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Development of a ChatGPT Integration Framework in the Informatics Curriculum to Support AI-Augmented Learning in Secondary Education

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Abstract

This study aims to develop a conceptual framework for integrating ChatGPT into the informatics curriculum to support AI-augmented learning in secondary education. Although ChatGPT offers significant potential, its use in classrooms is often unstructured and not fully aligned with curriculum goals. This study adopts a conceptual research approach based on a systematic review of literature published between 2019 and 2025. Relevant sources, including journal articles and conference proceedings, were analyzed using content analysis to identify key themes and patterns. These findings were then synthesized to construct a coherent framework grounded in both technological and pedagogical perspectives. The results show that the proposed framework consists of five interconnected components: input, process, AI role, learning strategies, and output. Within this framework, ChatGPT serves as a tutor, assistant, and evaluator, supporting more interactive and student-centered learning experiences. The integration of ChatGPT also contributes to the development of higher-order thinking skills, computational thinking, and learner autonomy. Overall, this study offers a practical and structured guideline for educators to integrate ChatGPT into informatics learning while maintaining alignment with educational objectives and pedagogical principles.

Keywords: ChatGPT; AI-Augmented Learning; Informatics Curriculum; Framework; Learning

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INTRODUCTION

The rapid development of Artificial Intelligence (AI), particularly generative AI such as ChatGPT, is reshaping educational practices by enabling interactive, adaptive, and personalized learning (Kasneci et al., 2023; Baidoo-Anu & Owusu Ansah, 2023). This development creates opportunities to support more student-centered learning, but it also requires clear pedagogical guidance to ensure that AI contributes meaningfully to learning.

In secondary informatics education, students often encounter difficulties with abstract concepts such as programming, algorithms, and computational thinking. Traditional teacher-centered instruction may limit opportunities for active exploration and independent problem solving. ChatGPT can support these activities by providing explanations, examples, feedback, and assistance with programming

tasks (Lo, 2023; Finnie-Ansley et al., 2022). However, its educational value depends on how it is integrated into learning rather than simply on its availability.

AI-augmented learning positions AI as a tool that supports human learning rather than replaces teachers or students (Dwivedi et al., 2023; Holmes et al., 2022). In practice, however, ChatGPT use in education can remain unstructured. Students may rely on immediate answers without sufficiently engaging in reasoning or reflection, while teachers may face difficulties aligning generative AI with curriculum objectives and appropriate learning strategies. These concerns highlight the need for a structured and pedagogically grounded approach.

Previous studies have demonstrated the potential of ChatGPT to support engagement, independent learning, problem solving, and programming activities (Kasneci et al., 2023; Lo, 2023; Finnie-Ansley et al., 2022). Nevertheless, much of the existing literature emphasizes the benefits, applications, or challenges of generative AI rather than providing a framework that systematically connects ChatGPT with curriculum components, learning strategies, and expected outcomes. In addition, the relationship between ChatGPT-supported learning and pedagogical perspectives such as constructivism and self-regulated learning remains insufficiently integrated into a specific framework for secondary informatics education.

This study therefore addresses the following research question: How can ChatGPT be systematically integrated into secondary school informatics learning through a pedagogically grounded conceptual framework?

To address this question, the study develops a conceptual framework that connects curriculum and learner inputs, learning processes, ChatGPT roles, pedagogical strategies, and expected learning outcomes. The framework is intended to provide a structured basis for implementing ChatGPT while maintaining student agency, teacher guidance, and alignment with learning objectives.

Accordingly, this study aims to develop a conceptual framework for the systematic and pedagogically grounded integration of ChatGPT into secondary school informatics learning.

METHODS

Research Design

This study employed a conceptual research design to develop a theoretically grounded framework for integrating ChatGPT into secondary school informatics learning. Conceptual research is appropriate for identifying, organizing, and connecting concepts derived from existing knowledge to construct a coherent conceptual framework (Jabareen, 2009). The study focused on the integration of ChatGPT into informatics learning by examining its technological affordances, pedagogical functions, learning strategies, and potential learning outcomes.

