Development of STEM Virtual Laboratory in Science Assisted by Articulate Storyline to Empower Self-Regulated Skills and Computational Thinking Skills of Junior High School Students: A Need Analysis

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Abstract. Science education at the Junior High School level necessitates innovative breakthroughs in developing learning resources that can ignite interest and refine basic skills in students. This research aims to conduct a needs analysis (Need Analysis) as a basis for designing and developing a STEM Virtual Science Laboratory assisted by Articulate Storyline, focusing on empowering Self-Regulated Skills and Computational Thinking Skills in junior high school students. This research method involves surveys, interviews, and tests to identify the specific needs of junior high school students and the challenges they face in learning science. The results of this analysis will guide the design and development of virtual laboratories tailored to student characteristics and needs. The Science Virtual STEM Laboratory was designed utilizing the Articulate Storyline platform, enabling an interactive and immersive learning experience. The primary focus of development is on empowering Self-Regulated Skills, such as self-planning and progress monitoring, as well as developing Computational Thinking Skills, including problem-solving and algorithmic thinking. The results of this research can serve as a foundation for developing innovative and relevant learning tailored to student's needs in the digital era. Additionally, implementing the STEM Virtual Science Laboratory can mark the initial stride in preparing students to tackle the increasingly complex and technology-based challenges of future learning and work.

Keywords: computational thinking skills, self-regulated skills, virtual STEM laboratory

1. Introduction

Science evolves with technological advancements, significantly impacting various aspects of human life [1]. Humans must avoid the consequences of these developments, necessitating adequate preparation of human resources (HR) to adapt and compete globally. This preparation can be achieved through educational pathways encompassing primary, secondary, and tertiary education [2],[32].

Technology is crucial in preparing HR, particularly in the education sector. Technological advancements in education entail implementing ideas from diverse sources to cultivate an optimal learning environment for students [3]. Moreover, technology introduces highly effective tools such as learning devices for students, research tools to ensure accurate and relevant data analysis, as well as various media and social networking platforms for global collaboration [4],[33].

According to [5], the primary role of technology in learning is visual. Visual projection is effectively and efficiently applied in classroom learning as it can captivate students, making learning interactive and engaging, thereby increasing student motivation and enjoyment in the learning process. In addition to visual projections, web-based learning through an internet browser significantly supports students' active engagement by facilitating interaction with peers, promoting independent learning, and enhancing student enthusiasm, as they can utilize technology based on their interests [6],[34].

21st-century learning necessitates that students possess learning and innovation skills, including critical thinking, effective communication, collaboration, and creativity [7]. In addition to these four essential skills, students in the 21st century also require fundamental competencies, notably computational [8],[35]. This assertion is echoed by Nadiem Makarim, Minister of Education, Culture, Research, and Technology, who emphasized the importance of computational thinking for Indonesian students in the current digital era [9]. Computational thinking skills encompass foundational abilities essential for problem-solving, system design, and understanding human behavior, drawing upon concepts from computer science [10].

Computational thinking skills are perceived as a goal-directed process employing heuristic reasoning, encompassing activities such as learning planning, coping with uncertainty, and exploration to discover solutions [11]. These process activities align with the component of self-regulated skills [12],[36]. Self-regulated skills denote students' capacity to regulate their learning, enhancing their ability to independently solve problems and complete assignments, with the teacher serving as a facilitator to create a more meaningful learning experience [13]. This demonstrates a correlation between self-regulated skills and computational thinking skills, as both enable students to utilize concepts, strategies, and components controlled by themselves in the learning process [14].

In this way, this approach facilitates the development of students' computational thinking skills and self-regulated skills through learning activities that utilize implementation media, enhancing learning outcomes in the 21st century [37]. Teaching media should integrate technology to align with 21st-century learning principles [15]. One practical example of such media is the virtual STEM Laboratory, which incorporates relevant technology for research and experimentation, supporting science learning while fostering computational thinking and self-regulated skills. The development of a virtual STEM laboratory is integrated using the articulate storyline device due to its diverse features, making it more adaptable and effective. It facilitates independent learning for students and offers significant opportunities for professional development [16];[17]. To identify students' needs for developing a virtual STEM laboratory, it is necessary to conduct needs analysis research as a basis for designing and developing a Science Virtual STEM Laboratory with the assistance of Articulate Storyline.

2. Method

The subjects of this research were second-grade junior high school students at SMP N 16 Surakarta for the 2023/2024 academic year, comprising 32 students and two science teachers.

