BIO-INOVED
Jurnal Biologi-Inovasi Pendidikan
Volume 7, Issue 2, June 2025 page. 166-179

P-ISSN : 2684-9062 | E-ISSN : 2714-9803
https://ppjp.ulm.ac.id/journal/index.php/bino
DOI: 10.20527/bino.v7i2.21669

Advancing biology education through HOTS-based learning on digestive system concepts: A systematic literature review

Tiffany Safitri [1, 2], Didit Ardianto [1], Irvan Permana [1] *, Surti Kurniasih [1], Eni Nuraeni [3]

[1] Master Program of Science Education, Postgraduate School, Universitas Pakuan, Bogor, West Java, Indonesia
[2] Ibnu Hajar Islamic School, Bogor, West Java, Indonesia
[3] Study Program of Biology Education, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia

** Corresponding Author Email: irvanpermana@unpak.ac.id*

Article Information

Keyword:
Problem-based learning; Critical thinking; STEM; Creative thinking; Problem-solving

Kata Kunci:
Pembelajaran berbasis masalah; Berpikir kritis; STEM; Berpikir kreatif; Pemecahan masalah

History:
Received : 19/01/2025
Revised : 14/05/2025
Accepted : 03/06/2025
Published : 13/06/2025

Abstract

Developing higher-order thinking skills—critical thinking, creative thinking, and problem-solving—is essential for preparing students to address complex, real-world problems. This systematic literature review, conducted using the PRISMA 2020 guidelines and qualitative content analysis, explores how HOTS is integrated into teaching the human digestive system in secondary education by addressing three key questions: (1) which HOTS are most frequently developed, (2) which instructional strategies are most effective, and (3) what challenges and opportunities exist in implementation. Fourteen peer-reviewed articles published between 2020 and 2024 were analyzed. Results show that critical thinking is the most emphasized skill, followed by creative and problem-solving abilities. Problem-Based Learning (PBL) emerged as the most widely used strategy (21.4%), with STEM, the discovery learning model, and the contextual teaching learning model contributing significantly. Key challenges include curriculum transitions, limited scaffolding, and uneven student participation. Conversely, opportunities arise from integrating technology, applying real-world contexts, and promoting collaboration. While the search included international databases, most studies meeting the inclusion criteria were authored by Indonesian researchers, which may limit cross-contextual generalization. This review underscores the value of combining student-centered learning models with contextual and technological support to enhance HOTS in biology education.

Abstrak. *Pengembangan keterampilan berpikir tingkat tinggi—berpikir kritis, kreatif, dan pemecahan masalah—merupakan hal penting untuk mempersiapkan siswa menghadapi permasalahan kompleks di dunia nyata. Studi tinjauan literatur sistematik ini dilakukan berdasarkan pedoman PRISMA 2020 dan menggunakan pendekatan analisis isi kualitatif untuk mengeksplorasi integrasi HOTS dalam pembelajaran sistem pencernaan manusia di jenjang pendidikan menengah, dengan menjawab tiga pertanyaan utama: (1) HOTS apa yang paling sering dikembangkan, (2) strategi pembelajaran apa yang paling efektif, dan (3) tantangan serta peluang apa yang muncul dalam implementasinya. Sebanyak 14 artikel terbitan tahun 2020–2024 ditelaah. Hasil menunjukkan bahwa berpikir kritis merupakan keterampilan yang paling dominan, diikuti oleh berpikir kreatif dan pemecahan masalah. Problem-Based Learning merupakan strategi paling banyak digunakan (21,4%), disusul pendekatan STEM, model discovery learning, dan model contextual teaching learning. Tantangan utama meliputi transisi kurikulum, kebutuhan scaffolding, dan partisipasi siswa yang tidak merata. Di sisi lain, peluang muncul melalui integrasi teknologi, penerapan konteks nyata, dan kolaborasi aktif. Meskipun pencarian dilakukan melalui basis data internasional, sebagian besar artikel yang memenuhi kriteria inklusi ditulis oleh peneliti Indonesia, yang dapat membatasi generalisasi lintas konteks. Kajian ini menegaskan pentingnya kombinasi pendekatan kontekstual, teknologi, dan pembelajaran berpusat pada siswa dalam meningkatkan HOTS di pendidikan biologi.*

A. Introduction

In the 21st century, higher-order thinking skills (HOTS) are increasingly recognized as crucial competencies for students to navigate a rapidly evolving and complex global landscape. These skills encompass analysis, evaluation, and creation, beyond the basic cognitive tasks of remembering and understanding (Anderson et al., 2001; Bloom, 1956). This study defines HOTS as a set of advanced cognitive abilities, including critical thinking, creative thinking, and problem-solving, following frameworks by Ennis (1985) and Nitko & Brookhart (2011). These three indicators are the focus of this review because they are consistently emphasized in science education literature as essential for scientific reasoning, innovation, and decision-making (Muhibbuddin et al., 2023; Sujatmika et al., 2024).

Learning approaches grounded in Higher-Order Thinking Skills (HOTS) are intended to enhance students' capacity to critically analyze intricate problems, devise original solutions, and make thoughtful, logical decisions. Effective in nurturing higher-order thinking abilities, instructional models like Discovery Learning, Inquiry-Based Learning, Project-Based Learning (PjBL), and Problem-Based Learning (PBL) have been widely recognized for their contribution to skill development in educational settings (Aisy et al., 2024; Aliyawinata et al., 2021; Antonio & Prudente, 2023; Rochmahwati et al., 2024; Tanjung & Rasyidah, 2024; Zohar & Dori, 2003). In particular, PBL and PjBL provide real-world problem contexts that challenge students cognitively, while inquiry and discovery learning emphasize exploration and hypothesis testing (Anwar et al., 2023; Judijanto et al., 2024; Nurdin et al., 2019; Pedaste et al., 2015; Pratama et al., 2024).

In the context of science education, fostering higher-order thinking skills is crucial for enabling students to relate scientific ideas to practical, real-life situations (Auliah et al., 2024; Sujatmika et al., 2024). However, international assessments, such as PISA, show that Indonesian students underperform in HOTS domains. The PISA 2022 results indicated that only 28% of Indonesian students achieved proficiency levels requiring HOTS, compared to the OECD average of 44% (OECD, 2023). This issue is also reflected in national research. For example, Nurhatmanti et al. (2021) found that 70% of students in Palembang demonstrated inferior HOTS performance in science subjects. Similarly, Susilo et al., (2023) reported that seventh-grade students at a junior high school in West Java scored only 27% in analyzing, 24% in evaluating, and 20% in creating domains of HOTS. Fauzi & Wicaksono (2021) further showed that junior high school students in Malang consistently performed at a low HOTS level. This disparity emphasizes the urgency to reform educational strategies, particularly in science education, to foster HOTS and improve Indonesia's global competitiveness, especially in light of the demands of the Fourth Industrial Revolution (Schwab, 2016).

A preliminary survey of 10 science teachers in Indonesia revealed that over 70% still rely on lecture-based methods, emphasizing factual recall. Classroom observations further confirm that students struggle with tasks requiring analysis, such as interpreting digestive models or evaluating dietary decisions. These findings support prior literature emphasizing the lack of HOTS emphasis in traditional teaching (Bustami et al., 2020; Muhibbuddin et al., 2023; Qasrawi & Beniabdelrahman, 2020).

