



## Enhancing Self-Regulated Learning with ChatGPT: A Study in Science Education

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**Abstract:** In the dynamic digital era, artificial intelligence (AI) like ChatGPT presents revolutionary opportunities to advance classroom learning, particularly in science education. This research focuses on the utilization of ChatGPT to develop a learning model that supports the enhancement of students' Self-Regulated Learning (SRL) abilities. The study investigates four main aspects: (1) How can student-centered science learning improve SRL skills such as goal setting, self-management, and reflection? (2) How can the use of active and collaborative learning strategies in science increase students' motivation and SRL? (3) How can formative and summative assessments focused on developing SRL skills enhance science learning? (4) What are the researchers' experiences in using ChatGPT as a tool to develop and refine learning units, and their reflective research on its use as a teaching aid? An exploratory methodology was applied, utilizing ChatGPT to generate teaching materials tailored to classroom needs. Initial findings highlight ChatGPT's potential to support the development of SRL skills by providing quick access to structured and verified information. However, its use must be carefully managed to prevent over-reliance and ensure critical evaluation of sources. Educators are responsible for guiding students in the wise use of AI, fostering critical thinking, and promoting independent learning. Integrating ChatGPT into lesson design can enhance science education by creating engaging units, providing clear rubrics, and supporting formative assessment. This research underscores the positive potential of ChatGPT in fostering inclusive and adaptive science education, while also addressing the need for responsible technology management to ensure student development and well-being.

**Keywords:** Artificial Intelligence, science education, Self-Regulated Learning (SRL), learning model, ChatGPT

### 1. INTRODUCTION

In the continuously evolving technological era, AI such as ChatGPT holds significant potential to revolutionize classroom learning, particularly within the context of science education (Burgsteiner et al., 2016; Choi-Lundberg, 2023; Gašević et al., 2023). ChatGPT, a generative language model developed by OpenAI, has the capability to generate text, translate languages, and answer questions in an informative and engaging manner (Boscardin et al., 2024; Haleem et al., 2022; Javaid et al., 2023). These capabilities can be leveraged to create more personalized, interactive, and effective learning experiences for science students (Dai et al., 2023; Xu et al., 2023).

As a science educator, I am interested in exploring how ChatGPT can be utilized to develop a learning model that supports the enhancement of students' SRL abilities. SRL refers to an individual's capacity to manage their own learning processes, including setting goals, monitoring

progress, and employing effective learning strategies (Y. Li et al., 2023; Safsouf et al., 2021). Research indicates that SRL is a crucial skill for science students to achieve academic success (Baars & Viberg, 2022; Wong & Viberg, 2024).

Although research on the use of ChatGPT in education is still emerging, several studies have demonstrated its positive potential in enhancing student learning. ChatGPT can assist students in better understanding complex scientific concepts and improving their problem-solving abilities (Rahman & Watanobe, 2023).

However, there remain several research gaps that need to be addressed. One primary gap is the need for more in-depth studies on how ChatGPT can be integrated into science pedagogy to effectively facilitate SRL among students. Additionally, further research is needed to understand how ChatGPT can be used to support students with varying levels of ability and diverse backgrounds.

This research aims to contribute significantly to our understanding of how ChatGPT can be utilized to enhance science education. The findings of this study could aid science educators in developing more effective learning models that support the development of students' SRL skills. Moreover, this research could drive the development of educational tools and resources that harness the power of ChatGPT to improve student learning outcomes.

## **2. METHODS**

Inspired by Pavlik's (2023) exploration of ChatGPT in journalism and media studies, the first research question of this study is: How can student-centered science learning enhance students' SRL skills, such as goal setting, self-management, and reflection? This question is further specified into: “How can student-centered science learning encourage students to take ownership of their learning and set SMART (specific, measurable, achievable, relevant, and time-bound) learning goals?”, “How can student-centered science learning help students develop effective learning strategies for time management, task organization, and problem-solving?”, and “How can student-centered science learning encourage students to reflect on their learning experiences, evaluate their progress, and make adjustments to enhance learning effectiveness?”

The second research question is: How can the use of active and collaborative learning strategies in science improve students' motivation and SRL? This question is elaborated into: “How can active learning strategies, such as project-based learning, inquiry-based learning, and problem-based learning, encourage students to actively engage in science learning and foster curiosity?”,

“How can collaborative learning in science help students develop communication, cooperation, and problem-solving skills?”, and “How can active and collaborative learning strategies help students apply their science knowledge to real-world situations and develop 21st-century skills?”