Sample selection was conducted using purposive sampling. Research data were collected through closed and open-ended questionnaires, as well as observations, to assess the need for virtual STEM laboratories and to determine the profiles of self-regulated skills and computational thinking skills among the students. Data collection was carried out offline for the second-grade students. The data collection for self-regulated skills was conducted using a closed questionnaire with indicators as outlined in Table 1.

Table 1. Self-Regulated Skills Questionnaire Indicators

No	Measured Aspects	Indicator
1	Designing learning (forethought)	Create flexible learning plans and strategies Feeling obliged to be responsible for learning Focus attention and motivate oneself to remain consistent in learning Utilize and search for learning resources with or without the help of others
2	Monitor learning progress while implementing the design (performance control)	Monitoring learning progress to achieve predetermined goals Changing learning strategies or modifying goals if necessary
3	Evaluate learning outcomes completely (self-reflection)	Reflecting on the process and results of performance Self-evaluation to develop learning strategies for future occasions

Data on computational thinking skills were collected using indicators outlined in Table 2.

Table 2. Indicators of Computational Thinking Skill

CT Skill Components	Indicator
Decomposition	Formulate data, processes, or problems into smaller, more manageable parts.
Pattern Recognition	Observe patterns, trends, and regularities in data.
Abstraction	Identify and extract relevant information to define the main idea.

The results of students' and teachers' responses to the questionnaire, in the form of a checklist with a 1-4 Likert scale and criteria outlined in the table, were then analyzed using a data quantification process from the questionnaire. The data analysis technique employs the following equation:

$$P = \frac{f}{N} \times 100$$

Information:
P = Answer percentage
f = frequency of respondents' answers
N = Total frequency

Table 3. Likert scale

Scale Score	Category
4	Very good
3	Good
2	Pretty good
1	Not good

3. Result and Discussion

A needs analysis was conducted to ascertain the requirements of prospective users of Virtual STEM laboratory products designed to enhance computational thinking and self-regulated skills. The identification of needs among second-grade junior high school students was collected through a questionnaire encompassing computational thinking skill profiles, student self-regulated skill profiles, identification of learning implementation, and desired aspects of the virtual STEM laboratory.

Based on the data obtained from the needs analysis, the profile of students' computational thinking skills and self-regulated skills in science learning reveals a relatively low percentage, as depicted in Figure 1.

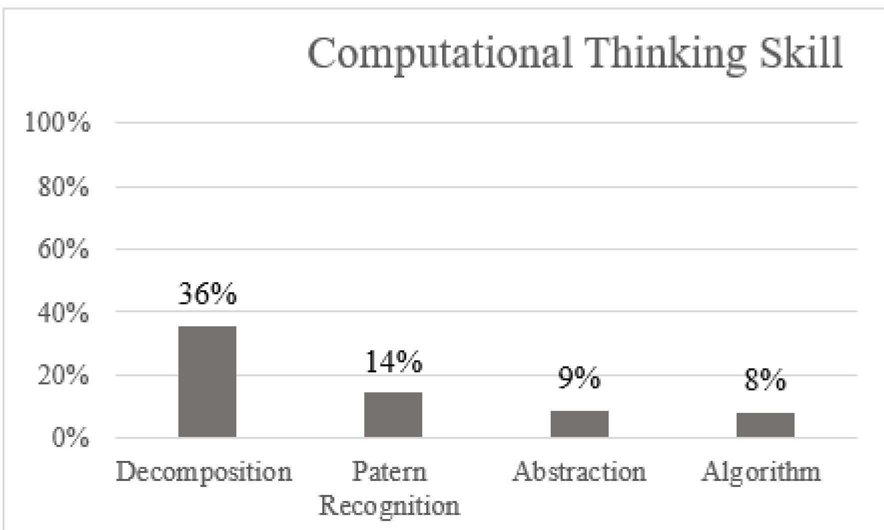

Figure 1. Computational Thinking Skill Profile

Based on Figure 1, which illustrates the computational thinking skill profile data of 32 second-grade junior high school students, it is evident that only 36% of students were able to decompose problems, 14% could manage patterns in problems, 9% could generalize a problem, and 8% were able to develop problem-solving strategies. Additionally, they encountered difficulty simplifying issues from small to large.

Only a small percentage of students have attained a certain skill level in computational thinking. Specifically, 36% of the students demonstrated the ability to decompose problems, indicating proficiency in breaking down problems into smaller parts. Furthermore, as many as 14% of students could identify and manage patterns in problems, suggesting their comprehension of recurring patterns within problem contexts. However, only 9% of students demonstrated the ability to generalize a problem, indicating the need for further efforts to enhance students' capability to apply abstract thinking to the problems they encounter.

