The Influence of Scaffolding and Task Complexity on the Cognitive Load of Startups: An Experiment

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Abstract. This study aims to examine the influence of scaffolding and task complexity on cognitive load in startup using an experimental design. A total of 60 startup in Yogyakarta were randomly divided into four groups: high scaffolding with complex tasks, high scaffolding with simple tasks, low scaffolding with complex tasks, and low scaffolding with simple tasks. Cognitive load was measured through a validated questionnaire. The results of the variance analysis showed that scaffolding significantly reduces cognitive load, while task complexity significantly increases cognitive load. Additionally, there is a significant interaction between scaffolding and task complexity, where scaffolding is more effective in reducing cognitive load for complex tasks. These findings support cognitive load theory and emphasize the importance of scaffolding support in the startup work environment, especially for complex tasks. This study suggests the implementation of scaffolding strategies in startup training to manage cognitive load, as well as further research with a more diverse population and longitudinal design.

Keywords: scaffolding, task complexity, cognitive load, startup, experiment

1 INTRODUCTION

Startups often operate in dynamic and challenging environments, where are required to complete complex tasks quickly and efficiently. Complex tasks can impose a cognitive load on novice learners such as startup [1]. Cognitive load, which is the amount of mental effort needed to process information, becomes a crucial factor in determining the performance of startups. Excessive cognitive load can hinder learning and productivity, while well-managed cognitive load can enhance work effectiveness [2].

Two main factors that affect cognitive load are scaffolding [3] and task complexity [4]. Scaffolding is a learning technique that involves providing gradual support to startup to help them reach higher levels of understanding or skill [5]. On the other hand, task complexity refers to the level of difficulty and the amount of information that startup must process when completing tasks [6]. Tasks that are too complex can increase the cognitive load on startup.

Cognitive load theory is a psychological concept used to measure and understand the amount of mental or cognitive effort required by individuals when performing certain tasks or activities [7]. Cognitive load theory has been extensively studied in educational contexts, but its application in business environments, particularly startups, is

G. W. Pradana et al. (eds.), *Proceedings of the 4th International Conference on Social Sciences and Law (ICSSL 2024)*, Advances in Social Science, Education and Humanities Research 877,
https://doi.org/10.2991/978-2-38476-303-0_16

still limited. Most previous research has focused on formal education contexts, such as schools [8] and universities [9], and few have explored how scaffolding and task complexity affect cognitive load in startup business environments. Previous studies have used survey designs [10] or case studies [11] to examine cognitive load. Although these approaches provide valuable insights, they do not always allow for isolating and accurately measuring the effects of independent variables such as scaffolding and task complexity.

This study aims to examine the influence of scaffolding and task complexity on cognitive load in startup. This research uses an experimental design to isolate the effects of scaffolding and task complexity and to accurately measure the cognitive load of startup. A more rigorous experimental design is needed to test the causal relationships between scaffolding, task complexity, and cognitive load in startup business environments. Experiments allow researchers to control other variables and isolate the effects of the variables being studied [12].

Scaffolding, in the context of cognitive load theory, refers to supportive strategies or techniques designed to help individuals understand, complete, or manage complex tasks [3]. This concept was introduced by Vygotsky in his cognitive development theory, which suggests that individuals can reach higher cognitive potential with appropriate help and guidance [13]. In the context of startup businesses, scaffolding refers to the gradual support provided to startup in training activities to help them achieve higher understanding or skills. Scaffolding is designed to help individuals manage cognitive load by providing the guidance, structure, and assistance needed to understand and complete tasks effectively. Scaffolding can include instructions, examples, feedback, and guidance [3]. Over time, this support is reduced as competence increases, eventually allowing them to complete tasks independently. Scaffolding provides support and structure that helps startup process information and complete tasks more efficiently, thereby reducing their cognitive load [7]. Therefore, the first hypothesis proposed in this study is as follows:

Hypothesis 1: Providing scaffolding will affect the cognitive load of startup.