Among various biology topics, the human digestive system is particularly suited for HOTS development. It encompasses complex physiological processes such as enzymatic breakdown, nutrient absorption, and disease diagnosis (Sensoy, 2021). For example, understanding digestive disorders requires students to evaluate symptoms, infer causes, and propose treatment options, aligning with HOTS indicators. Nevertheless, teaching this topic often defaults to memorization, lacking authentic tasks that engage students in critical, creative, or problem-solving processes (Mack et al., 2023; Prasetya et al., 2024; Tapia et al., 2021). Existing reviews, such as those by Yanti & Thohir (2024) and Diena et al. (2023), have discussed HOTS in general science learning contexts. However, none focused on the human digestive system as a subdomain of biology education. Likewise, while studies confirm the effectiveness of PBL, PjBL, and SSI-based learning for promoting HOTS (Aisy et al., 2024; Prasetya et al., 2024), the application of these strategies in the context of digestive system topics has not been comprehensively analyzed. This highlights a gap that this study seeks to address.

To bridge this gap, the present study undertakes a systematic literature review (SLR) to examine the integration of HOTS-oriented instructional approaches in teaching the digestive system within secondary education contexts. The review is guided by three questions: (1) What higher-order thinking skills can be developed through digestive system topics? (2) What learning strategies are most effective in enhancing HOTS within this context? (3) What challenges and opportunities exist in implementing HOTS-based approaches in digestive system education? Through this SLR, the study seeks to critically analyze existing practices, identify gaps, and propose improvements to instructional strategies. By answering these questions, the study provides evidence-based recommendations to enhance biology instruction in line with curriculum reforms such as the Merdeka Curriculum, which emphasizes critical and creative thinking, particularly in Indonesia, where curriculum reforms demand innovative teaching approaches (Pramana et al., 2021).

B. Material and method

Through a systematic literature review (SLR), this study aims to explore the dominant patterns, teaching approaches, and obstacles encountered in integrating HOTS in the digestive system at the secondary school level. The review process adheres to the PRISMA 2020 guidelines (Page et al., 2021), which offer a comprehensive and transparent framework for systematically identifying, screening, and selecting pertinent studies, thereby reinforcing the methodological rigor of the study (Moher et al., 2009).

The population in this study consisted of research articles related to the implementation of HOTS in secondary education, particularly on the digestive system topic, published in peer-reviewed journals. The sample was selected based on inclusion and exclusion criteria to ensure relevance and quality (Gough et al., 2017). Articles were identified through systematic searches in Scopus, Google Scholar, ERIC (Education Resources Information Center), and DOAJ (Directory of Open Access Journals), using keywords such as "HOTS," "digestive system," "critical thinking," and "secondary education." Boolean operators (AND, OR) and truncations were applied to refine searches further (Booth et al., 2016).

Data collection followed the PRISMA guidelines, including four stages: identification, screening, eligibility, and inclusion (Page et al., 2021). An initial search yielded 595 articles from various databases. The screening process began with a review of titles and abstracts to remove duplicates and studies that were not relevant. Afterward, full-text articles were examined in detail to determine their eligibility according to the established inclusion and exclusion criteria. The inclusion criteria ensured that articles were peer-reviewed, focused on secondary education, and addressed HOTS in the context of the digestive system. Only articles published in English between 2020 and 2024 were considered. Exclusion criteria included conference proceedings, book chapters, and studies unrelated to the research objectives. Table 1 provides an overview of the search terms and results.

The PRISMA process is visualized in a flow diagram (see Figure 1), summarizing the stages of article selection, including the number of articles at each step and reasons for exclusion. This visual representation aids in transparency and allows readers to trace the decision-making process (Liberati et al., 2009).

The inclusion criteria were developed to ensure that only relevant and high-quality studies were analyzed. These criteria were systematically used to evaluate article abstracts, as shown in Table 2.

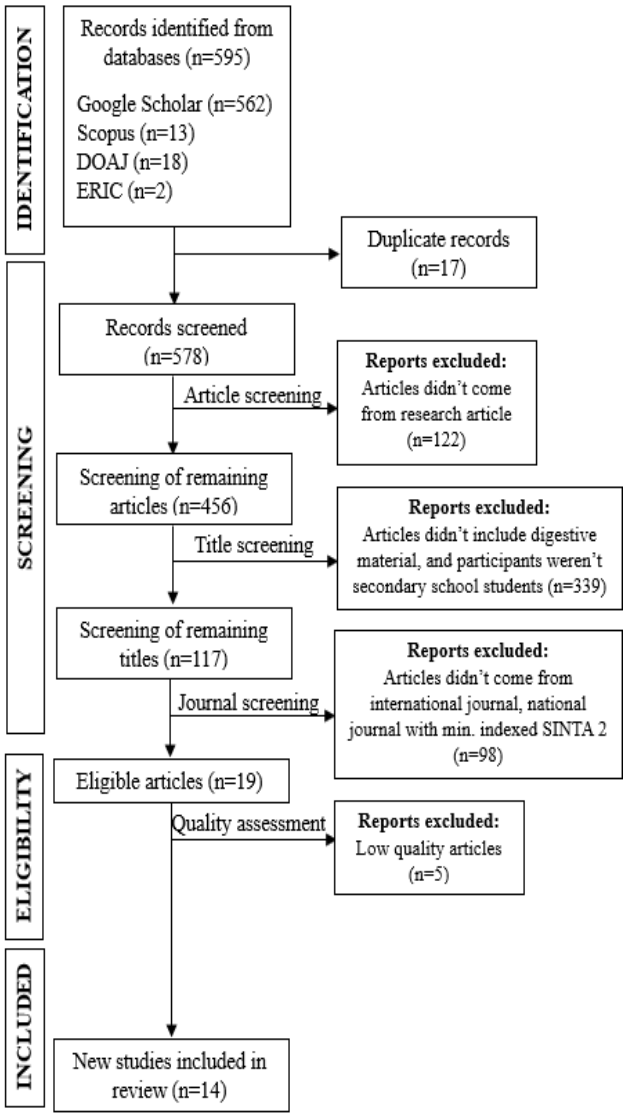

Figure 1 PRISMA diagram of the article selection process

Table 1 Results of initial literature search

Search terms	Database	Count
"higher order thinking skills" AND "digestive" AND "students"	Google Scholar	562
"critical thinking" OR "problem solving" OR "creative thinking" AND "digestive" AND "students"	Scopus	13
	ERIC	2
	DOAJ	18
Total		**595**

Table 2 Criteria of inclusion and exclusion

Inclusion criteria	Exclusion criteria
Articles were published in peer-reviewed journals indexed by Scopus, Copernicus, or SINTA 2.	Articles were conference proceedings, book chapters, or non-peer-reviewed articles.
Focused on secondary education, particularly on the digestive system topic.	Focused on unrelated topics such as university-level education or non-biological contexts
Discussed HOTS developmental outcomes aligned with the framework by Nitko & Brookhart (2011)	Articles did not provide data relevant to the study's research questions.
Articles were written in English and published between 2020 and 2024.	Articles were not written in English or published between 2020 and 2024.

Data extraction was carried out systematically using a predefined template to ensure consistency and comprehensiveness (Kitchenham et al., 2009). The extracted data encompassed several key aspects: study details, including authors, publication year, journal, and indexing status; research objectives and methodologies; key findings related to HOTS dimensions (critical thinking, creative thinking, and problem-solving); instructional strategies; and challenges and opportunities in implementing HOTS in various educational settings.

Data analysis involved quality assessment using a rubric adapted from Mullet et al. (2017), which scored seven dimensions of research quality, such as clarity of research objectives, literature review relevance, and conceptual framework robustness. Only studies with a score of 21 or higher were included in the final analysis to ensure the reliability and validity of the findings (Grant & Booth, 2009).

Extracted data were analyzed thematically to identify trends, instructional strategies, and challenges in implementing HOTS. This approach was informed by methods for thematic synthesis as described by Thomas & Harden (2008). The analysis aimed to highlight patterns across studies, particularly regarding the effectiveness of instructional approaches and contextual factors influencing HOTS development (Zohar & Dori, 2003).