Higher-level skills, such as developing problem-solving strategies, remain relatively uncommon among students, with only 8% demonstrating proficiency in this area. Therefore, this data serves as a foundation for evaluating and designing more effective learning strategies to enhance computational thinking skills among second-grade junior high school students.

In addition, second-grade junior high school students face challenges in identifying problem patterns and developing strategies to solve problems. This difficulty is associated with their self-regulated skills, as depicted in Figure 2 below.

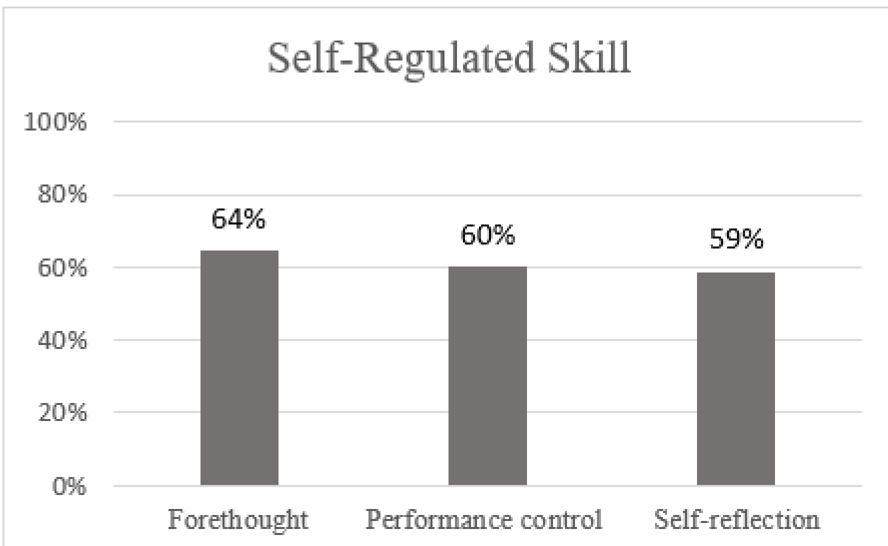

Figure 2. Student Self-Regulated Skill Profile Survey

Based on Figure 2, which displays the results of a survey of students' self-regulated skill profiles in the second grade of junior high school, it is evident from each indicator that only 64% of students can design learning activities, 60% are capable of monitoring learning progress during implementation of learning designs, and as many as 59% of students were able to evaluate learning outcomes comprehensively.

Most students have demonstrated a positive level of self-regulation skills, although there is room for improvement. Specifically, 64% of the students demonstrated the ability to design their learning activities, indicating that most students can plan their learning strategies effectively. Furthermore, as many as 60% of students could monitor their learning progress while implementing their learning plans [40]. This indicates that many students possess self-awareness of their learning progress and can make necessary adjustments. However, regarding the evaluation of learning outcomes, the data reveals that only 59% of students can evaluate learning outcomes comprehensively. Despite the majority of students possessing this ability, there is still a need to improve evaluation skills to make them more comprehensive.

The obtained data is still suboptimal. This is because students lack learning responsibilities, such as planning strategies for themselves, modifying their learning style if the results do not meet the target, and conducting self-evaluation of their learning style shortcomings [20]. Furthermore, school learning is predominantly characterized by theoretical explanations with monotonous learning methods lacking accompanying practice. Consequently, learning tends to be passive and fails to foster independent learning among students [21].

The suboptimal nature of self-regulated skills is also linked to science learning in the classroom. In science education, students are encouraged to develop independence through hands-on investigative experiences in various real-world activities, aligning with the demands of 21st-century skills [22]. Additionally, in 21st-century science learning, students are trained to conduct experiments and research in the laboratory to acquire effective skills and firsthand experience, given that the subject matter often involves abstract concepts related to natural phenomena [23]. Therefore, science teachers should encourage students to engage in laboratory activities to enhance their learning experience [39]. Based on the results of the preliminary analysis conducted on second-grade junior high school students, it was found that they perceive science learning activities to be suboptimal, as summarized in Figure 3.