The third research question in this study is: How can formative and summative assessments focused on developing SRL skills enhance science learning? This question is further elaborated into: “How can frequent and integrated formative assessments help teachers monitor student progress and provide constructive feedback to enhance SRL skills?”, “How can summative assessments focused on SRL skills, such as self-reflection, portfolios, and presentations, encourage students to demonstrate deep understanding and develop critical thinking skills?”, and “How can assessments be used to encourage students to take ownership of their learning and become effective self-regulated learners?”

The fourth research question asks: How is my experience in using ChatGPT as a tool to develop and improve learning units and reflective research on its use as an aid in the teaching process? All tools offer capabilities that exceed what the human mind and body can achieve unaided, which is why we create and use them" (Cope, 2021). Positioning AI as a research tool, I will reflect on its use in this study.

This is an exploratory study aiming to document my experiences with ChatGPT and reflect on its potential implications. This exploratory research applies a self-study methodology to investigate technology (Hamilton et al., 2008). Through this study, I acknowledge that my identity as an educator and researcher has influenced the types of AI prompts I am interested in exploring. As part of my exploration, I critically analyze ChatGPT's outputs on science education, comparing them with key themes in the literature. Additionally, I seek to investigate the practical applications of using ChatGPT in the classroom. Anecdotally, educators are already using ChatGPT for teaching science. As discussed earlier, I am also interested in exploring ChatGPT's applications as a research tool.

The italicized text below has been directly copied from ChatGPT. It is important to note that the following responses are time-specific, meaning the same questions entered into ChatGPT at different times might yield different responses. The responses below were collected in June 2024.

### **3. RESULT**

ChatGPT Prompt 1: How can student-centered science learning empower students to take ownership of their own learning and set SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) learning goals?

*Student-centered science learning empowers students by placing them at the center of their educational experience, fostering autonomy, and encouraging them to set SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) learning goals. This approach shifts the focus from passive reception of knowledge to active engagement in the learning process. By allowing students to explore scientific concepts through inquiry-based activities, projects, and collaborative tasks, they develop a deeper understanding of the material. They are encouraged to ask questions, conduct experiments, and draw conclusions independently or in groups, which promotes critical thinking and problem-solving skills. Through regular reflection on their progress and achievements, students learn to assess their strengths and areas needing improvement, leading to the formulation of SMART goals that guide their learning journey effectively. This process not only enhances their academic growth but also nurtures lifelong skills such as self-regulation, resilience, and a passion for discovery in science. Thus, student-centered science learning empowers students to take ownership of their education and become proactive learners capable of achieving their learning objectives.*

ChatGPT Prompt 2: How can student-centered science learning assist students in developing effective learning strategies for time management, task organization, and problem-solving?

*Student-centered science learning plays a crucial role in assisting students in developing effective learning strategies for time management, task organization, and problem-solving by fostering autonomy and active engagement. In student-centered environments, students often have the freedom to explore scientific concepts through hands-on activities, projects, and collaborative tasks. This autonomy encourages them to take responsibility for their learning process, including managing their time effectively to meet project deadlines and milestones. By engaging in inquiry-based learning and project-based tasks, students learn to break down complex problems into manageable steps, develop organizational skills to outline tasks and allocate resources efficiently, and enhance their problem-solving abilities through experimentation and reflection. Collaborative activities also promote teamwork and communication skills, as students work together to analyze data, brainstorm solutions, and evaluate outcomes, thereby preparing them for real-world challenges where these skills are essential. Overall, student-centered science learning empowers*

*students to develop not only a deep understanding of scientific concepts but also the practical skills necessary for lifelong learning and success.*

ChatGPT Prompt 3: How can student-centered science learning encourage students to reflect on their learning experiences, evaluate their progress, and make adjustments to enhance learning effectiveness?