This study did not involve human or animal subjects directly; therefore, ethical approval was not required. The review adhered to ethical guidelines in academic publishing, including proper citation and acknowledgment of original authors (Cooper, 2017).

C. Results and discussion

Based on the 14 articles analyzed, the distribution of publications shows an interesting trend. The articles analyzed are published between 2020 and 2024, with the peak number of publications occurring in 2024 with seven articles. This study originated in Indonesia, indicating that the country has done much research on HOTS in the digestive system. All reviewed articles utilized a quantitative research approach, focusing on applying HOTS-based learning within the context of digestive system topics. The aspects analyzed included critical thinking, creative thinking, and problem-solving skills. A summary of the selected studies is provided in Table 4.

Table 4 Summary of included empirical articles

Author(s) (year)	Findings	Research recommendations
Supiandi et al. (2022)	The application of the Contextual Teaching and Learning (CTL) approach notably improves students' critical thinking abilities, evidenced by a significant gain of 40.71 points in the experimental group, compared to a more modest increase of 29.14 points observed in the control group.	The study recommends that teachers apply the CTL model in biological learning for diverse gender characteristics.
Atika et al. (2024)	Problem-based learning (PBL) significantly improved critical thinking skills (from 48% to 73%) with high student engagement and positive responses. Implementation effectiveness was rated as very good (89%).	Researchers are advised to implement the PBL model in other science topics with larger sample sizes to gain broader insight into its effectiveness.
Pratama et al. (2024)	The experiential discovery learning model enhanced critical thinking and metacognitive skills, with significant post-test improvements at the 5% level. The study lacked a control group.	It is recommended to further develop the practicum-based discovery learning model using control groups to strengthen comparative results and generalizability.
Datau et al. (2024)	Developed learning tools improved creative thinking, with pre-test scores rising from 50% to 88% post-test. Teacher and student activities were rated highly practical, with an 88% positive student response.	Future research is encouraged to examine the effectiveness of the SSCS model in other biology topics or across different educational levels.

Author(s) (year)	Findings	Research recommendations
Bustami et al. (2020)	Critical thinking skills are strongly correlated with digestive system concept comprehension (41% contribution). Contextual Teaching and Learning (CTL) enhanced critical thinking and comprehension with validated instruments.	The study suggests that biology educators should enhance students' critical thinking abilities by incorporating the CTL model into their instructional practices.
Khairuna (2023)	STEM-based worksheets significantly improved creative thinking (average score: 85.30) and completion rates (87.5%). The worksheets aligned well with the 2013 curriculum and were highly suitable by experts.	The design should be attractive to stimulate student interest in learning. Students suggested adding more columns for answering questions to enhance their responses
Prasetya et al. (2024)	Virtual labs improved digital literacy and critical thinking. Interactive and collaborative features promoted engagement with real-world problems and independent inquiry with valid and reliable assessments.	Further research is encouraged to investigate the use of virtual laboratories based on PBL to foster additional 21st-century skills, including collaboration and communication.
Safitri et al. (2023)	Telegram bot media effectively enhanced critical thinking skills, receiving positive student feedback. The medium was valid and feasible and increased motivation and engagement.	To improve user engagement, the researcher recommends creating media that features a more appealing and interactive interface.
Putri et al. (2023)	PBL improved critical thinking for students with both high and low prior knowledge. No interaction was observed between the learning model and prior knowledge.	It is recommended that the developer create media featuring a more engaging and interactive design to increase user involvement.
Aisy et al. (2024)	PBL significantly improved critical thinking (N-gain: 0.628, effect size: 1.1659). SSI contexts posed challenges, particularly for complex information processing.	Future studies are suggested to apply PBL-SSI in other science materials to verify its effectiveness across various contexts.
Khastini et al. (2023)	E-student worksheets enhanced learning outcomes, with higher post-test scores for the experimental group (77.2) than the control group (64.4). Statistical analysis confirmed significant improvements.	Further research could refine e-worksheets with adaptive features and assess their impact on different cognitive domains or grade levels.
Padh et al. (2024)	E-LKPD was highly valid (90.87%), with creative thinking scores increasing from 34.86 to 72.08 (moderate N-gain: 0.55). Positive feedback indicated its suitability for Islamic education contexts.	Further research should explore Islamic STEM-based e-LKPD applications in other subjects and educational levels. Investigate the long-term effectiveness of e-LKPD on creative thinking skills and overall student outcomes.
Wardani et al. (2024)	PBL improved analytical thinking but had no significant effect on problem-solving skills. Contextual problems fostered engagement, autonomy, and meaningful learning.	Researchers should explore integrating SESD-PBL on other science topics or evaluate long-term impacts on students' real-life problem-solving skills.
Anwar et al. (2023)	Discovery learning significantly improved critical thinking (gain score: 41.43). The experimental group outperformed the control group, and implementation was rated very good (90.56%).	Future studies should test this model across other biological topics and student levels to confirm its broader effectiveness.

Distribution of HOTS dimensions

An analysis of the distribution of HOTS in the reviewed literature indicates a predominant emphasis on critical thinking (71.4%), with a lesser focus on creative thinking (21.4%) and problem-solving (7.1%) (see Figure 2). However, this distribution should not be construed as a definitive hierarchy of importance among these skills within the digestive system education. Instead, it reflects current research trends and pedagogical emphases. To provide a more nuanced understanding, it is essential to consider the specific subtopics within the digestive system curriculum, such as the concept and function of the digestive system, anatomical structures of digestive organs, digestive processes including enzymatic activities and absorption, and disorders or diseases related to the digestive system (Yamaguchi et al., 2018). Not all of these subtopics inherently demand the same level of cognitive engagement. For instance, understanding the anatomical structures may primarily involve memorization and comprehension (Pradhan et al., 2024), aligning with lower-order thinking skills.

In contrast, exploring digestive processes and related disorders offers greater potential for developing critical thinking and problem-solving abilities (Ho et al., 2023; National Academies of Sciences, Engineering, and Medicine, 2023), as students analyze cause-and-effect relationships, evaluate dietary impacts, and interpret case studies. Creative thinking can be fostered through activities like designing health campaigns or creating models,

encouraging originality and application of knowledge (Samaniego et al., 2024). Recent studies support these approaches; for example, Afridah et al. (2022) demonstrated that guided inquiry-based teaching materials effectively enhance critical thinking and scientific attitudes in students learning about the digestive system. Similarly, Tapia et al. (2021) found that a flipped classroom model incorporating inquiry-based learning significantly improved students' understanding and engagement with digestive system topics. Therefore, aligning instructional strategies with the cognitive demands of specific subtopics can more effectively cultivate various HOTS in students.

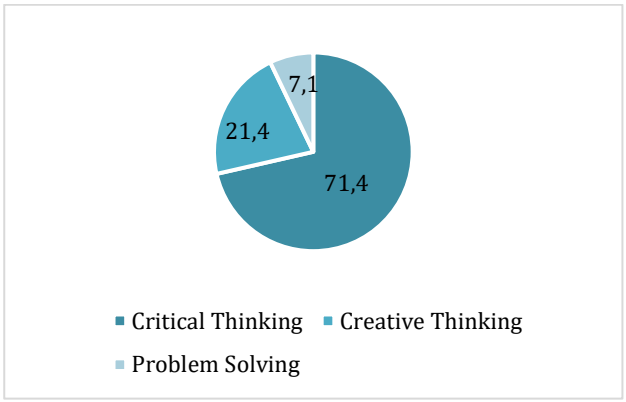

Figure 2 Distribution of HOTS in digestive system learning

Figure 2 illustrates the dominance of critical thinking in digestive system learning research. This prominence underscores its importance in science education, particularly for understanding complex topics such as the digestive system. Critical thinking, a core component of 21st-century skills, enables students to analyze information, evaluate data objectively, and make evidence-based decisions. For example, in learning about the digestive system, tasks such as analyzing enzyme function, identifying digestion-related health issues, and evaluating dietary solutions require critical thinking (Aisy et al., 2024; Anwar et al., 2023; Atika et al., 2024). This finding aligns with studies indicating that topics involving intricate biological processes often necessitate analytical approaches (Prasetya et al., 2024; Safitri et al., 2023). These results highlight the suitability of critical thinking-focused methods in addressing the cognitive demands of digestive system topics.

