The Impact of Homework on Enhancing Critical Thinking Skills in STEM Education: A Literature Review

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Abstract

Students' critical thinking skills can be enhanced through various approaches. Homework, as one of these pedagogical strategies, has been integrated into teaching to foster critical thinking across different subjects. This paper aims to review research on homework, with a specific focus on its integration in STEM education. The study reviewed fifteen (15) research articles that examined the effectiveness of homework in STEM education. The results indicate that, among the various types of homework, project/research-based and collaborative homework have significant potential to improve students' critical thinking skills. However, while there are many benefits to using homework to develop critical thinking skills, this review also highlights those limitations in resources, along with variations in students' learning styles and social skills, can negatively impact the improvement of critical thinking. Moreover, the findings suggest that well-planned, high-quality homework, when assigned in smaller quantities, can significantly enhance students' critical thinking. Nevertheless, the generalisability of these results is subject to certain limitations, as most studies claiming the effectiveness of homework in promoting critical thinking are short-term. Therefore, longitudinal research is necessary to evaluate the long-term impact of homework on enhancing students' critical thinking skills.

Keywords: homework, critical thinking, STEM, science education

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Introduction

In the ever-evolving landscape of education, particularly within the fields of Science, Technology, Engineering, and Mathematics (STEM), the development of critical thinking skills has become a cornerstone of effective learning. As educators and policymakers strive to prepare students for complex problem-solving and innovation, homework continues to play a central role in reinforcing classroom instruction. However, beyond its traditional function of practice and review, homework has the potential to cultivate deeper cognitive abilities. This paper explores the impact of homework on enhancing critical thinking skills in STEM education, examining how well-designed assignments can encourage analysis, evaluation, and creative problem-solving skills which are essential for success in both academic and real-world contexts.

Therefore, this review aims to fill that gap by synthesizing current literature on homework and its impacts on developing students' critical thinking. The objectives of this study are to examine existing research and explore the influence of homework on the development of critical thinking skills, with a particular focus on STEM education. The review starts by presenting a summary of the literature on homework and its connection to students' critical thinking abilities. It then outlines the methods used for selecting and analysing relevant studies. The findings are discussed, followed by a conclusion that highlights the study's contributions, acknowledges its limitations, and offers recommendations for future research aimed at designing effective homework strategies.

Literature Review

Homework

In academic research, the concept of homework is approached from multiple viewpoints. Cooper (1989a) describes homework as any task assigned by educators that learners are expected to complete outside of normal classroom hours, giving them the flexibility to work in various environments. These assignments, for instance, can be completed at home, within the classroom, online, or even in other educational settings outside of school. Similarly, Olympia et al. (1994) define homework as school-issued tasks meant to extend students' academic practice into non-school hours and settings. What is particularly noteworthy in these definitions is that homework doesn't have to be confined to the home, where it is completed often depends on the student's preference or circumstance.

Another interpretation suggests that homework consists of tasks aimed at helping learners prepare for upcoming instructional content (Kaur, 2011). Moreover, such assignments are intended to reinforce, broaden, and revisit classroom learning during out-of-school hours. According to Kazantzis and Ronan (2010), homework can take many forms, tailored to students' individual needs, and often encourages deeper investigation, critical analysis, and engagement with classroom topics. It also functions as a tool to help guide students through focused exploration and understanding of specific subjects. However, homework refers to any assignment (individual work, group projects, or research activities) given by a teacher to be completed outside regular school hours, regardless of the location or format. This definition also includes any task intended to strengthen students' capacity to apply independent and critical thinking to what they have learned in class.

Critical Thinking in STEM

In scholarly literature, critical thinking is portrayed as a complex and layered concept, with definitions shaped by the insights of philosophers, psychologists, and educators (Lewis & Smith, 1993). These varied viewpoints have produced differing definitions of critical thinking by analysing the unique considerations relevant to each academic discipline. Giving a single, precise definition of critical thinking is not an easy task. Nonetheless, it is commonly described as a metacognitive process involving a combination of sub-skills and mental dispositions (Magno, 2010). When used effectively, critical thinking increases the chances of arriving at a sound conclusion or solving a problem logically. Although it is widely regarded as a fundamental educational goal, many students report having limited opportunities to learn about or practice their critical thinking abilities (Dwyer et al., 2014). Fisher (2011) defines critical thinking as "reasonable, reflective thinking that is focused on deciding what to believe or do" (p. 45). This definition highlights the idea that decision-making (whether about belief or action) is inherently practical, framing critical thinking as a functional skill. In other words, students with well-developed critical thinking abilities can identify issues, gather and evaluate relevant information, examine it from multiple perspectives, and reach thoughtful, independent decisions about beliefs or actions. As a result, many educators and policymakers prioritize content delivery, often overlooking the importance of encouraging curiosity, questioning, and creative thought among students. Even though there is still debate about the exact meaning and necessary components of critical thinking, terms such as creative thinking, deep thinking, and cognitive skills can be used interchangeably with critical thinking which also considered as a cognitive process that involves complex reflection, analysis, and the ability to generate innovative solutions (Moore, 2013).

Methodology

Research Design

This research adopts an approach similar to a systematic review, commonly referred to as a systematized literature review, which includes selected features of the systematic review methodology (Grant & Booth, 2009). According to Moher et al. (2009), conventional literature reviews are often described as "unsystematic and unfocused," lacking the precision and discipline associated with systematic reviews.

