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Task Complexity and Students' Cognitive Load in Science among Grade 11 Students at Kitubo National High School Bukidnon

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Abstract: This research study investigates the task complexity and students' cognitive load in science of grade-11 science students in Kitobo National High School, Kitubo, Kitaotao, Bukidnon during the second quarter of the academic year 2024-2025. The study aims to examine 1. The level of task complexity for the students in science; 2. The level of students' cognitive load in science; 3. The relationship between task complexity and students' cognitive load in science. The participant of the study involves 87 science students from 3 different sections of grade-11 selected through purposive sampling. Participants answered a 42-item survey questionnaire divided into two parts focusing on the task complexity and cognitive load. The data collected were analyzed using statistical tool called SPSS. Analysis of the data shows several insights on the cause and effect of task complexity and cognitive load as well as the close direct proportionality of the variables. While complex task triggers the students to do more and improve their output better, there is still a need to improve in delivering and presentation of the task and lesson. A well-structured task that aligns with students' cognitive capabilities and reduce extraneous cognitive load can significantly enhance learning outcomes. By balancing task complexity with appropriate support, educators can foster deeper understanding and more effective learning experiences. Educators should continue refining task design to ensure it supports cognitive load management while promoting engagement. Further research is needed to explore how specific task structures impact different types of cognitive load across various learning environments. Additionally, developing targeted strategies to reduce extraneous load in digital learning contexts could provide valuable insights for improving online education.

Keywords: Task Complexity, Nature of task, Cognitive engagement, Support and resources, Cognitive Load, Intrinsic cognitive load, Extraneous cognitive load, and Germane cognitive load

I. Introduction

Task Complexity is the measure of the difficulty and the intricacy that is involved in performing a task. It has a significant effect in the decision-making and performance of humans. In scientific disciplines, task complexity is a vital concept in understanding how students manage during learning activities. To evaluate task complexity, the use of the Task-Component-Factor Dimension Framework is needed. This categorizes tasks based on the number of elements involved, the interactions between elements, and the cognitive demand that is imposed unto learners. Research has indicated that increased cognitive effort and varying outcomes in performances correlates with higher task complexity. The close relation between task complexity and that of students' prior knowledge plays significant role. Students with strong prior knowledge performs better on complex tasks underwhelmed compared to those students that lack prior knowledge which may struggle despite under similar conditions resulting to low performance and learning outcome. Understanding these dynamics is crucial for educators in sculpting assessments and curricula itself that would optimize the learning experiences for science students considering their cognitive capabilities and limitations.

Science students often encounter significant challenges relating with task complexity concerning the cognitive aspect particularly. When Students are presented with too much information, as task may contain inherent difficulty of the content, the demand of the task far exceeds the students' cognitive capacity. Tasks with higher complexity tends to cause the students to have difficulty on focus and learning objectives. The tasks may also be presented with number of elements that must be processed simultaneously raising the task complexity. This may result to the students struggling in retaining the information leading to frustration and disengagement. The increase of cognitive load to students hinders their learning process and it influences the students' self-efficacy belief and their motivation. Students that feel overwhelmed tends to be reluctant in engaging materials with challenging tasks specially when the students perceive the task to be excessively complex. Many science tasks require adequate scaffolding to help students effectively manage cognitive load. Inadequate scaffolding results to students feeling lost and overwhelmed which would hinder their engagement and development of necessary reasoning skills. As the task's complexity keeps on increasing, students may perceive the tasks to be too challenging and beyond their capabilities. This can lead to avoidance and students' disengagement from further learning worsening the gaps in performance and understanding. Reducing extraneous load and providing adequate scaffolding for learning helps science students' overcome challenging tasks more effectively.