*Student-centered science learning encourages students to reflect on their learning experiences, evaluate their progress, and make adjustments to enhance learning effectiveness through several key practices. Firstly, by engaging in hands-on activities, experiments, and projects, students actively participate in the learning process, which naturally prompts them to reflect on what they are learning and how they are learning it. This reflective practice helps students identify their strengths and weaknesses, understand their learning styles, and recognize areas needing improvement. Secondly, student-centered approaches often involve self-assessment and peer feedback, where students evaluate their own work and receive constructive criticism from their peers or instructors. This feedback loop enables students to assess their progress objectively, identify gaps in their understanding, and adjust their learning strategies accordingly. Finally, by encouraging students to set goals and track their own learning outcomes, student-centered learning promotes accountability and ownership of their educational journey. Students learn to identify specific areas for improvement, set actionable goals using SMART criteria (Specific, Measurable, Achievable, Relevant, Time-bound), and implement strategies to achieve these goals effectively. Ultimately, student-centered science learning empowers students to become active participants in their learning process, fostering a culture of continuous improvement and enhancing overall learning effectiveness.*

ChatGPT Prompt 4: How can active learning strategies, such as project-based learning, inquiry-based learning, and problem-based learning, motivate students to actively engage in science learning and develop curiosity?

*Active learning strategies, such as project-based learning, inquiry-based learning, and problem-based learning, motivate students to engage actively in science by making the learning process interactive, relevant, and student-centered. These methods allow students to explore scientific concepts through hands-on projects, experiments, and real-world problem-solving tasks. This experiential approach makes learning more meaningful and enjoyable, sparking students' curiosity and interest in discovering how scientific principles apply to everyday life. Additionally, by giving students the autonomy to ask questions, design experiments, and pursue topics of*

*personal interest, these strategies foster a sense of ownership and intrinsic motivation. This engagement not only enhances their understanding of scientific concepts but also cultivates critical thinking, creativity, and a lifelong love for learning.*

ChatGPT Prompt 6: How can active and collaborative learning strategies help students apply their scientific knowledge to real-world situations and develop 21st-century skills?

*Active and collaborative learning strategies help students apply their scientific knowledge to real-world situations by engaging them in projects, inquiries, and problem-solving activities that mimic real-life challenges. For instance, project-based learning allows students to tackle relevant issues such as designing sustainable energy solutions, thereby applying physics and environmental science concepts. These strategies also foster 21st-century skills such as critical thinking, collaboration, and communication. By working in teams, students learn to share ideas, manage group dynamics, and present their findings, which enhances their ability to work effectively with others and articulate complex information. Furthermore, integrating technology and encouraging independent research develop digital literacy and self-directed learning, essential skills for success in modern scientific and professional environments.*

ChatGPT Prompt 7: How can frequent and integrated formative assessment assist teachers in monitoring student learning progress and providing constructive feedback to improve SRL skills?

*Frequent and integrated formative assessment is crucial for helping teachers monitor student learning progress and provide timely, constructive feedback to enhance self-regulated learning (SRL) skills. These assessments, such as quizzes, reflective journals, and peer reviews, offer ongoing insights into students' understanding and learning strategies. By regularly reviewing students' work and responses, teachers can identify misconceptions, strengths, and areas needing improvement, allowing them to tailor their instruction and support to individual needs. This continuous feedback loop encourages students to reflect on their learning processes, set realistic goals, and adjust their strategies accordingly. For instance, feedback on a project's progress can prompt students to revise their approach or seek additional resources, fostering a proactive and adaptive learning attitude. Additionally, integrating self-assessment and peer feedback helps students develop metacognitive skills, enhancing their ability to evaluate their own work and that of their peers critically. This practice promotes a deeper understanding of the learning objectives and empowers students to take ownership of their learning journey.*

ChatGPT Prompt 8: How can summative assessment focused on SRL skills, such as self-reflection, portfolios, and presentations, encourage students to demonstrate their deep understanding and develop critical thinking skills?

*Summative assessments focused on self-regulated learning (SRL) skills, such as self-reflection, portfolios, and presentations, encourage students to demonstrate deep understanding and develop critical thinking skills by requiring them to actively engage with and reflect on their learning process. Self-reflection prompts students to analyze their progress, understand their learning strategies, and identify areas for improvement, fostering metacognitive skills essential for critical thinking. Portfolios allow students to compile and showcase a diverse range of their work over time, providing a comprehensive view of their learning journey and the ability to critically evaluate their achievements and growth. Presentations require students to articulate their knowledge and reasoning clearly, defend their ideas, and respond to questions, which enhances their ability to think critically and communicate effectively. Together, these assessment methods promote a deeper engagement with the material, encouraging students to connect concepts, analyze information, and apply their knowledge in meaningful ways.*

ChatGPT Prompt 9: How can assessment be used to motivate students to take ownership of their own learning and become effective independent learners?