The dominance of critical thinking can be attributed to several factors. First, critical thinking is highly relevant in science education, including biology, as it prioritizes data analysis, information evaluation, and evidence-based decision-making (Sujatmika et al., 2024). Digestive system topics, for example, involve complex concepts such as enzymatic mechanisms, mechanical and chemical digestion processes, and the relationship between organ functions and digestive disorders. These require students to identify problems, evaluate scientific data, and produce science-based solutions (Mack et al., 2023). Furthermore, critical thinking is more straightforward to measure than creative thinking and problem-solving, as its indicators, such as analysis, evaluation, and conclusion drawing, are well-standardized in many assessment instruments (Ennis, 1985; Nitko & Brookhart, 2011). Consequently, researchers prioritize the development of critical thinking as their primary focus.

The analysis shows that creative thinking is the second most developed aspect, covering 23.1% of the articles analyzed. Studies demonstrate that STEM and technology-based approaches significantly enhance students' creative thinking skills. For instance, Padh et al. (2024) reported that using an E-LKPD with a STEM approach improved students' creative thinking skills, with an N-gain of 0.55 (medium category). Activities fostering idea generation and innovative problem-solving were particularly effective. Similarly, Khairuna (2023) emphasized that STEM-based worksheets encourage students to explore novel solutions. Datau et al. (2024) supported these findings, demonstrating that the SSCS-based learning model effectively trained students in originality, elaboration, and flexibility, yielding significant N-gain results. These results are consistent with van Hooijdonk et al. (2020), who highlighted the role of fluency and originality in enhancing creativity. Such creative thinking indicators are particularly relevant for tasks requiring innovative approaches, such as designing experiments or exploring digestive health solutions.

While less frequently emphasized (7.7%), problem-solving remains a crucial aspect of HOTS. Wardani et al. (2024) found significant improvements in problem-solving skills when teaching the digestive system, with experimental group averages rising to 82.63 compared to 75.72 in control groups. Key indicators included problem identification, solution exploration, and evaluation of applied solutions. Amanda et al. (2024) corroborated these findings, showing that problem-solving-oriented learning fosters systematic thinking and evidence-based decision-making. For example, tasks such as diagnosing digestive disorders or evaluating treatment effectiveness directly engage students' problem-solving abilities. These findings suggest that while less prominent, problem-solving is integral to comprehensive HOTS development.

Problem-solving often requires longer timeframes as it involves comprehensive stages, from problem identification to solution evaluation (Wardani et al., 2024). In the context of digestive system learning, for instance, students must analyze cases of digestive disorders, design evidence-based solutions, and evaluate their effectiveness. However, the limited instructional time for biology in schools (only 1–2 hours per week) poses significant challenges for in-depth, integrated problem-solving-

based learning. Additionally, the lack of focus on problem-solving might reflect insufficient resources or teacher training to implement effective learning strategies for this skill. For example, problem-based learning (PBL) and investigative approaches require teachers' thorough preparation and mastery of facilitation strategies (Amanda et al., 2024).

Instructional strategies

The learning strategies employed to develop HOTS in digestive system topics vary in their effectiveness across critical thinking, creative thinking, and problem-solving. This study makes a distinction between learning models and learning approaches. Learning models include PjBL, PBL, and Discovery Learning, each with its structured method to engage students in the learning process. In contrast, STEM is considered an overarching approach that integrates science, technology, engineering, and mathematics, which can be applied within these models to enhance critical, creative, and problem-solving skills. Table 5 illustrates the distribution of various learning strategies, with PBL being the most commonly implemented (21.4%), followed by STEM-based learning (14.3%), discovery learning (14.3%), and contextual teaching learning (14.3%). PBL's dominance can be attributed to its structured approach. It promotes active learning by engaging students in real-world problem-solving scenarios, particularly suited for biological topics like the digestive system. This dominance of PBL can be attributed to its structured approach, which promotes active learning by engaging students in real-world problem-solving scenarios. This approach is particularly suited to biological topics like the digestive system.

Table 5 Learning strategies to enhance HOTS in digestive system learning

Learning strategies	Count	Percentage (%)
Problem-Based Learning (PBL) model	3	21,4
Science, Technology, Engineering, and Mathematics (STEM) approach	2	14,3
Discovery Learning model	2	14,3
Contextual Teaching Learning (CTL) approach	2	14,3
Electronic Worksheet learning tool	1	7,1
Problem-based Learning and Socio-Scientific Issues (PBL-SSI) model	1	7,1
Telegram Bots learning tool	1	7,1
PBL model-based Virtual Laboratory learning tool	1	7,1
Search, Solve, Create, Share (SSCS) model	1	7,1
Total	**14**	**100,0**

The efficacy of PBL in developing HOTS, particularly critical thinking, is supported by several studies. For example, Wardani et al. (2024) identified five key stages in PBL—orienting to the problem, organizing learning, guiding inquiry, presenting results, and evaluating the process—which align closely with the cognitive demands of HOTS. As Table 5 highlights, methods like PBL accounted for significant enhancements in critical thinking scores, with studies reporting up to a 20.56-point average increase compared to control groups (Aisy et al., 2024). This finding underscores PBL's capability to foster deeper analytical thinking, essential for understanding complex topics like enzymatic processes and nutrient absorption in the digestive system.

The preference for PBL and STEM-based approaches in digestive system material is aligned with the topic's inherently practical and conceptual nature. Digestive system content requires students to analyze processes like digestion, absorption, and the role of enzymes. PBL, as a learning model, emphasizes problem analysis and solution development, which mirrors the scientific inquiry process, making it particularly effective in this context. STEM, as an approach, can be integrated into learning models such as PBL and PjBL to provide interdisciplinary connections between science, technology, engineering, and mathematics, thus enhancing students' critical and creative thinking. STEM approaches incorporating Laboy-Rush stages such as reflection, discovery, and application (Padh et al., 2024) help students connect theoretical concepts with real-world applications. For instance, Khairuna (2023) demonstrated that STEM-based e-LKPDs improved creative and analytical thinking by linking digestion-related phenomena to everyday health practices.

Beyond PBL and STEM, discovery learning and contextual teaching and learning (CTL) show considerable potential, although each is less frequently applied (14.3%). Discovery learning, as outlined by Pratama et al. (2024), involves a six-stage syntax that fosters inquiry and generalization. While less dominant than PBL, discovery learning effectively develops critical thinking by encouraging students to form and test hypotheses related to digestive mechanisms. However, its application is often limited by the need for well-designed scaffolding and more intensive teacher preparation, which may explain its lower prevalence in classrooms (Anwar et al., 2023).