As a conceptual study, this research did not involve human participants, experimental intervention, or primary data collection from a classroom setting. Scientific literature was used as the primary source of data. The purpose of the analysis was to synthesize relevant theoretical and research-based findings and

translate them into a structured framework for ChatGPT-supported informatics learning.

Literature Identification and Selection

The literature was identified through a structured literature review focusing on research concerning ChatGPT and generative AI in education, AI-supported learning, programming and informatics education, and pedagogical approaches relevant to AI-supported learning. Publications from 2019 to 2025 were prioritized to capture recent developments in generative AI and its application in education. Earlier publications were retained when they provided foundational theoretical concepts directly relevant to the framework, particularly constructivism and self-regulated learning.

Google Scholar was used as the primary academic search platform. The search employed combinations of keywords including "ChatGPT in education," "generative AI in education," "AI-augmented learning," "AI in programming education," "constructivism and AI in education," and "self-regulated learning and AI." The identified literature was subsequently screened according to its relevance to the research objectives and the conceptual framework.

The inclusion criteria were: (1) publications addressing AI, generative AI, ChatGPT, programming or informatics learning, or relevant pedagogical theories; (2) publications providing empirical findings, theoretical perspectives, or conceptual discussions that could contribute to framework development; (3) academically credible sources published in journals, conference proceedings, or academic books; and (4) publications containing sufficient information to identify relationships among technology, learning processes, pedagogical strategies, or learning outcomes.

Publications were excluded when they were unrelated to educational contexts, did not substantially address the research focus, or provided insufficient conceptual relevance to the proposed framework. Foundational theoretical works were included when their concepts were directly applicable to the pedagogical foundation of the framework, including constructivism (Piaget, 1970; Vygotsky, 1978) and self-regulated learning (Zimmerman, 2000, 2002).

Data Analysis

The selected literature was analyzed using qualitative content analysis based on the principles of systematic examination and interpretation of textual material (Krippendorff, 2018). The analysis was conducted through three stages.

First, relevant information was extracted from each selected source. The extracted information included the identified role and affordances of AI or ChatGPT, types of learning activities supported by the technology, pedagogical principles, teacher and student roles, and potential learning outcomes.

Second, the extracted information was organized into thematic categories. The analysis identified recurring concepts concerning learning inputs, learning processes, ChatGPT roles, learning strategies, and expected learning outcomes. These categories were refined by comparing concepts across the literature and identifying similarities, complementary functions, and conceptual relationships.

Third, the relationships among the identified categories were synthesized to determine how technological and pedagogical elements could be integrated into secondary-school informatics learning. The synthesis resulted in five interconnected components: input, process, AI role, learning strategy, and output. These components became the principal dimensions of the proposed conceptual framework.

The analysis was qualitative and conceptual rather than statistical. No effect sizes or quantitative estimates were calculated because the purpose of the study was not to determine the statistical effectiveness of ChatGPT, but to synthesize existing knowledge and establish a theoretically grounded structure for its pedagogical integration.

Framework Development Procedure

The conceptual framework was developed through a four-stage synthesis process. First, relevant concepts and findings were identified from the selected literature. Second, the concepts were categorized according to their technological, pedagogical, instructional, and learning functions. Third, relationships among the categories were examined to determine how ChatGPT could be positioned within the learning process. Fourth, the identified relationships were integrated into a coherent framework for secondary-school informatics learning.

The resulting framework consists of five interconnected components: input, process, AI role, learning strategy, and output. The input component represents the learning materials, curriculum competencies, learning objectives, and student characteristics that establish the instructional context. The process component represents structured learning activities involving interaction with ChatGPT, including prompting, concept exploration, programming practice, problem solving, and reflection.

The AI role component defines the functions that ChatGPT may perform within the learning process, including tutor, learning assistant, feedback provider, and programming support. These functions are informed by literature concerning AI-supported feedback, scaffolding, learning assistance, and programming support (Aleven et al., 2017; Graesser et al., 2005; Finnie-Ansley et al., 2022).

The learning strategy component establishes the pedagogical principles that regulate the use of ChatGPT. Constructivism provides a foundation for active knowledge construction through learning experiences and interaction (Piaget, 1970; Vygotsky, 1978), while self-regulated learning emphasizes students' ability to plan, monitor, and evaluate their learning processes (Zimmerman, 2000, 2002). Problem-based learning is incorporated as an instructional strategy through which ChatGPT can support inquiry, exploration, and problem solving.