Furthermore, task complexity refers to the amount of information and level of difficulty associated with a task [4]. According to cognitive load theory, overly complex tasks can increase cognitive load, which can hinder the process of acquiring information in learning or training [7]. Therefore, managing task complexity is key to ensuring that cognitive load is at an optimal level. More complex tasks require more mental effort to understand and complete, which can increase the cognitive load on startup. Therefore, the second hypothesis proposed in this study is as follows:

Hypothesis 2: Higher task complexity will affect the cognitive load of startup.

When startup are faced with complex tasks without adequate support or scaffolding, they tend to experience high cognitive load. However, with the appropriate scaffolding, task complexity can be better managed. Scaffolding helps manage cognitive load by providing the necessary guidance and support to process information effectively. Providing scaffolding for complex tasks can help startup manage these tasks better, allowing them to allocate their cognitive resources more effectively and reduce

excessive cognitive load. Therefore, the third hypothesis proposed in this study is as follows:

Hypothesis 3: The interaction between scaffolding and task complexity will affect cognitive load.

2 METHOD

2.1 Research Design

This study employs an experimental design to examine the effects of scaffolding and task complexity on the cognitive load of startup. An experimental design was chosen to allow control and manipulation of independent variables and to isolate their effects on the dependent variable.

2.2 Participants

Participants in this study are startup from various service sector startups. The criteria for participants include having a startup that has been in operation for at least six months and willingness to participate in the experiment. Participants are startups that are part of a digital marketing training program in Yogyakarta. A total of 60 participants are needed, who will be randomly divided into four experimental groups. Participants are provided with comprehensive information about the study's aims and procedures. Those willing to participate will sign a consent form.

2.3 Research Variables

Independent Variables.

1. *Scaffolding:* This involves providing support or assistance to startup. Two levels of scaffolding will be applied: high scaffolding (providing clear guidance, comprehensive feedback, and examples) and low scaffolding (providing minimal guidance and limited feedback).
2. *Task Complexity:* This refers to the complexity level of tasks given to startup during the training. Two levels of task complexity will be applied: high complexity (tasks requiring extensive information processing and complex skills) and low complexity (simple tasks with minimal information and basic skills).

Dependent Variable.

Cognitive Load: This is the cognitive load experienced by startup. Cognitive load will be measured using a questionnaire developed based on a validated instrument that measures individuals' perceptions of the mental effort required to complete tasks.

2.4 Research Procedure

This study employs an experimental approach to investigate the impact of scaffolding and task complexity on the cognitive load of startup. The experimental approach involves intervening by manipulating the experimental groups. In this study, the experimental groups were manipulated by adjusting the levels of scaffolding (high and low) and task complexity (high and low).

The experimental design utilized is a 2x2 factorial between-subjects design. This design aims to examine the main effects and interaction effects of two independent variables (scaffolding and task complexity) on the dependent variable (cognitive load). The experimental approach offers the benefit of high internal validity as it can demonstrate causal relationships between variables and control extraneous variables through proper randomization techniques. A laboratory experiment was conducted in this study to control extraneous variables and achieve higher internal validity. The experimental design of this study is summarized in Table 1.

Table 1. Experimental Design

		Task Complexity	
Scaffolding		High	Low
	High	Cell 1	Cell 2
	Low	Cell 3	Cell 4

Description:
- Cell 1: High scaffolding, high task complexity.
- Cell 2: High scaffolding, low task complexity.
- Cell 3: Low scaffolding, high task complexity.
- Cell 4: Low scaffolding, low task complexity.

Each group will be given tasks according to the predetermined levels of scaffolding and complexity. Tasks will be adjusted to the startup context. After completing the tasks, participants will be asked to fill out a questionnaire measuring their cognitive load. The questionnaire consists of items measuring participants' perceptions of mental effort, task difficulty, and tension experienced while completing the tasks.

2.5 Research Instruments

The main instrument in this study is a cognitive load questionnaire validated in previous research. This questionnaire includes a 7-point Likert scale to assess participants' perceptions of the mental effort required, task difficulty, and tension felt while performing tasks. The questionnaire is adapted and modified from Leppink et al. (2013) [14] and Klepsch et al. (2017) [15].

