between technological and engineering literacy and critical thinking is clearly intertwined: technological literacy significantly supports and enriches the capacity for critical thinking, whilst at the same time it can only develop to a high standard in the presence of critical reflection. A learner who does not understand how technology works at the level of processes, systems and societal impacts finds it more difficult to analyse and evaluate the technological solutions they encounter in a meaningful way. [29] note that the engineering design process (EDP) acts as a platform for situational learning, in which pupils develop higher-order thinking whilst solving authentic problems. Curriculum reforms in several countries confirm that STEM approaches, particularly through the EDP, enable pupils to develop critical thinking, creativity and communication skills [17]. Technological and engineering literacy can thus significantly support the analysis and evaluation of technological problems and the transition from the reproduction of knowledge to reasoned judgement.

1.3 Critical thinking as a complex, domain-specific competence

It is appropriate to begin by explaining what the concept of critical thinking means, as critical thinking has been defined differently across various periods and in different fields [11] [3] [4] [19] [8] [7]. In what follows, we shall attempt to answer the question: To what extent is critical thinking linked to subject-specific knowledge, and can it be understood as a general cognitive ability?' It must be emphasised that critical thinking goes beyond the expression of a particular personal belief [11], as it involves specific cognitive abilities (such as judgement, analysis, evaluation and others) that an individual can learn through a specific process [11] [6] [8] [19]. These are specific cognitive abilities and skills, but they are contingent upon the individual's ability to apply them (e.g. a willingness to test one's own views, a willingness to investigate, etc.), whereby, for example, sound reasoning requires knowledge of the subject area in question [11] [3] [4] [22] [19] [8] [32] [31].

The definition of critical thinking has evolved over the years; the American philosopher John Dewey [3], who used the term 'reflective thinking', argued that an individual should not accept beliefs automatically:

active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends. ([3]: 6; [4]: 9).

Hitchcock emphasises that 'critical thinking //..//*is a widely accepted educational goal'* [11], a view also put forward by other authors, such as Siegel [28], whereby it involves goal-oriented thinking; however, as Hitchcock [11] emphasises, definitions of critical thinking may vary depending on criteria, standards, etc. [11]. When discussing educational objectives, Hitchcock highlights the importance of taking learners' autonomy into account [11]; furthermore, the development of critical thinking also helps learners to succeed in everyday life, meaning they can make independent and considered judgements says Hitchcock [11]. However, as he explains, questions remain regarding how effectively critical thinking can be transferred between different subject areas, how to distinguish critical thinking from other types of thinking, and so on [11]. We also believe that incorporating argumentation and the other elements mentioned by Hitchcock [11] into teaching can help to distinguish more clearly between opinion and critical thinking.

McPeck's view is also particularly relevant to this paper; he argues that critical thinking should not be taught as a separate

subject but should be integrated into school subjects [22] [11]. Our analysis of the authors' works revealed that the importance of subject-specific knowledge and contextual content in critical thinking is underscored by Dewey [3] [4], Weinstein [30], Bailin et al. [1], Willingham [32] [31], Hitchcock [11] and others [11], suggesting that critical thinking can be meaningfully fostered and applied within the context of specific subject areas, in our case, reading literacy and technological and engineering literacy.

At this point, we shall briefly highlight the importance of incorporating critical thinking into the educational process; we shall therefore go on to mention two significant historical milestones which demonstrate that critical thinking is, in fact, of exceptional importance. Among the key milestones in the development of critical thinking, we would highlight the turning point in 1956 when Bloom included higher-order cognitive processes associated with critical thinking – in particular, analysis, synthesis and evaluation [11] [11] – in his 'taxonomy of cognitive educational objectives' [11]. It is also worth noting that as early as 1962, Ennis '*proposed 12 aspects of critical thinking as a basis for research on the teaching and evaluation of critical thinking ability'* (as cited by Hitchcock in [11]). These two contributions had a significant influence on the establishment of critical thinking as an educational objective; however, as Hitchcock [11] argues, critical thinking does not involve drawing conclusions without verifying evidence as well as the other important components of critical thinking identified by the aforementioned authors. [11] [3] [4]. We also agree that critical thinking is linked both to cognitive abilities and dispositions and to knowledge of the field in which an individual is making judgements [11]. In the context of our study, these fields are reading literacy and technological and engineering literacy. As Hitchcock explains, high-quality judgement requires the use of appropriate criteria, reasons and evidence, as well as the ability to analyse and evaluate information. [11]. Hitchcock argues that the educational objective is therefore:

"The real educational goal is recognition, adoption and implementation by students of those criteria and standards[1]*. That adoption and implementation in turn consists in acquiring the knowledge, abilities and dispositions of a critical thinker."* [11].

In this paper we follow this position and treat critical thinking as a general cognitive competence whose meaningful application nonetheless depends on domain-specific knowledge – a distinction we return to in the discussion of reading and technological and engineering literacy below.