Finally, the output component represents the expected learning outcomes of the framework, including higher-order thinking, computational thinking, programming competence, problem-solving ability, and learner autonomy. These outcomes are conceptual targets derived from the synthesis of relevant literature and pedagogical theories rather than empirically validated effects of the proposed framework.

Through this procedure, the study produced a conceptual framework that connects curriculum and learner inputs, structured learning processes, ChatGPT

functions, pedagogical strategies, and expected learning outcomes. The framework positions ChatGPT as a learning-support technology that augments instructional activities while maintaining the active roles of students and teachers.

RESULTS & DISCUSSION

Results

The results of the conceptual analysis are presented in the form of a framework for integrating ChatGPT into secondary school informatics learning. The framework was developed through a structured synthesis of literature concerning generative AI in education, ChatGPT-supported learning, programming education, and relevant pedagogical perspectives. The synthesis indicates that ChatGPT can function beyond a conventional source of information by supporting interaction, explanation, problem solving, code generation, and feedback during learning activities (Kasneci et al., 2023; Lo, 2023; Finnie-Ansley et al., 2022). However, the educational value of generative AI depends largely on how it is incorporated into learning activities and guided by teachers (Dwivedi et al., 2023; Holmes et al., 2022).

The literature synthesis identified five interconnected components that form the proposed framework: input, process, AI role, learning strategy, and output. These components describe the relationship between curriculum requirements, learning activities, the functional role of ChatGPT, pedagogical approaches, and expected learning outcomes.

Table 1. Selected Literature Supporting the Development of the Framework

Author(s)	Year	Focus	Contribution to the Framework
Kasneci et al.	2023	ChatGPT and generative AI in education	Identifies opportunities and challenges of large language models for learning and supports the need for guided and responsible AI use
Lo	2023	Impact of ChatGPT on education	Highlights ChatGPT's potential as a learning assistant and its implications for student learning
Finnie-Ansley et al.	2022	AI in programming education	Demonstrates the relevance of generative AI to programming-related activities and code generation
Dwivedi et al.	2023	Generative conversational AI	Provides a broader perspective on the opportunities, challenges, and implications of generative AI
Aleven et al.	2017	Adaptive feedback	Supports the role of technology in providing feedback and adaptive learning assistance
Graesser et al.	2005	Intelligent tutoring and scaffolding	Supports the use of technology as a scaffold for complex learning processes

Holmes et al.	2022	Human-centered AI in education	Emphasizes human agency and the continuing role of learners and teachers
Piaget	1970	Constructivism	Provides a theoretical basis for active knowledge construction
Vygotsky	1978	Social constructivism	Supports learning through interaction and guided support
Zimmerman	2000, 2002	Self-regulated learning	Provides a basis for planning, monitoring, and evaluating learning activities

Table 1 shows that the proposed framework is based on a synthesis of complementary technological, pedagogical, and theoretical perspectives rather than on a single previous study. Research on ChatGPT highlights its potential as a learning assistant, while studies on AI-supported learning and intelligent tutoring emphasize the importance of interaction, feedback, and scaffolding (Aleven et al., 2017; Graesser et al., 2005). At the same time, human-centered perspectives emphasize that AI should support human learning and instructional processes rather than replace teachers or students (Holmes et al., 2022).

The first component of the framework is input, which includes learning materials, curriculum competencies, learning objectives, and student characteristics. These elements establish the instructional context in which ChatGPT is introduced. In practice, this means that the use of ChatGPT should begin with clearly defined learning objectives and an understanding of students' prior knowledge and needs. This prevents the technology from being used simply as an unrestricted source of answers.

The second component is process, which refers to the learning activities in which students interact with ChatGPT. These activities may include prompt construction, concept exploration, programming practice, problem solving, code generation, debugging, questioning, and reflection. The process emphasizes active student involvement, where ChatGPT is used to support learning activities rather than simply provide completed answers.