Unlike traditional reviews, which typically do not prioritize transparency or follow specific procedures, systematic reviews follow a clearly defined process for identifying, selecting, and synthesizing original research (Moher et al., 2009). However, carrying out a full systematic review is highly demanding in terms of time and resources, often requiring collaboration among multiple researchers and extended time periods (Moher et al., 2009). Given these limitations, a traditional, desk-based literature review that integrates aspects of the systematic review framework is more suitable for this study, considering the constraints related to available time, resources, and the objective to examine empirical research.

Search Strategy

This study conducted a literature search using the keywords "Homework" AND ("critical thinking" OR "thinking skills") and was limited to empirical studies. The initial round of searching produced an extensive number of results which indicate the need for a more focused and refined search approach. To narrow down the results and improve relevance, the search

criteria were revised to include only those publications where the keyword “homework” appeared in the title rather than in the abstract or full text. This change helped ensure that the selected studies placed gamification at the core of their investigation, rather than merely mentioning it as a peripheral or background concept.

Study Selection

The initial search identified a total of 135 articles. After a preliminary screening process, 73 articles were removed due to duplication, irrelevance based on their titles, or abstract. The remaining 62 articles were then reviewed in more detail to assess their suitability. An additional 47 articles were excluded for not aligning with the focus of this literature review. This process ultimately resulted in 15 relevant articles, which were then included in the final review.

Data Extraction and Analysis

The data from the chosen articles were thoroughly examined, and preliminary insights were noted. The homework strategies and methods discussed in the studies were carefully analysed and systematically coded based on the research questions. These homework strategies/methods were then organized into three primary categories: Project based, research based, collaborative or other. Furthermore, studies that highlighted negative effects of homework or reported a decrease in critical thinking skills were also recorded. In the final step, the impact of homework on each of these categories was assessed to offer a comprehensive overview.

Results

This study reviewed fifteen (15) research articles to investigate the role of homework in enhancing students' critical thinking skills within the context of STEM education. The analysis focused on the various types of homework and their effectiveness in fostering critical thinking.

The findings suggest that certain types of homework have a particularly strong impact on the development of critical thinking skills. Specifically, project-based/research-oriented and collaborative homework assignments were found to be the most effective in promoting critical thinking (Galloway et al., 2013; Olympia et al., 1994; Tyser & Cerbin, 1991; Watkins, 2012). These types of homework encourage students to engage in deeper analysis, synthesis, and problem-solving, all of which are essential components of critical thinking. Additionally, collaborative homework, which involves group work and peer interactions, also demonstrated considerable benefits in enhancing students' critical thinking (Arthurs & Templeton, 2009; Simpkins et al., 2015; van Voorhis, 2000). The collaboration required in these assignments allows students to evaluate different perspectives, engage in meaningful discussions, and work together to solve complex problems, further developing their analytical skills.

In contrast, traditional homework formats, such as problem sets or simple rote memorization tasks, were found to have less significant effects on critical thinking. These assignments generally reinforce existing knowledge but do not foster the deeper cognitive processes required for critical thinking. Overall, the research highlights the importance of incorporating project/research-based and collaborative homework into STEM curricula as they contribute significantly to the development of critical thinking skills. These approaches encourage students to apply their knowledge in real-world contexts and to work collaboratively with others, both of which are crucial for cultivating strong critical thinking abilities.

Contrary to previous findings from various studies, it has been shown that approaches such as project-based and research-based homework may not effectively promote critical thinking skills in students who are accustomed to traditional instruction aligned with national curricula (Kong, 2014). Students who are familiar with teacher-centered teaching methods often face challenges when engaging in project work. Additionally, for students with limited reading and writing skills, project or research-based homework may not be an effective learning strategy (Noble, 2004; Westwood, 2016). Teachers typically assign project or research-based homework with the aim of helping students grasp subject concepts through the work itself (Livengood et al., 2012). However, such projects may not adequately provide clear examples, illustrations, or practical applications of the concepts, particularly for students who are used to more traditional, teacher-directed learning methods.

Conclusion

This study has examined how critical thinking skills can be enhanced through various homework strategies. The study highlights a significant positive impact of homework on the development of critical thinking skills. While the homework approaches such as project based and collaborative assignments offer several advantages for fostering critical thinking, the study also emphasizes that limitations such as resource constraints, as well as differences in students' learning styles and social skills, can negatively affect the expected learning outcomes. Despite these challenges, the findings suggest that well-designed, high-quality homework assignments, when assigned in moderation, can significantly boost students' critical thinking abilities. However, the generalizability of these results is subject to certain limitations. For instance, while many studies supporting the effectiveness of homework in promoting critical thinking are short-term and conducted by researchers rather than teachers themselves, the outcomes could differ if the perspectives of experienced teachers who regularly implement homework approaches were considered. Therefore, incorporating teachers' firsthand experiences could provide a more holistic understanding of how homework strategies impact the development of critical thinking skills. Nevertheless, the generalisability of these results is subject to certain limitations, as most studies claiming the effectiveness of homework in promoting critical thinking are short-term. Therefore, longitudinal research is necessary to evaluate the long-term impact of homework on enhancing students' critical thinking skills.

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