The mental effort used in problem-solving and learning refers to the Cognitive Load of the learner. Dolmans et al., (2022) research participants experienced greater cognitive load with more complex tasks, which had affected their test scores but not the overall performance (Dolmans et al., 2022). It was also said that ICL increase from 4.2 to 5.7 in simple versus complex tasks indicated that high complexity tasks demand greater mental effort (Dolmans et al., 2022). Element interactivity within tasks can heighten cognitive load, complicating learning processes (Sweller et al., 2023). Higher tasks complexity correlates with longer

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response times, requiring increased cognitive effort for completion (Lee, 2019). Even in the Philippine educational setting, studies had supported this notion that as tasks complexity increases, so does the cognitive load experienced by the learners. It was also discussed in the study by Mendoza and Dela Cruz (2020) that more complex tasks led to higher ICL which impacted the students' ability to retain information and perform well in assessments (Mendoza and Dela Cruz 2020). Lim et al. (2021) examined the relationship between cognitive load and task complexity in language learning context in which their finding indicates that tasks requiring higher levels of element interactivity resulted in increased cognitive demand (Lim et al., 2021). This aligned with Sweller's cognitive load theory (Sweller et al., 1998). Garcia and Cruz (2023) highlighted that students' higher self-efficacy were better equipped to handle increased cognitive demands, thereby mitigating the negative effects of task complexity.

These studies imply that there is intricate relationship between task complexity and cognitive load which highlighted the need for instructional designs that considers these factors to enhance learning outcomes in the Philippine educational context. This study aims to analyze how much of task complexity affects the cognitive load of science students. This allows us to grasp the situation of the students' ICL and the ECL in the Filipino classroom. The study is conducted at Kitobo National High School. The participants of the study are senior high school Grade 11 science students in the S.Y. 2024-2025.

Objectives of the Study

The study investigates the relationship between task complexity and students' cognitive load in science among Grade-11 science students of Kitobo National High School, Kitubo, Kitaotao, Bukidnon, Philippines, for the second quarter of the academic year 2024-2025. Specifically, it aims to:

1. Determine the level of task complexity of Grade-11 science students in terms of:

    a. Nature of Task,

    b. Cognitive Engagement, and

    c. Support and Resources.

2. Determine the level of cognitive load of Grade-11 science students in terms of:

    a. Intrinsic Cognitive Load (ICL),

    b. Extraneous Cognitive Load (ECL), and

    c. Germane Cognitive Load (GCL).

3. Examine the correlation between task complexity and cognitive load, including their elements.

II. Methodology

Research Design

This study uses a quantitative research design to examine the relationship between task complexity and students' cognitive load in science. A descriptive-correlational design was chosen to measure students' perceived cognitive load and the complexity of tasks they encounter in science. The aim is to analyze patterns and determine if there is a significant correlation between the two variables. The research will focus on Grade 11 Science students at Kitubo National High School using a survey questionnaire to collect data.

Participants and Sampling Method

The participants in this study will be Grade 11 Science students at Kitubo National High School. A purposive sampling technique was used to select these students, as they are the only ones currently enrolled in the science program. The final sample includes 87 students from three different sections of the Grade 11 Science program. All students from these sections participated in the survey.

Data Collection Methods

The survey questionnaire consists of two parts: 1.) Task Complexity will measures the students' perception of task complexity in science. Respondents will be asked to rate the difficulty of various tasks on a 5-point Likert scale ranging from 1 = easy to 5 = difficult, and 2.) Cognitive Load will assesses the students' cognitive load. Respondents will be asked to rate their level of agreement with various statements about their cognitive load, using a 5-point Likert scale where 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree. Both sections will be analyzed separately to assess the different variables. For task complexity, higher values on the scale will indicate more complex tasks, while for cognitive load, higher values will indicate a greater perceived cognitive load.

The survey instrument was subjected to content validation by three experts in the field of education and cognitive load to ensure its relevance and clarity. In terms of reliability, Cronbach's alpha was used, and items with low or negative item-total correlations were removed to improve the reliability of the instrument. The final version of the questionnaire, after these adjustments, was deemed reliable for use in the study. Before data collection, written informed consent was obtained from both the students and

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their parents. The purpose of the study was explained to the participants, and they were assured that their responses would be confidential and used solely for academic purposes. Each participant was asked to sign the consent form after being fully informed about the study's nature.