Contextual Teaching and Learning (CTL), on the other hand, emphasizes constructivism, inquiry, questioning, modeling, reflection, learning

communities, and authentic assessment (Bustami et al., 2020; Supiandi et al., 2022). This approach creates a student-centered learning environment where learners actively make sense of scientific concepts. CTL has significantly contributed to developing students' critical thinking skills through strategies such as argumentation, deduction, evaluation, and decision-making. As Bustami et al. (2020) showed, CTL improved students' understanding of the digestive system by encouraging active exploration and meaningful questioning. Supiandi et al. (2022) further support this, stating that CTL's structured syntax promotes student activity and autonomy, resulting in significantly better gains in critical thinking than conventional instruction.

Integrating technology-enhanced methods such as virtual labs (Prasetya et al. 2024) and Telegram bots (Safitri et al. 2023) further supports HOTS development by providing multimodal and interactive learning environments. When embedded within inquiry-driven or contextual models like CTL and discovery learning, these tools offer promising pathways to make science learning more engaging and cognitively demanding.

The predominance of PBL and the limited use of discovery learning can also be contextualized within the broader educational needs of biology. Digestive system material often demands conceptual understanding and practical application—areas where PBL excels (Wahyuni et al., 2023). While many of the studies analyzed in this review were conducted in Indonesia, the effectiveness of PBL and other learning models like PjBL and discovery learning has been widely recognized internationally, making them relevant in various educational contexts. However, future research should expand these studies' geographical scope to better understand how these models can be applied in diverse educational settings outside Indonesia.

Challenges and opportunities

Implementing higher-order thinking skills (HOTS) in the digestive system material presents challenges across teacher readiness, student preparedness, and learning environment and resources. An analysis of 13 studies revealed that the most frequently reported challenges included curriculum transitions (25.0%) and limited instructional time (25.0%), followed by the need for scaffolding (16.7%), and other issues such as internet accessibility, student discipline, complexity of content, and unequal participation (each 8.3%) (see Figure 3).

Teacher-related challenges

The shift from the 2013 Curriculum to the Merdeka Curriculum constitutes the most dominant challenge (25.0%). Teachers must redesign instructional strategies, assessments, and materials that align with new competency-based and student-centered goals. However, several studies (Khairuna, 2023; Prasetya et al., 2024) indicate that many still rely on outdated frameworks, limiting the development of HOTS. Moreover, although time constraint (25.0%) was frequently cited, this issue often reflects teachers' limited ability to design efficient, time-conscious learning activities that foster deeper thinking (Haleem et al., 2022). This suggests a need for stronger professional development, especially for research teachers who may lack classroom experience in applying HOTS pedagogies.

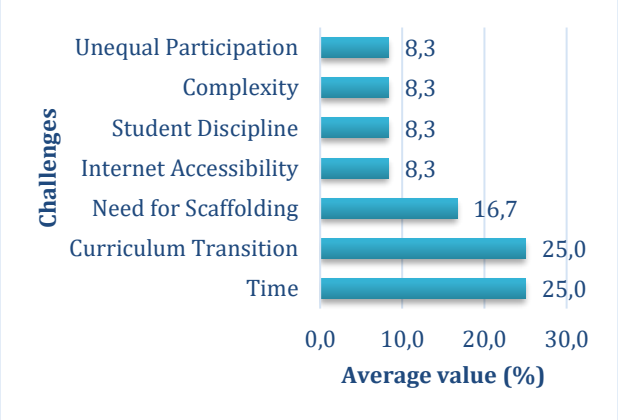

Figure 3
Challenges in implementing HOTS learning on the digestive system material

Student-related challenges

From the student's perspective, implementing HOTS demands a shift from memorization to active inquiry and reasoning, which may be unfamiliar or intimidating. Studies report challenges such as student discipline (8.3%), unequal participation (8.3%), and difficulty managing complex content (8.3%)—indicating that not all students are cognitively or behaviorally prepared to engage in tasks requiring higher-order thinking. Aisy et al. (2024) and Bustami et al., (2020) observed that students tend to depend on peers, struggle with independence, and feel overwhelmed when presented with ambiguous or open-ended tasks. These findings suggest that long-term habituation, rather than brief interventions, is needed to nurture critical and creative dispositions (Taber, 2018).

Resource-related challenges

The need for scaffolding (16.7%) and limited internet accessibility (8.3%) reflects challenges in the availability and design of appropriate learning resources. Effective HOTS learning often requires multimodal support, including e-learning tools, simulations, and interactive content. However, schools may lack stable internet or diverse instructional media, especially in under-resourced regions. Safitri et al. (2023) found that digital platforms like Telegram bots were less effective when

connectivity issues disrupted engagement. Moreover, studies such as Khairuna (2023) and Datau et al. (2024) emphasize the importance of well-structured scaffolding to support inquiry processes, particularly in complex topics like enzymatic activity and nutrient absorption.

Despite the challenges, implementing HOTS in the digestive system learning also presents promising opportunities. Based on the analysis of 13 articles, the main opportunities include real-world application (41.7%), technological support (33.3%), and enhanced student participation (25.0%) (see Figure 4). These reflect the evolving education landscape in Indonesia, where curriculum frameworks, digital tools, and student-centered approaches increasingly support higher-order thinking.

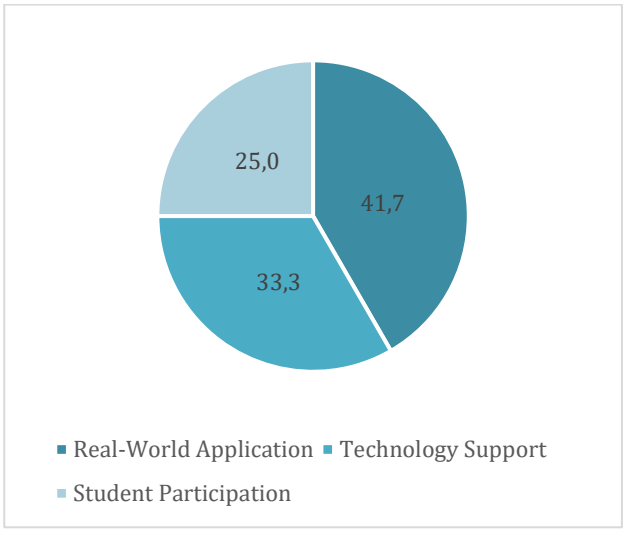

Figure 4
Opportunities in implementing HOTS learning on digestive system material

Curriculum support and policy alignment
Both the 2013 Curriculum and the more recent Merdeka Curriculum provide structured opportunities to develop HOTS through student-centered pedagogies, problem-based projects, and authentic assessments. This shift is reflected in several studies that align their learning designs with these curricular expectations. For instance, Khairuna (2023) and Prasetya et al. (2024) show how instructional designs based on STEM and inquiry-based models correspond with national curriculum demands for critical and creative thinking. Although some materials still rely on outdated KI-KD formats, the broader policy direction supports authentic, project-based learning as a foundation for HOTS.

Real-world contextualization
The most significant proportion of opportunity identified (41.7%) is the potential to contextualize digestive system content in students' daily experiences. Topics such as food digestion, nutritional choices, and digestive disorders are relevant and relatable. Wardani et al. (2024) demonstrated how problem-solving tasks based on real scenarios, such as food combinations and nutrient absorption, can develop critical and creative thinking. Similarly, Khastini et al. (2023) reported that e-worksheets designed with real-life scenarios improve students' analytical skills. This aligns with Anderson et al. (2001) revised Bloom's taxonomy, where real-world application is critical for achieving higher cognitive levels.

Digital technology and interactive platform
Technological integration (33.3%) represents another significant opportunity. Studies show that multimedia tools like virtual labs, animated videos, and Telegram bots enhance student engagement and comprehension (Pratama et al., 2024; Safitri et al., 2023). Though not all articles explicitly mention commercial platforms like Google Classroom, Kahoot, or coding apps, the principles of these tools—namely interactivity, feedback, and higher-order engagement—are evident in the digital media applied in several studies. Such tools allow teachers to present open-ended challenges, simulate complex biological processes, and guide discovery learning, consistent with Mayer's (2024) multimedia learning theory, which posits that well-designed digital tools can enhance cognitive processing and retention.