The third component is the AI role. Within the framework, ChatGPT may function as a tutor, learning assistant, feedback provider, and support tool for programming-related activities. These roles are consistent with previous research on AI-supported explanation, scaffolding, feedback, and programming assistance (Aleven et al., 2017; Graesser et al., 2005; Finnie-Ansley et al., 2022). However, the teacher remains responsible for providing instructional direction, evaluating AI-generated information, and ensuring that its use remains aligned with curriculum objectives.

The fourth component is learning strategy. The framework incorporates constructivism, self-regulated learning, and problem-based learning as pedagogical orientations for structuring students' interaction with ChatGPT. Constructivist perspectives emphasize active knowledge construction through learning experiences and interaction (Piaget, 1970; Vygotsky, 1978). Self-regulated learning emphasizes students' ability to plan, monitor, and evaluate their own learning processes (Zimmerman, 2000, 2002). Problem-based learning provides

opportunities for students to use ChatGPT as a support tool during inquiry, exploration, and problem solving rather than as a source of predetermined solutions.

The fifth component is output, which represents the expected learning outcomes resulting from the interaction among the input, learning process, AI role, and learning strategy. The expected outcomes include higher-order thinking skills, computational thinking, programming competence, problem-solving ability, and learner autonomy. These outcomes represent the intended direction of the framework and should not be interpreted as empirically verified effects of the proposed model.

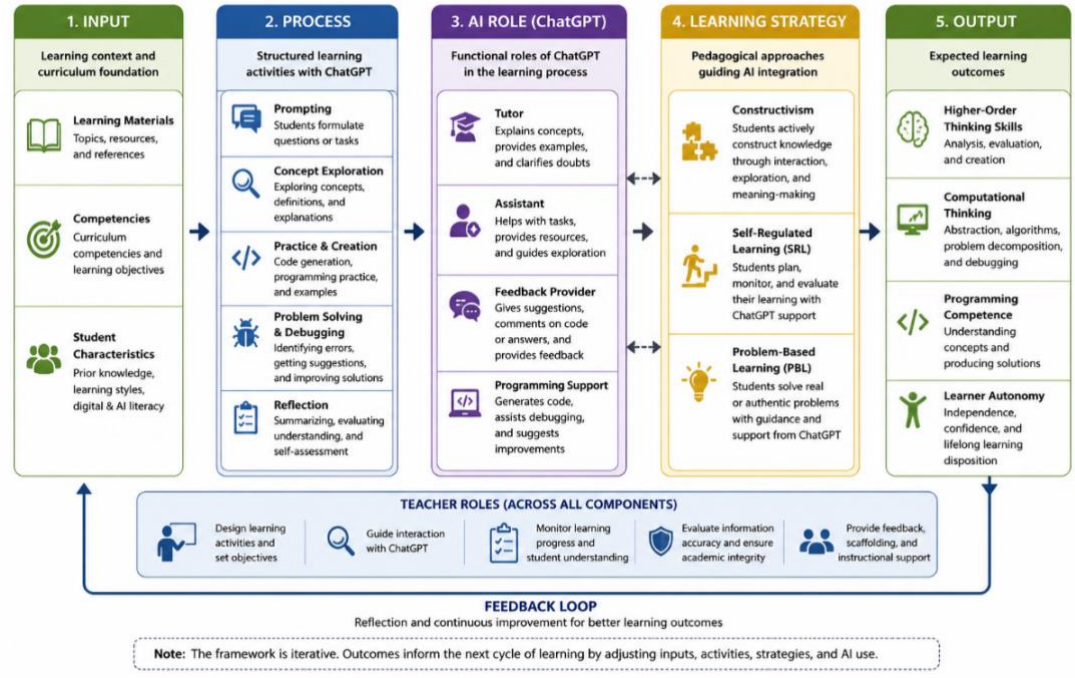

Figure 1. ChatGPT Integration Framework in Secondary School Informatics Learning

Figure 1 illustrates the relationships among the five components of the proposed framework. The framework begins with curriculum and learner inputs, which establish the objectives and conditions of learning. These inputs are then developed into structured learning activities in which ChatGPT provides contextual support. The selected learning strategies guide how students interact with the technology, while teacher guidance is maintained throughout the learning process. The process ultimately leads to the expected learning outcomes.