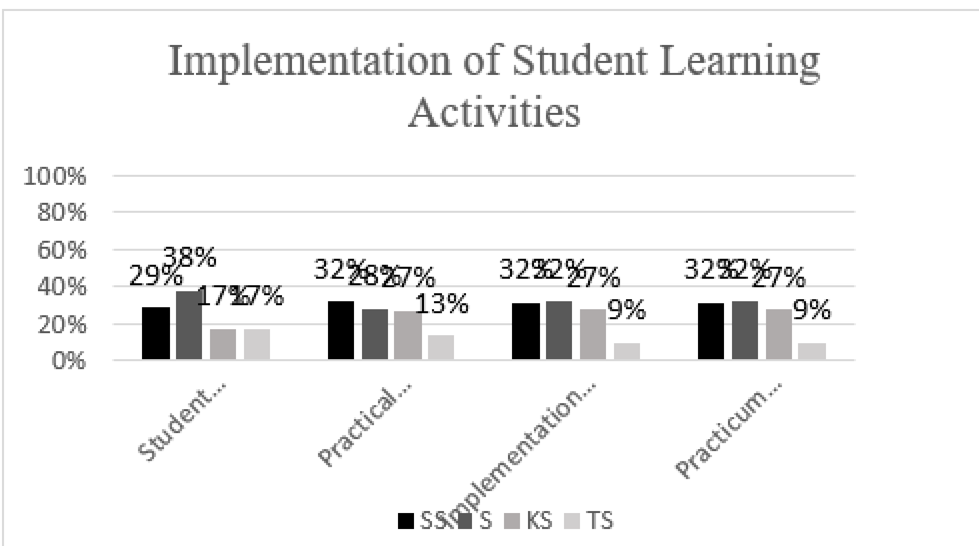

Figure 2. Survey of the Implementation of Science Learning Activities

The implementation of science learning activities in schools has not yet reached its maximum potential, as illustrated in Figure 3. The data depicted in Figure 3 emphasizes several crucial aspects of students' learning experiences, including classroom learning, laboratory practicum implementation, and the effectiveness of practicums in the STEM laboratory.

Based on the results of the analysis, it is evident that the results for each indicator are still below 50%, indicating that the majority of students have not experienced optimal science learning experiences in certain aspects. Classroom learning experiences form the foundation of the learning process, yet the data shows that most students have not reached the expected level of satisfaction or engagement. Similarly, practical experience in the laboratory, crucial for reinforcing understanding of science concepts through direct experience, still requires more attention [38].

Practical activities in STEM laboratories also faced obstacles, with practicum fluency still below 50%. This allows for certain obstacles or challenges in implementing practicums that must be overcome to ensure a more effective learning experience. Some of the reasons are that practicum activities in schools have not gone well due to limited equipment and expensive experimental materials not provided by the school, limited time, and the possibility of work accidents being a consideration factor for science teachers not carrying out practicums in the laboratory. Educational practicum activities in laboratories that are not optimal can be carried out in various ways, one of which is by developing a virtual laboratory [24]. The teacher said that what is needed is a virtual laboratory that has a design that can attract and motivate students in learning, the content of the material is appropriate to real life, the variables provided are detailed, can hone students' skills, and is safe for students to use.

The development of a virtual laboratory aims to enhance junior high school students' self-regulated and computational thinking skills, integrating a STEM approach. STEM is essential in science education [25] as it not only fosters problem-solving skills but also involves experiments using scientific processes, mathematical analysis, technology utilization, and design or engineering principles [26]; [27]. This approach helps train students to think computationally and independently, improving their self-regulated and computational thinking skills. Additionally, the development of a virtual STEM laboratory integrates an articulate storyline device, offering diverse features to enhance adaptability and facilitate learning while providing ample opportunities for professional development [28]. Articulate storylines were also considered more effective because they integrate technology into the learning process, enabling students to learn independently and boosting their self-confidence through direct feedback [29];[30]. Additionally, integrating virtual laboratories with Articulate storylines enhances the enjoyment of learning [31]. Therefore, through this integration, the virtual STEM laboratory is expected to enhance students' self-regulated skills and computational thinking abilities in problem-solving.

4. Conclusion

The research indicated that implementing science learning activities in schools has not yet reached an optimal level. Specifically, students lack sufficient opportunities to engage in practical learning experiences, including implementing practicums at school. Additionally, there is a need for greater emphasis on developing computa-tional thinking skills, which include problem decomposition, pattern recognition, ab-straction, and problem-solving strategy planning. Strengthening these skills is crucial for enhancing students' proficiency in computing and problem-solving in the future. Regarding self-regulated skills, the majority of students have shown progress. How-ever, there is still room for improvement, particularly in enhancing students' evalua-tion skills. Therefore, a more focused learning approach and adequate teacher sup-port are necessary to bolster students' self-regulation skills. Based on the research findings, it can be concluded that implementing more innovative, integrated, and technology-oriented learning strategies is imperative to enhance the quality of science education in schools. Virtual STEM laboratories serve as a foundational tool to em-power students' computational thinking skills and self-regulated skills.

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