Student-centered participation and authentic assessment
Active participation (25.0%) supports HOTS by encouraging discussion, role distribution, and collaborative learning. Datau et al. (2024) emphasize that group work, when structured well, fosters both teamwork and critical reasoning. This is supported by Atika et al. (2024), who highlight increased motivation and learning gains in interactive settings. While most articles emphasize learning activities, some studies also reflect authentic assessment approaches, such as group projects, presentations, and reflection logs, which are increasingly promoted in the Merdeka Curriculum. These assessment forms go beyond memorization by evaluating students' ability to analyze, synthesize, and apply knowledge, in line with assessment for learning principles (Nitko & Brookhart, 2011). These findings align with Vygotsky's (1978) social constructivist theory, which emphasizes the role of collaboration in knowledge construction.

Recommendations for practice
Implementing HOTS learning on the digestive system requires an integrated and contextualized instructional approach. Findings from this study suggest that educators should combine diverse learning models—such as STEM-based Problem-Based Learning (PBL), inquiry-based learning, and

multimedia-supported instruction—to enhance student engagement and deepen conceptual understanding. This aligns with international evidence highlighting that blended pedagogical strategies foster critical and creative thinking more effectively than single-method approaches (Bell, 2010; Saavedra & Opfer, 2012).

Research by Martaningsih et al., (2022) in Indonesia showed that integrating STEM with PBL significantly improved students' problem-solving abilities, particularly in complex science topics. This finding resonates with studies by English & King (2015), who emphasize that STEM integration promotes inquiry, problem-solving, and application of knowledge in real-world contexts. Such multifaceted strategies are crucial in preparing students to navigate 21st-century challenges, fostering cognitive flexibility, collaboration, and contextual reasoning (Trilling & Fadel, 2009).

Another key recommendation is the use of interactive digital tools, such as HOTS-oriented e-worksheets, which are designed not only to digitize traditional worksheets but also to increase student interaction through multimedia elements like animations, videos, and interactive simulations (Mayer & Fiorella, 2021; Safirah et al., 2024). These tools are consistent with the Cognitive Theory of Multimedia Learning, which posits that learning is more effective when students are simultaneously actively engaged with visual and auditory content (Mayer, 2024).

In line with trends in national curricula and international best practices, using platforms such as virtual laboratories, Kahoot, Google Classroom, and simulation-based assessments can foster higher-order thinking by allowing students to visualize abstract concepts and engage in formative, performance-based assessments (Bower, 2017; OECD, 2018). These tools are especially valuable when combined with inquiry-based strategies and formative feedback mechanisms.

Furthermore, the success of HOTS-oriented learning strongly depends on teacher competence. Therefore, systematic professional development and mentoring programs are essential to support teachers in designing, implementing, and assessing HOTS activities. As Voogt et al. (2013) point out, continuous teacher learning is crucial to adapting pedagogical practices to evolving curriculum demands. In the Indonesian context, this includes enhancing teachers' ability to design authentic tasks, utilize technology effectively, and facilitate student-centered learning environments.

Recommendations for future research

For future research, more experiments are needed to explore more diverse combinations of methods in HOTS development, such as combining PBL with technology-based approaches or more in-depth, real-world, context-based approaches. Research must also focus on developing and evaluating interactive learning media, such as HOTS-based e-worksheets, in the digestive system topic to determine their impact on improving understanding of science concepts. It is advisable to conduct longitudinal research to evaluate the sustained effects of HOTS-centered learning across various educational stages, thereby ensuring the continued development of critical thinking, creativity, problem-solving, and decision-making skills. Further exploration of underutilized instructional approaches is also necessary to identify methods with significant potential for enhancing HOTS in digestive system education.

D. Conclusion

This systematic review of 14 peer-reviewed studies found that digestive system topics can effectively develop higher-order thinking skills (HOTS), particularly critical, creative, and problem-solving abilities. Among the strategies analyzed, Problem-Based Learning (PBL) was most frequently applied (21.4%), followed by STEM, Discovery Learning, and Contextual Teaching and Learning (each 14.3%). These approaches were successful when supported by real-world contexts, scaffolding, and digital media. Despite challenges like curriculum shifts and limited access, significant opportunities lie in integrating interactive technology and student-centered learning. Future studies should explore combined models, such as PBL-CTL or STEM-based discovery, to strengthen HOTS-based science education instruction.

E. Acknowledgement

The first author would like to express my heartfelt gratitude to Dr. Didit Ardianto, M.Pd, Dr. Ivan Permana, M.Pd, Dr. Surti Kurniasih, M.Si, and Dr. Eni Nuraeni, M.Pd for their invaluable guidance, constructive feedback, and continuous encouragement throughout the process of writing and publishing this article. Their critical insights and support have been essential in enhancing the quality of this work.

F. References

Afridah, A., Iswari, R. S., & Lisdiana, L. (2022). Development of guided inquiry-based digestive system teaching materials to improve critical thinking and scientific attitudes. *Journal of Innovative Science Education*, *11*(1), 115–124. DOI: https://doi.org/10.15294/jise.v10i1.50082

Aisy, M. R., Trisnowati, E., & Siswanto, S. (2024). The effect of the problem-based learning (PBL) model in the context of socio-scientific issues (SSI) on critical thinking ability on digestive system material. *Jurnal Inovasi Pendidikan IPA*, *10*(2), 185–195. DOI: https://doi.org/10.21831/jipi.v10i2.75231

Aliyawinata, T. T. Al, Utari, E., & Mahrawi, M. (2021).

The effect of discovery learning on students' higher-order thinking skills. *International Journal of Biology Education Towards Sustainable Development*, *1*(1), 1–9. DOI: https://doi.org/10.53889/ijbetsd.v1i1.47

Amanda, F. F., Sumitro, S. B., Lestari, S. R., & Ibrohim, I. (2024). Enhancing critical thinking and problem solving skills by complexity science-problem based learning model. *Multidisciplinary Journal of Educational Research*, *14*(1), 96–114. DOI: http://dx.doi.org/10.17583/remie.9409

Anderson, L., Krathwohl, D., Airasian, P., Cruikshank, K., Richard, M., Pintrich, P., Raths, J., & Wittrock, M. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Addison Wesley Longman, Inc.

Antonio, R. P., & Prudente, M. S. (2023). Effects of inquiry-based approaches on students' higher-order thinking skills in science: A meta-analysis. *International Journal of Education in Mathematics, Science and Technology*, *12*(1), 251–281. DOI: https://doi.org/10.46328/ijemst.3216

Anwar, Y., Slamet, A., & Daniaty, U. (2023). Improving critical thinking skills through discovery learning models assisted animation video on digestive system material. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(3), 433–444. DOI: https://doi.org/10.22219/jpbi.v9i3.29042

Atika, R., Hasan, A. M., Lamondo, D., Solang, M., Nusantari, E., & Yusuf, F. M. (2024). Enhancing critical thinking in junior high school students through problem-based learning on the human digestive system material. *International Journal of Research and Review*, *11*(8), 194–203. DOI: https://doi.org/10.52403/ijrr.20240821

Auliah, A., Djangi, J., & Fadly, D. (2024). The effect of implementation socio-scientific issue approach in the context of controversial environmental issues on students' HOTS (higher order thinking skills). *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7924–7930. DOI: https://doi.org/10.29303/jppipa.v10i10.8463

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *83*(2), 39–43. DOI: https://doi.org/10.1080/00098650903505415

Bloom, B. S. (1956). *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. New York: David McKay Company.