Research Questions

Aligned with the objectives, the study seeks to answer the following:

1. What is the level of task complexity of Grade-11 science students in terms of:
   a. Nature of Task,
   b. Cognitive Engagement, and
   c. Support and Resources?
2. What is the level of cognitive load of Grade-11 science students in terms of:
   a. Intrinsic Cognitive Load (ICL),
   b. Extraneous Cognitive Load (ECL), and
   c. Germane Cognitive Load (GCL)?
3. What is the relationship between task complexity and cognitive load, including their elements?

Data Analysis

Data from the survey will be analyzed using SPSS (Statistical Package for the Social Sciences). The analysis will include; 1.) Descriptive statistics (mean, standard deviation, frequency distribution) to summarize the participants' responses for both task complexity and cognitive load, and 2) Pearson's correlation coefficient will be calculated to measure the relationship between task complexity (as rated on the 1–5 difficulty scale) and cognitive load (as rated on the 1–5 agreement scale), and to determine if any statistically significant correlations exist. The results will be interpreted to describe patterns in how students perceive the complexity of tasks and how this may impact their cognitive load.

Ethical Considerations

This study adheres to ethical research standards. Informed consent was obtained from all participants and their parents, ensuring that the students understood the study's purpose and voluntarily agreed to participate. Confidentiality and anonymity were emphasized in the consent forms, which the participants were required to sign. All responses will remain confidential, and individual identities will not be disclosed in the reporting of results.

III. Results and Discussions

Task Complexity

Nature of Task

The indicators here reflect how students perceive the relationship between different concepts, the need for information integration, and the dynamic elements of the task. The mean scores in Nature of Task, it show that students reported moderate complexity in "tasks requiring integration of information" with a mean of 2.66 and "tasks involving relationships between concepts or procedures" with a mean of 2.60. These ratings suggest that while students found these tasks moderately challenging, they were still manageable. Additionally, the statement "The elements of the science task change dynamically as I progress, making it engaging" was rated moderately with a mean of 2.90, indicating that dynamic elements of the task were perceived as engaging but still requiring balanced effort.

However, the lowest rated indicator is "The science task presents multiple pieces of information that enhance my understanding," with a mean of 2.47, suggesting that while students found this aspect somewhat easy, it still required some cognitive effort. These results imply that students were able to manage the complexity of the tasks but had to exert consistent effort in integrating various pieces of information.

Cognitive Engagement

The Cognitive Engagement indicators assess how challenging and intriguing the students find the tasks, as well as how engaging and rewarding the learning process is. As shown in Table 2, students perceived tasks requiring critical thinking and problem-solving skills as moderately challenging, with indicators like "The critical thinking and problem-solving skills required by the science task are valuable for my education" (mean of 2.76) and "The concepts involved in the science task are abstract or theoretical, which intrigues me" (mean of 2.83). Both indicators had a median score, reflecting that students found these tasks engaging yet moderately complex.

The highest rated indicator is "Revisiting material helps me gain a deeper understanding necessary for completing the science task" (mean of 2.95) and "Engaging with terminology in the science task expands my vocabulary and comprehension skills" (mean of 2.91). These high scores suggest that students considered revisiting material and engaging with terminology as key to their learning, even though they required substantial effort. These findings are consistent with research on cognitive engagement, which emphasizes the importance of revisiting and reinforcing material to deepen understanding (Mukhrib, 2021).

Support and Resources

The Support and Resources indicators assess the clarity and effectiveness of task instructions, visual aids, examples, and logical sequencing in aiding student understanding and managing task complexity. Srated the clarity of task instructions highly (mean of 2.56), indicating that instructions were moderately clear and helpful for understanding the task. Similarly, "Relevant examples provided for the science tasks are useful for deepening my understanding" (mean of 2.64) was also rated as moderately helpful, suggesting that the examples aided in task comprehension without being overwhelming.