2 Interconnections between the areas under consideration

In Slovenian educational practice, technological and engineering literacy is traditionally situated within the subject area of engineering and technology and is often treated separately from linguistic and cognitive competences. Such disciplinary separation may also affect the didactic integration of technical, linguistic and cognitive competences. There is a possibility that the acquisition of technical knowledge is not always systematically linked to the development of the ability to reflect critically on it, interpret it through reading, and evaluate it in a reasoned manner. As [27] note, one of the key challenges in the field of technology and engineering education remains precisely that of conveying a comprehensive picture of what technological literacy encompasses, as its scope is so broad and constantly evolving that it cannot be treated as a narrow discipline.

In some of the models under consideration, critical thinking is positioned as a component of a particular form of literacy, rather than as a separate, equivalent third competence. The STEL standards [13] place critical thinking within technological literacy itself, whilst the nine building blocks of reading literacy [10] treat critical reading as part of reading literacy. In this paper, we propose a conceptual model in which all three competences are functionally linked within a specific problem-based context, which, to our knowledge, goes beyond existing conceptualisations. It should be emphasised that the choice of precisely these two forms of literacy – reading and technological-engineering – is based on the curricular framework of the subject 'Technology' in Slovenian primary schools and does not imply a claim that these are the only or universally necessary two competences for the development of critical thinking in general.

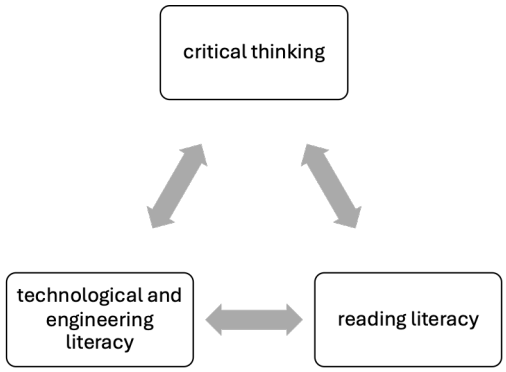

Figure 1: Critical thinking and both forms of literacy are interlinked in the context of solving authentic problems presented through technology and text

The intersection of all three areas under consideration is most clearly evident in situations involving authentic problem-solving, which require pupils to simultaneously decode and interpret instructions or technical documents, an understanding of the technological context and how systems operate, and a critical evaluation of proposed solutions and their consequences. As highlighted in previous chapters, reading literacy enables or facilitates pupils' understanding of the problem context conveyed through text, whilst technological and engineering literacy support the understanding and evaluation of technical information and moving beyond the level of mere knowledge reproduction. In this regard, a distinction must be made between domain-specific critical reading or evaluation, which forms part of the respective literacy itself (e.g. the ninth component of reading literacy), and the more general, transdisciplinary critical thinking, the development and application of which can be supported by their integration within an authentic problem-based

[1] See Hitchcock (2024) for a discussion of the criteria and standards of critical thinking.

context. Without this combination, it is difficult for a learner to move beyond the level of reproduction and reach the level of informed judgement. This functional interdependence is not merely a logical deduction from the previous chapters, but a synthesised thesis that follows from a comparison of the two theoretical frameworks. Whilst underdeveloped reading literacy can limit the processing of technical texts, and limited technological and engineering literacy can hinder the content-based assessment of technological issues, both competences represent important factors that can support the development and application of critical thinking in this specific context. In this sense, the three competences do not operate in parallel, but are functionally interdependent and can complement one another; a more comprehensive development could be supported by cross-curricular didactic approaches. We regard the proposed model as a conceptual starting point for further theoretical discussion and empirical testing.

3 Conclusion

This paper is based on the premise that integrating reading literacy with technological and engineering literacy can support the development and application of critical thinking in solving authentic problems presented through technology and text. A review of the relevant literature from three mutually complementary fields – reading literacy, technological and engineering literacy, and critical thinking, suggests that the current didactic separation of these competences in school practice diminishes the quality of higher-order cognitive processes and limits pupils' ability to engage in autonomous, reasoned and reflective judgement in a technology-mediated world. The proposed interdisciplinary model, which regards reading, technological and engineering literacy as important competences that can support the development of critical thinking in the context under consideration, opens a new conceptual space for understanding the relationships between these competences. This is a theoretical thesis awaiting further conceptual or, potentially, empirical testing, rather than a definitively confirmed finding. A limitation of the theoretical grounding presented here is that direct empirical evidence linking reading comprehension to critical thinking currently derives mainly from secondary and tertiary populations; empirical validation with primary-school pupils remains a task for future research. At the same time, it offers a didactic starting point for designing approaches that transcend traditional subject boundaries and promote the integrative development of all three competences within the framework of primary education. Interdisciplinary integration is not merely a methodological advantage, but a direct reflection of the thesis advocated by this paper: the integration of different perspectives can contribute to a more comprehensive understanding of complex cognitive phenomena.

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