Booth, A., Sutton, A., & Papaioannou, D. (2016). *Systematic approaches to a successful literature review: Second edition.* SAGE Publications Inc. DOI: https://doi.org/10.5596/c13-009

Bower, M. (2017). *Design of technology-enhanced learning: Integrating research and practice.* Leeds: Emerald Group Publishing. DOI: https://doi.org/10.1108/9781787141827

Bustami, Y., Leliavia, L., Elisabeth, N., Gandasari, A., & Ratnasari, D. (2020). Contextual teaching learnıng in human digestive system: The contribution of critical thinking skills. *Biosfer: Jurnal Pendidikan Biologi*, *13*(1), 101–113. DOI: https://doi.org/10.21009/biosferjpb.v13n1.101-113%0A10.21009/biosferjpb.v13n1.101-113

Cooper, H. (2017). *Research synthesis and meta-analysis: A step-by-step approach.* Sage publications DOI: https://doi.org/10.4135/9781071878644

Datau, W. A., Latjompoh, M., Solang, M., Lamondo, D., & Nusantari, E. (2024). Development of SSCS model learning tools on digestive system topic to train students' creative thinking skills. *International Journal of Research and Review*, *11*(7), 86–89. DOI: https://doi.org/10.52403/ijrr.20240709

Diena, I. A., Wilujeng, I., & Perdana, P. A. (2023). Science learning based on higher order thinking skill and its supporting components. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 681–686. DOI: https://doi.org/10.29303/jppipa.v9i9.4169

English, L. D., & King, D. T. (2015). STEM learning through engineering design: Fourth-grade students' investigations in aerospace. *International Journal of STEM Education*, *2*(1), 1-18. DOI: https://doi.org/10.1186/s40594-015-0027-7

Ennis, R. H. (1985). Critical thinking and the curriculum. *National Forum: Phi Kappa Phi Journal*, *65*(1), 28–31.

Fauzi, A., & Wicaksono, A. G. C. (2021). The profile of students HOTS at Malang, Indonesia in responding to higher-thinking biology questions. *Biosfer*, *14*(2), 144–153. DOI: https://doi.org/10.21009/biosferjpb.21030

Gough, D., Oliver, S., & Thomas, J. (2017). An introduction to systematic reviews (2nd Edition). *Psychology Teaching Review*, *23*, 95–96. DOI: https://doi.org/10.53841/bpsptr.2017.23.2.95

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. DOI: https://doi.org/https://doi.org/10.1016/j.susoc.2022.05.004

Ho, Y. R., Chen, B. Y., & Li, C. M. (2023). Thinking more wisely: using the Socratic method to develop critical thinking skills amongst healthcare students. *BMC Medical Education*, *23*(1), 1–16. DOI: https://doi.org/10.1186/s12909-023-04134-2

Judijanto, L., Fauzi, M. S., Hendrilia, Y., Kadir, D., & Pranuta, N. (2024). The differences o f students' learning outcomes using the discovery learning model and problem based learning in science learning at primary schools. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7354–7360. DOI: https://doi.org/10.29303/jppipa.v10i10.9046

Khairuna, K. (2023). STEM-based worksheet on digestive system material to improve students' creative thinking skills. *Jurnal Biolokus*, *6*(1), 25–33. DOI: https://doi.org/10.30821/biolokus.v6i1.2524

Khastini, R. O., Rohmah, W. S., & Sahida, A. N. (2023). The effectiveness of the e-student worksheets to improve students' learning outcomes and critical thinking skills on digestive system concepts. *International Journal of Biology Education Towards Sustainable Development*, *3*(1), 52–61. DOI: https://doi.org/10.53889/ijbetsd.v3i1.160

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering – A systematic literature review. *Information and Software Technology*, *51*(1), 7–15. DOI: https://doi.org/https://doi.org/10.1016/j.infsof.2008.09.009

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Journal of Clinical Epidemiology*, *62*(10), e1-34. DOI: https://doi.org/10.1016/j.jclinepi.2009.06.006

Mack, S., Barron, S. L., & Boys, A. J. (2023). Digesting digestion: An educational laboratory to teach students about enzymes and the gastrointestinal tract. *Journal of Chemical Education*, *100*(2), 907–913. DOI: https://doi.org/10.1021/acs.jchemed.2c00992

Martaningsih, S. T., Maryani, I., Prasetya, D. S., Prwanti, S., Sayekti, I. C., Aziz, N. A. A., & Siwayanan, P. (2022). STEM problem-based learning module: A solution to overcome elementary students' poor problem-solving skills. *Pegem Journal of Education and Instruction*, *12*(4), 340–348. DOI: https://doi.org/10.47750/pegegog.12.04.35

Mayer, R. E. (2024). The past, present, and future of the cognitive theory of multimedia learning. *Educational Psychology Review*, *36*(1), 1–25. DOI: https://doi.org/10.1007/s10648-023-09842-1

Mayer, R. E., & Fiorella, L. (2021). *The Cambridge handbook of multimedia learning*. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/9781108894333

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J. A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J. J., Devereaux, P. J., Dickersin, K., Egger, M., Ernst, E., Gøtzsche, P. C., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097. DOI: https://doi.org/10.1371/journal.pmed.1000097

Muhibbuddin, M., Artika, W., & Nurmaliah, C. (2023). Improving critical thinking skills through higher order thinking Skills (HOTS)-based science. *International Journal of Instruction*, *16*(4), 283–296. DOI: https://doi.org/10.29333/iji.2023.16417a

Mullet, D. R., Rinn, A. N., & Kettler, T. (2017). Catalysts of women's talent development in STEM: A systematic review. *Journal of Advanced Academics*, *28*(4), 253–289. DOI: https://doi.org/10.1177/1932202X17735305

National Academies of Sciences, Engineering, and Medicine. (2023). *Advances in the diagnosis and evaluation of disabling physical health conditions*. Washington, DC: The National Academies Press. DOI: https://doi.org/10.17226/26941

Nitko, A. J., & Brookhart, S. M. (2011). *Educational assessment of students*. Boston: Pearson/Allyn & Bacon. Retrieved from https://books.google.co.id/books?id=aiEpQwAACAAJ

Nurdin, K., Hanafy, M. S., & Mustami, M. H. (2019). The implementation of inquiry-discovery learning. *Journal of Language Teaching and Learning, Linguistics and Literature*, *7*(1), 164–175. DOI: https://doi.org/10.24256/ideas.v7i1.734

Nurhatmanti, R., Lian, B., & Dedy, A. (2021). Analysis of students' higher order thinking skills (HOTS) in natural science subjects class V elementary school. *Indonesian Journal of Primary Education*, *5*(2), 208–213. DOI: https://doi.org/10.17509/ijpe.v5i2.37107

OECD. (2018). The future of education and skills: Education 2030. *OECD Publishing*, 23. Retrieved from http://www.oecd.org/education/2030/E2030 Position Paper (05.04.2018).pdf

OECD. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. In *PISA* (Vol. 46, Issue 183). OECD Publishing. DOI: https://doi.org/10.22201/iisue.24486167e.2024.183.61714

Padh, K. M. S., Zulfiani, Z., & Sofyan, A. (2024). STEM-based e-LKPD development in Islamic context to enhance creative thinking in digestive studies. *Ta'dib*, *27*(1), 183–192. DOI: https://doi.org/10.31958/jt.v27i1.11973

Page, M. J., McKenzie, J. E., Bossuyt, P., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The prisma 2020 statement: An updated guideline for reporting systematic reviews. *Medicina Fluminensis*, *57*(4), 444–465. DOI; https://doi.org/10.21860/medflum2021_264903