*Assessment can motivate students to take ownership of their learning and become effective independent learners by providing continuous, personalized feedback and fostering goal-setting. Formative assessments, such as quizzes and reflective journals, offer timely insights into student progress, enabling them to identify strengths and areas for improvement. By involving students in self-assessment and goal-setting activities, such as setting SMART goals and maintaining learning journals, they learn to take responsibility for their learning journey. Summative assessments like portfolios and project-based evaluations showcase students' progress over time, encouraging pride in their accomplishments and a deeper understanding of their growth. This approach not only motivates students but also helps them develop essential self-regulation and critical thinking skills, promoting lifelong learning.*

ChatGPT Prompt 10: What are my experiences in using ChatGPT as a tool to develop and refine learning units, as well as reflective research on its use as an aid in the teaching process?

*Using ChatGPT as a tool to develop and refine learning units has been a transformative experience. ChatGPT offers quick access to a vast array of information, enabling the creation of comprehensive and diverse learning materials efficiently. It aids in generating ideas, structuring content, and providing examples, making the development process smoother and more creative. Reflectively, utilizing ChatGPT in the teaching process has highlighted its strengths in enhancing lesson planning and providing instant feedback, which supports differentiated instruction. However, it's important to critically evaluate its suggestions to ensure accuracy and relevance. Overall, ChatGPT serves as a valuable aid in educational settings, promoting innovative teaching practices and enhancing the learning experience.*

#### 4. DISCUSSION

RQ1: How can student-centered science learning enhance students' SRL skills, such as goal setting, self-management, and reflection?

The responses provided to prompts 1 through 3 addressing research question 1 are generally accurate in explaining how student-centered science learning can enhance students' SRL skills, particularly in goal setting, self-management, and reflection. The explanations highlight the importance of student ownership over their learning, the role of hands-on activities in fostering understanding and reflection, the benefits of collaboration in developing learning skills, and the use of SMART goals for measurable and realistic learning objectives.

Aligned with constructivist learning theory, as explained in previous studies, active student engagement in constructing their own knowledge is essential in the learning process (Reeve et al., 2020; Silvola et al., 2021). In science education, self-constructed knowledge activities are crucial because science is fundamentally learned through inquiry, encouraging students to explore and discover scientific concepts through hands-on activities, thereby continuously enhancing their SRL skills.

According to Bandura's theory, individuals possess beliefs in their abilities, known as self-efficacy (Bandura, 1978). Student-centered science learning can enhance students' self-efficacy by giving them the opportunity to take charge of their learning and successfully complete their responsibilities. In constructing scientific knowledge, students often rely on themselves to perform observations and experiments. When students successfully prove a theory or discover a new concept, they feel a sense of achievement, which in turn nurtures their self-efficacy.



ChatGPT's explanation that science learning can foster SRL by teaching students to set SMART goals is well-founded. In science education, students are trained to set goals before conducting experiments and to follow scientific steps to prove hypotheses. According to Locke and Latham's theory, setting specific, measurable, and challenging goals can enhance motivation and performance (Locke & Latham, 2015).

Although the responses provided by ChatGPT are fairly accurate, they lack depth in detailing the implementation of strategies and specifics related to science education. Users such as teachers or researchers need to further elaborate to delve deeper into the answers provided by ChatGPT. Additionally, because the explanations are quite general, they do not present supporting theories that could strengthen the arguments.

Generally, ChatGPT only provides the answers we seek and does not include contradictory statements unless we input the appropriate prompts. Since I only provided one-sentence questions for each prompt, the answers from ChatGPT only highlighted the positive aspects. From various sources, I have found that student-centered science learning may not be effective for all students. Some students prefer direct instruction and clearer structure. A study even indicates that the teacher-centered approach is the most instructionally efficient of all approaches, and is the most effective in enhancing both short-term and long-term knowledge acquisition (Goldschmidt et al., 2016). Furthermore, implementing science education that enhances SRL requires trained and experienced teachers (Cleary et al., 2022). The issue is that not all teachers are capable of doing this, especially with the large class sizes commonly seen in Indonesia. ChatGPT does not address these points unless the user provides detailed prompts. This implies that using ChatGPT also requires the ability to think critically when constructing prompts and evaluating the responses provided by ChatGPT (Essel et al., 2024).