The framework positions ChatGPT as an augmentative learning resource rather than an autonomous replacement for teachers or students' cognitive activity. This position is consistent with human-centered perspectives on AI in education, which emphasize the importance of maintaining human agency in technology-supported learning (Holmes et al., 2022). It also reflects the broader view that generative AI should complement human capabilities rather than replace human decision-making and educational relationships (Dwivedi et al., 2023).

Table 2. Mapping of Framework Components and ChatGPT Roles

Framework Component	Description	ChatGPT Role
Input	Learning materials, competencies, objectives, and student characteristics	Provide context-sensitive explanations and learning support
Process	Prompting, exploration, practice, questioning, problem solving, and reflection	Support interaction, explanation, examples, and feedback
AI Role	Tutor, assistant, feedback provider, and programming support	Explain concepts, assist problem solving, generate examples, and support debugging
Learning Strategy	Constructivism, self-regulated learning, and problem-based learning	Support active inquiry, reflection, monitoring, and problem solving
Output	Higher-order thinking, computational thinking, programming competence, and learner autonomy	Provide learning support toward achievement of targeted competencies

Table 2 further illustrates the relationship between the framework components and the functions of ChatGPT. The technological and pedagogical elements are interconnected rather than operating independently. ChatGPT provides technological affordances, while the learning strategy determines how those affordances are used in the classroom. Therefore, access to generative AI alone does not guarantee meaningful learning. The framework places instructional design and teacher guidance between technological capability and the expected learning outcomes.

Table 3. Comparison of Educational Technology Integration Approaches

Framework/ Model	Main Focus	Key Elements	Limitation for ChatGPT-Supported Informatics Learning	Relationship to the Proposed Framework
TPACK (Mishra & Koehler, 2006)	Teacher knowledge for technology integration	Technology, pedagogy, and content	Does not specifically describe how ChatGPT functions within learning activities or how students interact with generative AI	Provides a foundation for aligning ChatGPT with pedagogical and content knowledge
SAMR (Hamilton et al., 2016)	Level of technology integration	Substitution, augmentation, modification, and redefinition	Focuses on the degree of technological transformation rather than specific AI roles, learning strategies, or learning outcomes	Helps describe the potential level of transformation enabled by ChatGPT

ADDIE (Branch, 2009)	Systematic instructional design	Analysis, design, development, implementation, and evaluation	Provides a general instructional design process but does not specify the pedagogical role of generative AI	Can provide a broader instructional design process within which the proposed framework may be applied
Proposed ChatGPT Integration Framework	Pedagogical integration of ChatGPT in secondary informatics learning	Input, process, AI role, learning strategy, and output	Requires empirical validation in actual classroom contexts	Specifically connects curriculum requirements, ChatGPT functions, pedagogical strategies, learning activities, and expected informatics learning outcomes

Table 3 clarifies the position of the proposed framework in relation to established educational technology approaches. TPACK focuses on the knowledge required for meaningful technology integration, SAMR describes the degree of technological transformation, and ADDIE provides a systematic instructional design process. In contrast, the proposed framework focuses specifically on how ChatGPT can be positioned and used within secondary-school informatics learning while maintaining pedagogical alignment, student agency, and curriculum orientation. Thus, the framework is intended to complement rather than replace these established approaches.

The proposed framework is particularly relevant to informatics learning because programming requires students to engage in connected activities such as problem analysis, code construction, testing, debugging, and reflection. ChatGPT can provide explanations, examples, alternative solutions, and assistance during these activities. However, students still need to understand why a particular solution works, test the generated code, identify errors, and make appropriate revisions. The framework therefore emphasizes the learning process rather than the final answer produced by AI.

The pedagogical foundation of the framework is supported by constructivist and self-regulated learning perspectives. Constructivism views learners as active participants in constructing knowledge through experience and interaction (Piaget, 1970; Vygotsky, 1978). Within the proposed framework, ChatGPT can provide explanations, examples, and alternative perspectives, but students remain responsible for interpreting, testing, and applying the information. This creates opportunities for students to move from simply receiving information toward actively working with and evaluating it.