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47–61. DOI: https://doi.org/10.1016/j.edurev.2015.02.003

Pradhan, S., Das, C., Panda, D. K., & Mohanty, B. B. (2024). Assessing the utilization and effectiveness of YouTube in anatomy education among medical students: A survey-based study. *Cureus*, *16*(3), 2–7. DOI: https://doi.org/10.7759/cureus.55644

Pramana, C., Chamidah, D., Suyatno, S., Renadi, F., & Syaharuddin, S. (2021). Strategies to improved education quality in indonesia: A review. *Turkish Online Journal of Qualitative Inquiry (TOJQI)*, *12*(3), 1977–1994. Retrieved from https://www .researchgate.net/publication/353299393

Prasetya, W. A., Pratama, A. T., & Safitri, W. (2024). Development of problem-based learning virtual laboratory on human digestive system material to improve digital literacy and critical thinking students. *Journal of Natural Science Teaching*, *7*(1), 23–40. DOI: http://dx.doi.org/10.21043/thabiea .v7i1.25590

Pratama, A., Sari, T. N. I., Istiqomah, N., Widiyanti, E. R., & Kusniati, Y. (2024). Improving critical thinking and metacognitive skills through the discovery learning model assisted by practicum for high school students. *Biosfer: Jurnal Pendidikan Biologi*, *17*(2), 149–156. DOI: https://doi.org/ 10.21009/biosferjpb.34481

Qasrawi, R., & Beniabdelrahman, A. (2020). The higher and lower-order thinking skills (HOTS and LOTS) in unlock English textbooks (1st and 2nd editions) based on bloom's taxonomy: An analysis study. *International Online Journal of Education and Teaching*, *7*(3), 744–758. Retrieved from https ://iojet.org/index.php/IOJET/article/view/866

Rochmahwati, P., Yuliasri, I., Sukarno, & Pratama, H. (2024). Unleashing analytical mastery: Elevating HOTS with hybrid project-based learning in academic writing courses. *International Journal of Evaluation and Research in Education*, *13*(5), 3571–3578. DOI: https://doi.org/10.11591/ijere .v13i5.29595

Saavedra, A. R., & Opfer, V. D. (2012). Learning 21st-century skills requires 21st-century teaching. *Phi Delta Kappan*, *94*(2), 8–13. DOI: https://doi.org/ 10.1177/003172171209400203

Safirah, A. D., Nasution, N., & Dewi, U. (2024). Analysis of the development needs of HOTS-Based electronic student worksheets with culturally responsive teaching approach in elementary schools. *International Journal of Recent Educational Research*, *5*(1), 243–256. DOI: https://doi.org/10.46245/ijorer.v5i1.533

Safitri, E. Z., Biyatmoko, D., & Winarti, A. (2023). The development of interactive learning media for biology based on Telegram bots on digestive system materials in class VIII junior high school to train students' critical thinking skills. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *5*(1), 106–116. DOI: https://doi.org/10.20527/bino.v5i1.13588

Samaniego, M., Usca, N., Salguero, J., & Quevedo, W. (2024). Creative thinking in art and design education: A systematic review. *Education Sciences*, *14*(2), 192. DOI: https://doi.org/10.3390 /educsci14020192

Schwab, K. (2016). *The fourth industrial revolution*. Jenawa: World Economic Forum. Retrieved from www.weforum.org

Sensoy, I. (2021). A review on the food digestion in the digestive tract and the used in vitro models. *Current Research in Food Science*, *4*(2021), 308–319. DOI: https://doi.org/10.1016/j.crfs.2021.04. 004

Sujatmika, S., Masykuri, M., Prayitno, B. A., & Sutarno, S. (2024). Fostering critical thinking in science education: Exploring effective pedagogical models. *International Journal of Advanced and Applied Sciences*, *11*(7), 149–159. DOI: https://doi.org/ 10.21833/ijaas.2024.07.016

Supiandi, M. I., Bustami, Y., Utami, Y. E., Syafruddin, D., & Elisabeth, N. (2022). Critical thinking skills on human digestive system materials: Contextual teaching and learning based gender. *Turkish Journal of Computer and Mathematics Education*, *13*(1), 30–37. DOI: https://doi.org/10.17762/ turcomat.v13i1.11925

Susilo, F. J., Usodo, B., & Sari, D. (2023). The profile of high-order thinking skills of junior high school students. *International Journal of Mathematics and Mathematics Education*, *1*(1), 77–82. DOI: https://doi.org/10.56855/ijmme.v1i1.266

Taber, K. S. (2018). Scaffolding learning: Principles for effective teaching and the design of classroom resources. In *Effective Teaching and Learning: Perspectives, Strategies and Implementation* (pp. 1–43). New York: Nova Science Publishers. Retrieved from https://science-education-research.com/ downloads/publications/2018/Taber2018-ScaffoldingLearning-AMV.pdf

Tanjung, R. M., & Rasyidah, R. (2024). The effect of project-based learning model on higher order thinking. *Jurnal Pembelajaran dan Biologi Nukleus*, *10*(2), 464–476. DOI: https://doi.org/10.36987/ jpbn.v10i2.5788

Tapia, R. R., Martínez, M. A. C., Martinez, M. del C. M., & Iglesias, J. D. (2021). Flipped classroom for teaching digestive system to high schoolstudents: Performance, perception, and inquiry competence level. *Journal of Technology and Science Education*, *11*(1), 194–209. DOI: https://doi.org/10.3926 /jotse.1122

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*, 1–10. DOI; https://doi.org/ 10.1186/1471-2288-8-45

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times.* New Jersey: John Wiley & Sons.

van Hooijdonk, M., Mainhard, T., Kroesbergen, E. H., & van Tartwijk, J. (2020). Creative problem solving

in primary education: Exploring the role of fact finding, problem finding, and solution finding across tasks. *Thinking Skills and Creativity*, *37*(2020), 100665. DOI: https://doi.org/10.1016/j.tsc.2020.100665

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of computer assisted learning*, *29*(5), 403-413. DOI: https://doi.org/10.1111/jcal.12029

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes (Vol. 86).* Cambridge: Harvard University Press. DOI: https://doi.org/10.2307/j.ctvjf9vz4

Wahyuni, S., Syamsurizal, S., Irdawati, I., Violeta, V., & Fajrina, S. (2023). Implementation of the problem based learning model to increase the activity and learning outcomes of students in the digestive system material and the human respiratory system class XI MAN 2 Tanah Datar. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9263–9269. DOI: https://doi.org/10.29303/jppipa.v9i11.4537

Wardani, A. D. P., Fadly, W., & Zayas, J. D. M. (2024). Improving 8th grade students' contextualized problem-solving and analitycal thinking skills through problem-based learning in the digestive system: A study intervention findings in the complex domain. *Journal of Science Learning*, *7*(2), 165–177. DOI: https://doi.org/10.17509/jsl.v7i2.64283

Yamaguchi, T., Ishikawa, T., & Imai, Y. B. T. I. N. B. (2018). 3 - biomechanics of the digestive system. *Integrated Nano-Biomechanics,* 71–99. DOI: https://doi.org/10.1016/B978-0-323-38944-0.00003-6

Yanti, F. A., & Thohir, M. A. (2024). Higher order thinking skills in science learning: A systematic review from 2014-2023. *International Journal of Evaluation and Research in Education*, *13*(4), 2419–2427. DOI: https://doi.org/10.11591/ijere.v13i4.28082

Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive? *Journal of the Learning Sciences*, *12*(2), 145–181. DOI: https://doi.org/10.1207/S15327809JLS1202_1