The highest rated indicator is "Visual aids included in the materials enhance my comprehension of complex topics in the science task" (mean of 2.94), closely followed by "The logical sequence in which tasks are presented aids my learning process effectively" (mean of 2.92). These findings emphasize the importance of well-organized and visually supportive resources in facilitating task comprehension, thus reducing cognitive load. These results align with the literature on task design, which highlights the role of clear instructions and effective resources in supporting complex learning tasks (Sweller et al., 2011).

The overall mean score of 2.72 across all sub-variables can be interpreted that the science tasks were perceived as moderately complex, and required a balanced effort in terms of cognitive demand. As shown in Table 4, all three sub-variables—Nature of Task (mean of 2.60), Cognitive Engagement (mean of 2.66), and Support and Resources (mean of 2.90)—fall in the "Moderate" range, this suggest that while the tasks were challenging, they were manageable, demanding mental effort but not overwhelming to the students.

Overall, the results reveals that while the students generally perceive the science tasks and lessons as balanced in terms of complexity and support, there is room for enhancement in a few areas. The variables measuring task complexity and support materials indicate that the balance between challenge and cognitive load is currently appropriate, but future modifications might increase engagement and learning outcomes by slightly increasing task difficulty or incorporating more dynamic support mechanisms. Similarly, the moderate ratings for lesson structure and application suggest that while students find these aspects manageable and beneficial, there may be opportunities to refine the clarity, organization, and application of knowledge to further support deeper learning and stronger knowledge integration. The research finding of this study supports the study of (Mukhrib, 2021) which mentioned that task complexity elevates cognitive load, requiring more mental effort.

Students' Cognitive Load in Science

Intrinsic Cognitive Load (ICL)

In the Intrinsic Cognitive Load (ICL) the indicators with the lowest scores reflect tasks that required minimal cognitive effort. For instance, "I had to think deeply to grasp the lesson's requirements" received a mean score of 2.74, indicating that students found it manageable to grasp the lesson's demands. Other indicators, such as "I was able to keep track of the different topics discussed in the lesson" (mean = 3.15) and "The lesson required me to connect various pieces of information effectively" (mean = 3.15), also show a neutral perception of the cognitive load, suggesting a moderate level of cognitive effort required for these tasks. The overall mean of 3.17 suggests that the students found the intrinsic cognitive load manageable, which is interpreted as neutral.

These results suggest that the lessons were designed with a balanced level of complexity. A moderate intrinsic cognitive load allows students to engage with the material without feeling overwhelmed. The ability to connect various concepts and track different topics indicates that students could integrate new knowledge with existing understanding. While the task complexity was manageable, this moderate level of cognitive load encourages students to actively engage with the content, a crucial element for scientific thinking and long-term retention.

This finding aligns with the study "Difficulties faced in science subjects by Grade VI students in knowledge, comprehension, and application" which reported that students' fundamental knowledge is moderate in science, requiring a balanced level of difficulty in instructional design to promote better comprehension and application of knowledge (Anshul et al., 2023). This finding emphasizes the importance of a moderate intrinsic cognitive load for maintaining student engagement while ensuring cognitive growth.

Extraneous Cognitive Load (ECL)

In Extraneous Cognitive Load (ECL) the indicator with the lowest mean score is "I had to think deeply to grasp the lesson's requirements" with a mean of 2.74. Other indicators, such as "The instructions given during the lesson were clear and easy to follow" with a mean of 3.13 and "The layout of the materials we used was organized and helpful" with a mean of 3.30, suggest that while students found the science task and lesson structure generally effective, there is still a room for improvement. The overall mean of 3.27 for all the indicators suggests a moderate level of cognitive load for ECL, reflecting a generally well-organized science task and lesson, but with potential areas for improvement in reducing unnecessary cognitive effort.

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The moderate ECL suggests that students were able to focus on the science task without being distracted by confusing instructions or poorly organized materials. However, the indicators “The instructions given during the lesson were clear and easy to follow” and “The layout of the materials we used was organized and helpful” with a mean of 3.13 and 3.30, respectively indicates that while the lessons were functional, there could be more clarity and structure to reduce extraneous cognitive load. Minimizing unnecessary cognitive load would allow students to focus more on the material itself and less on navigating through the lesson.