Similarly, self-regulated learning emphasizes students' ability to plan, monitor, and evaluate their learning processes (Zimmerman, 2000, 2002). ChatGPT can support these processes by providing feedback and allowing students to ask follow-up questions or explore alternative explanations. Nevertheless, students should remain responsible for monitoring their understanding and evaluating whether the information provided by ChatGPT is accurate and relevant. The framework therefore treats AI as a support mechanism for self-regulated learning rather than as a substitute for students' metacognitive processes.

The framework also highlights the continuing importance of teacher involvement. Human-centered approaches to AI in education emphasize that technological development should preserve human agency and meaningful educational relationships (Holmes et al., 2022). Accordingly, teachers remain responsible for establishing learning objectives, designing appropriate activities, monitoring students' interaction with ChatGPT, evaluating AI-generated information, and providing pedagogical intervention when necessary. ChatGPT is therefore positioned as an instructional support mechanism rather than an autonomous teacher.

Despite its potential, the integration of ChatGPT also involves several risks that need to be considered. One major concern is the accuracy and reliability of AI-generated responses. Generative AI can produce responses that appear convincing but contain inaccurate or misleading information (Kasneci et al., 2023; Tlili et al., 2023). This concern is particularly relevant to programming education, where generated code may appear appropriate but may contain errors or fail to address the actual requirements of a problem. For this reason, verification, testing, and reflection should be included in AI-supported programming activities.

Another concern is academic integrity. The ability of ChatGPT to generate written responses and programming solutions may encourage students to submit AI-generated work without demonstrating sufficient understanding. Previous research has highlighted challenges surrounding conventional plagiarism detection approaches in the context of ChatGPT (Khalil & Er, 2023). The framework therefore encourages learning activities that require students to explain their reasoning, modify and test generated code, compare alternative solutions, and reflect on what they have learned. Such activities can shift the role of ChatGPT from an answer-generating tool toward a learning support resource.

A further issue concerns digital access and AI literacy. The potential benefits of generative AI may not be equally available to all students because access to technology, digital competence, and the ability to critically evaluate AI-generated information can differ across learners (Tang & Tsai, 2022). Teachers may also have different levels of readiness to integrate AI into their instructional practices. Consequently, implementation of the framework needs to consider classroom resources, students' prior knowledge, teacher readiness, and institutional policies.

These considerations also clarify the scope of the proposed framework. The framework should be understood as a conceptual model rather than an empirically validated instructional intervention. Its components and relationships were developed through the synthesis of existing literature and relevant learning theories. Therefore, the framework does not provide empirical evidence that its

implementation will directly increase higher-order thinking, computational thinking, programming competence, or learner autonomy. These outcomes represent expected learning directions that require further empirical investigation.

The main contribution of this study is therefore conceptual. By connecting curriculum and learner inputs, structured learning processes, ChatGPT roles, pedagogical strategies, and expected learning outcomes, the framework provides a systematic basis for designing ChatGPT-supported informatics learning. Rather than treating ChatGPT as an independent technological tool, the framework emphasizes the relationship between technology, pedagogy, curriculum, teacher guidance, and student learning. Future research should empirically test the framework in secondary-school classrooms and examine how factors such as teacher readiness, AI literacy, digital access, and classroom context influence its implementation and learning outcomes.

CONCLUSION

This study developed a conceptual framework for integrating ChatGPT into secondary school informatics learning. The framework consists of five interconnected components: input, process, AI role, learning strategy, and output. It positions ChatGPT as a learning support tool for explanation, interaction, problem solving, programming practice, and feedback rather than as a replacement for teachers or students' cognitive processes.

The framework contributes theoretically by connecting generative AI with constructivist and self-regulated learning perspectives and practically by providing educators with a structured basis for designing ChatGPT-supported informatics activities. Its comparison with TPACK, SAMR, and ADDIE further positions the framework as a complementary approach that specifically addresses the pedagogical use of ChatGPT in secondary informatics learning.

However, the framework remains conceptual and has not been empirically validated. Its expected outcomes, including higher-order thinking, computational thinking, programming competence, and learner autonomy, therefore require further investigation. Future research should test the framework in real classroom settings while examining teacher readiness, student AI literacy, digital access, academic integrity, and the reliability of AI-generated responses. Its applicability to other subject areas may also be explored.

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