RQ2: How can the use of active and collaborative learning strategies in science improve students' motivation and SRL?

ChatGPT's responses are fairly accurate in explaining how active learning strategies can motivate students and help them apply scientific knowledge to real-world situations. This aligns with prior theories that active learning strategies and collaboration make learning more interactive and engaging (Wang, 2020), increasing student involvement and motivation (Seo et al., 2021), ultimately fostering SRL (Psathas et al., 2023). Active learning and collaboration help students develop 21st-century skills such as critical thinking, collaboration, communication, and digital literacy.

However, while ChatGPT's answers are fairly accurate, they have some weaknesses. For instance, the responses do not provide concrete examples of active learning strategies in the context of science education. Moreover, although active and collaborative learning has positive impacts on students, if not designed in a structured manner, achieving learning objectives can be challenging. These two points were not addressed when I inquired about active and collaborative learning.

RQ3: How can formative and summative assessments focused on developing SRL skills enhance science learning?

The responses to prompts 7 through 9 are generally accurate in explaining how formative and summative assessments focused on developing SRL skills can enhance science learning. The explanations cover the importance of formative assessment for monitoring progress and providing feedback, the use of summative assessment for demonstrating deep understanding and critical thinking, and the role of assessment in motivating students to take ownership of their learning. This aligns with the theory that formative assessment, as discussed in various studies (Alt et al., 2023; T. Li et al., 2023; Whalley, 2021), plays a crucial role in enhancing students' SRL by providing timely feedback and opportunities for reflection and improvement. This approach focuses on continuous monitoring of student progress, allowing instructional adjustments to meet individual learning needs. On the other hand, summative assessments, as highlighted in the literature (Duque-Aguilar, 2021; El-Awaisi et al., 2022), typically evaluate student learning outcomes at the end of a learning period. While formative assessments support the development of metacognitive skills and self-assessment strategies (Versteeg et al., 2021), summative assessments provide a comprehensive overview of student achievement. By effectively combining formative and summative assessment practices, educators can create a balanced assessment approach that fosters students' SRL and continuous improvement.

RQ4: How is my experience in using ChatGPT as a tool to develop and improve learning units and reflective research on its use as an aid in the teaching process?

ChatGPT presents new opportunities for educators and researchers to enhance learning and research (Kumar et al., 2024; Otaki & Fauville, 2023). Educators can develop engaging and interactive learning materials with its assistance. For instance, teachers can create improved quiz questions, exercises, and learning scenarios. Besides aiding educators in creating captivating educational content, ChatGPT can provide rapid and personalized feedback to students on their assignments, helping them identify areas needing improvement.

For researchers, ChatGPT can assist in data analysis, literature compilation, and hypothesis development (Garg et al., 2023; Rice et al., 2024). ChatGPT's capability to quickly and efficiently analyze large and complex datasets helps researchers identify patterns and trends that might otherwise be overlooked. As an intelligent machine, ChatGPT can aid researchers in gathering and organizing relevant literature for their research topics, saving time and effort. Additionally, ChatGPT can facilitate brainstorming, enabling researchers to generate new hypotheses and explore creative research ideas.

Despite its significant potential in education, ChatGPT is still in development and has limitations that educators and researchers must consider. ChatGPT may produce errors, especially if the prompts used are complex or ambiguous. It is also limited in certain concepts or contexts, making it unable to always provide accurate and useful answers.

Therefore, as an educator and researcher, I personally approach the use of ChatGPT with caution and responsibility. I remain highly skeptical of the responses provided by ChatGPT. It is essential to use critical thinking to evaluate the information generated by ChatGPT and verify it with other sources. While ChatGPT simplifies many tasks, I also consider the ethical implications of its use, such as potential bias and plagiarism.

## **5. Conclusion**

This study shows that student-centered science learning supported by ChatGPT can improve Self-Regulated Learning (SRL) skills through activities such as goal setting, self-management, and reflection. Although ChatGPT has great potential in helping to develop learning materials and support formative assessment, its use requires guidance to prevent over-reliance and encourage students' critical thinking. The integration of AI technology such as ChatGPT in science education can have a positive impact if used wisely, especially in building 21st-century skills such as critical thinking, collaboration, and digital literacy. Teachers need to be trained to utilize ChatGPT effectively to create interactive learning and support students' SRL development.

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