This finding supports Hutchins et al. (2009), who emphasized the need for clear instructions and well-structured materials in reducing cognitive load. Enhancements in lesson clarity and organization could lead to a more effective learning environment, minimizing distractions and making the learning process more intuitive.

Germane Cognitive Load

In Gemane Cognitive Load (GCL) the indicators with the lowest mean is “I felt motivated to explore more about the topic after this lesson” with a mean of 3.24 followed by the indicators “I was able to connect this lesson to what I have learned before” and “I was able to apply what I learned in this lesson to other science topics” with a mean of 2.26 and 3.30 respectively. On the other hand, the indicators with highest mean is “The lesson helped me develop new skills related to science” with a mean of 3.45 followed by the indicators “I felt that my knowledge of the subject deepened through this lesson” and “This lesson helped me understand the science concepts better” with a mean of 3.39 and 3.36 respectively.

The indicators in this sub-variable, such as "This lesson helped me understand the science concepts better" and "I felt motivated to explore more about the topic after this lesson," assess how well students can apply and integrate the knowledge they gain in the lesson into broader contexts. With an overall mean of 3.33, the students reported a moderate level of satisfaction with how well they can transfer and apply what they learned which is qualitatively interpreted as manageable. The moderate score suggests that while students can make some connections and feel motivated to learn more, there is potential to enhance these experiences further. Increasing opportunities for students to apply their learning in practical, real-world contexts or in more interactive settings could lead to greater knowledge retention and deeper understanding. This is supported by the study of Anshul et al. (2023) Promoting Deeper, Meaningful Learning in the Contemporary Educational Landscape.

The overall mean score of 3.25 indicates that students experienced a moderate cognitive load across all three sub-variables: Intrinsic, Extraneous, and Germane Cognitive Load. While the cognitive load in the lesson was generally manageable, there are clear opportunities to improve the clarity of instructions, the organization of materials, and the depth of knowledge integration.

These results implies that the science lessons provided a moderate challenge to students. Future lessons should focus on enhancing the clarity and application of instructions and providing more interactive opportunities for students to deepen their understanding and skills. The moderate cognitive load found in this study reflects an effective learning environment, but further improvements can increase engagement and learning outcomes. The findings support the cognitive load theory as presented by Sweller et al. (2011), which highlight the importance of balancing cognitive load to optimize learning experiences.

The overall mean score of 3.25 indicates that the cognitive load experienced by students was moderate, falling within the manageable range (2.51–3.50). This means that the students perceived the science tasks as neither too overwhelming nor too easy, but at a level that was manageable for them. The individual mean scores for each type of cognitive load—ICL (3.17), ECL (3.26), and GCL (3.33)—also reflect a moderate level of cognitive load, indicating that students were able to engage with the material without excessive strain, while still being sufficiently challenged.

The Intrinsic Cognitive Load (ICL) score of 3.17 suggests that the lessons were moderately complex, requiring students to integrate new knowledge with existing understanding in a manageable way. This aligns with the idea that the lesson design was structured to encourage deeper cognitive engagement without being overly demanding. Similarly, the Extraneous Cognitive Load (ECL) score of 3.26 indicates that the lessons were generally well-organized and clear, but there might have been minor aspects of lesson presentation or materials that required extra cognitive effort. Finally, the Germane Cognitive Load (GCL) score of 3.33 suggests that while students were able to apply what they learned and connect new knowledge to prior learning, there is room to enhance their ability to engage with the material more deeply, possibly through more opportunities for practical application or interactive learning.

These results suggest that the instructional design of the science lessons was generally effective in balancing cognitive load, providing a learning environment that was manageable for students. However, while the lessons were not too demanding, the results also indicate potential areas for improvement, especially in terms of reducing unnecessary cognitive load and increasing opportunities for deeper engagement with the content. For instance, further refinements in lesson structure or providing more real-world applications of the learned concepts could help reduce extraneous cognitive load and increase germane cognitive load, leading to better knowledge retention and deeper understanding.

These findings are consistent with the studies by Anshul et al. (2023) and Hutchins (2009). Anshul et al. (2023) emphasized the importance of integrating new knowledge into existing cognitive frameworks for meaningful learning, which aligns with the moderate scores in ICL and GCL, suggesting that students were able to make connections but could benefit from more opportunities to deepen those connections. Similarly, Hutchins (2009) highlighted the need for improved clarity and organization in lesson materials to reduce extraneous cognitive load, a point that is reflected in the slightly higher score for ECL, which suggests that the lesson materials and structure were effective but could be made more efficient.

The descriptive statistics show that the average scores for all variables of task complexity and cognitive load range from moderate to high, with Germane Cognitive Load GCL having the highest mean score (3.33) and Nature of Task having the lowest mean score (2.63). These results suggest that the students generally perceived moderate to high levels of cognitive load, with their task complexity levels also perceived as moderate to slightly above average.

Cognitive Engagement has strong positive correlations with Nature of Task ($r = 0.570$, $p < 0.01$) and Support and Resources ($r = 0.609$, $p < 0.01$), indicating that students who perceive more engagement with the task also perceive the task as more complex in terms of nature and the support/resources available.

Cognitive Engagement is also significantly correlated with Extraneous Cognitive Load ECL ($r = 0.256$, $p = 0.017$), suggesting that as students engage more with the task, they tend to experience higher extraneous cognitive load. This could be due to the increased mental effort required to sustain engagement with challenging tasks or external distractions.

Intrinsic Cognitive Load ICL shows weak correlations with task complexity dimensions (ranging from 0.205 to 0.256), suggesting that while there is some relationship between task difficulty and intrinsic load, it is not very strong. This may imply that the intrinsic cognitive demands of a task (such as the inherent difficulty of the content) do not always directly correlate with students' perceptions of task complexity.

Extraneous Cognitive Load ECL is strongly correlated with Germane Cognitive Load GCL ($r = 0.795$, $p < 0.01$), implying that students who experience high extraneous load also tend to report higher levels of germane load, possibly due to the compensatory strategies they use to manage cognitive demands.

The results suggest several important implications for the design of educational tasks and the management of cognitive load in the classroom.

In the Cognitive Engagement and Extraneous Cognitive Load ECL, the significant positive correlation between Cognitive Engagement and Extraneous Cognitive Load ECL suggests that tasks designed to be more engaging may inadvertently increase extraneous load, possibly by demanding more mental effort from students. Educators should consider balancing engagement with manageable task complexity to prevent overwhelming students.

Moreover, Task Design and Cognitive Load, the weak correlation between Intrinsic Cognitive Load ICL and task complexity dimensions suggests that task difficulty may not always directly correlate with students' perceived cognitive load. This points to the importance of considering how tasks are structured, rather than just their inherent difficulty, to manage cognitive load effectively.

Although Support and Resources did not have a strong correlation with cognitive load measures, it is still essential to provide adequate resources and support to help students navigate complex tasks, particularly when the cognitive engagement is high. Well-structured guidance or scaffolding may mitigate some of the extraneous load caused by task difficulty or complexity.

Moreover, the strong correlation between Extraneous Cognitive Load ECL and Germane Cognitive Load GCL suggests that managing external cognitive load (e.g., distractions or task structure) is essential. If extraneous load is not controlled, students may have to devote more cognitive resources to handling it, leaving less room for deeper learning strategies that involve germane load.

Research by Mortianto et al. (2022) entitled Cognitive Load Theory on Virtual Mathematics Laboratory: Systematic Literature Review states that cognitive load affects learning by limiting working memory capacity, which can lead to overload. Effective instructional design aims to manage cognitive load, ensuring that the resources required for learning do not exceed available capacity, thus enhancing learning effectiveness. This was further supported by the research A Cognitive Load Theory Approach to Defining and Measuring Task Complexity Through Element Interactivity by Chen et al. (2023), according to them, cognitive load affects learning by influencing the number of interactive elements in tasks. Effective instructional design reduces extraneous cognitive load, allowing learners to focus on essential elements, thereby enhancing learning effectiveness and facilitating the acquisition of complex cognitive tasks. The results of this study support this idea, particularly the finding that engagement can increase cognitive load, which may hinder effective learning if not managed properly.

Moreover, Wilby and Paravattil (2021) suggested that high extraneous load can indeed prompt students to employ compensatory cognitive strategies, such as focusing more deeply on the content. However, this may interfere with assessors' attention and working memory, leading to poorer quality assessments in pharmacy education. This study’s finding that extraneous load is strongly correlated with germane load corroborates their claim, suggesting that high extraneous load may prompt students to employ compensatory cognitive strategies, such as focusing more deeply on the content to manage the external demands.

Lastly, the weak correlations between intrinsic cognitive load and task complexity dimensions support the argument that Cognitive load is influenced by intrinsic cognitive load, reflecting task difficulty, and extraneous cognitive load, which pertains to task presentation. The interaction between these factors and learner engagement significantly affects the overall cognitive load experienced during learning tasks. Chen et al. (2023).

IV. Conclusion

This study examined the relationship between task complexity and students' cognitive load in science, focusing on different types of cognitive load—Intrinsic, Extraneous, and Germane—along with task complexity-Nature of task, cognitive engagement and the support/resources provided. The descriptive statistics revealed that students perceived moderate levels of cognitive load, with Germane Cognitive Load (GCL) having the highest mean score (3.33), followed by Extraneous Cognitive Load (ECL) and Intrinsic Cognitive Load (ICL). The Nature of Task variable had the lowest mean score (2.63), suggesting that students perceived tasks as moderately complex.

The findings indicated a significant relationship between task complexity and students' cognitive load. Specifically, Cognitive Engagement was strongly positively correlated with both the Nature of Task ($r = 0.570$, $p < 0.01$) and Support and Resources ($r = 0.609$, $p < 0.01$). This suggests that tasks perceived as more engaging are also perceived as more complex and require more support and resources. Moreover, Cognitive Engagement was positively correlated with Extraneous Cognitive Load ($r = 0.256$, $p = 0.017$), indicating that as engagement increases, students experience higher extraneous load, likely due to increased mental effort in managing complex tasks. This finding aligns with the research by Mortianto et al. (2022) and Chen et al. (2023), which emphasizes the need to manage cognitive load effectively in task design to prevent overload and enhance learning outcomes.

Interestingly, the correlation between Intrinsic Cognitive Load (ICL) and task complexity dimensions was weak (ranging from 0.205 to 0.256), suggesting that the inherent difficulty of tasks may not directly influence perceived cognitive load. This implies that task structure, rather than task difficulty alone, plays a crucial role in shaping cognitive load. The strong positive correlation between Extraneous Cognitive Load (ECL) and Germane Cognitive Load ($r = 0.795$, $p < 0.01$) suggests that excessive external demands (e.g., distractions or unclear task design) can limit the cognitive resources available for deeper, more meaningful learning, highlighting the importance of minimizing extraneous load to maximize learning efficiency.

Recommendations

Based on the findings, the following recommendations are proposed:

- Educators should design tasks that align with students' cognitive capabilities. Tasks should be engaging and appropriately challenging but not overly complex to the point of overwhelming students. A balance must be maintained between task complexity and cognitive load management.
- Instructional design should focus on minimizing Extraneous Cognitive Load (ECL). Strategies such as streamlining task instructions, eliminating distractions, and providing scaffolding can help reduce unnecessary cognitive strain. Reducing extraneous load allows students to allocate more cognitive resources to Germane Cognitive Load (GCL), promoting deeper understanding and learning.
- Educators should prioritize well-structured tasks over inherently difficult ones. Task clarity and coherence are essential to enhance students' ability to process complex concepts effectively.
- Lastly, task design should encourage meaningful cognitive engagement. By providing adequate support and resources, educators can help students navigate complex tasks, thereby improving learning outcomes and fostering deeper comprehension of science concepts.

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