2.6 Data Analysis

Data obtained from the questionnaire will be analyzed using analysis of variance (ANOVA) to test the main and interaction effects between scaffolding and task complexity on cognitive load.

3 RESULTS AND DISCUSSION

3.1 Results

The number of participants in this study was 60, divided into four experimental groups. Table 2 below shows the demographics of the participants:

Table 2. Participant Demographics

Characteristic	Frequency (N=60)
Gender	
Male	39
Female	21
Age	
21-25	47
26-30	13
Startup Age	
6-12 months	52
1-2 years	8

Based on Table 2, it can be seen that the majority of the startup participating are male. Most of them are aged 21-25 years. Lastly, most startups are within the 6-12 month age range. Table 3 shows the descriptive statistics of the average cognitive load experienced by the startup.

Table 3. Average Cognitive Load

Group	Average Cognitive Load
High Scaffolding, High Task Complexity	3.2
High Scaffolding, Low Task Complexity	2.5
Low Scaffolding, High Task Complexity	4.8
Low Scaffolding, Low Task Complexity	3.7

Based on Table 3, the lowest average cognitive load is in the group with high scaffolding and low task complexity, at 2.5. However, we cannot draw conclusions directly from descriptive statistics, as the differences in the average cognitive load of startup might be due to sampling error. Next, to prove whether the differences in cognitive load among each group can be seen from the ANOVA test results. Before proceeding to the ANOVA test, a homogeneity test was conducted using the Test of Homogeneity of Variances, yielding a Sig. value of $0.304 > 0.05$, thus ANOVA can be used to test the main effects and interaction effects shown in Table 4.

Table 4. ANOVA

	df	F value	Sig.
Scaffolding	1	18.56	0.000
Task Complexity	1	22.13	0.000
Scaffolding * Task Complexity	1	12.34	0.001

The effect of scaffolding on the cognitive load of startup
Based on the analysis of variance in Table 4, it is shown that scaffolding has a significant effect on cognitive load (Sig. 0.000 < 0.05). This result supports the hypothesis that providing scaffolding will negatively affect the cognitive load of startup, reducing their cognitive load. Thus, Hypothesis 1 is supported. Scaffolding provides support that makes it easier for startup to understand and complete tasks, so they are not overly burdened by the information they need to process. This is consistent with cognitive load theory, which states that gradual guidance and assistance can reduce the mental effort required to complete tasks.

The effect of task complexity on the cognitive load of startup
Based on the analysis of variance in Table 4, it is shown that task complexity has a significant effect on cognitive load (Sig. 0.000 < 0.05). This result supports the hypothesis that higher task complexity will affect the cognitive load of startup. Thus, Hypothesis 2 is supported. Complex tasks require more mental effort and information processing, increasing the cognitive load of startup. This highlights the importance of considering the level of task complexity.

The interaction effect of scaffolding and task complexity on the cognitive load of startup
Based on the analysis of variance in Table 4, it is shown that the interaction between scaffolding and task complexity has a significant effect on cognitive load (Sig. 0.001 < 0.05). This result indicates that scaffolding is effective in reducing cognitive load for complex tasks. Thus, Hypothesis 3 is also supported. The support and guidance provided through scaffolding help startup focus better on completing tasks, even when those tasks are complex. This emphasizes the importance of providing adequate support in situations involving complex and challenging tasks.

3.2 Discussion

This study found that scaffolding significantly reduces cognitive load, while task complexity increases it. Additionally, the interaction between scaffolding and task complexity shows that scaffolding is more effective in reducing cognitive load for complex tasks. This research highlights the importance of scaffolding in reducing cognitive load for startup by demonstrating that appropriate support and guidance can help manage task complexity. In the dynamic and challenging startup environment, often face complex tasks that require critical thinking and quick decision-making. Scaffolding,

through clear structures and constructive feedback, helps break down these tasks into more manageable parts, thereby reducing the mental strain felt [3]. Thus, effective implementation of scaffolding becomes a strategy to create a productive work environment and support long-term growth, with clear guidance, feedback, and comprehensive examples reducing cognitive load. These findings support cognitive load theory, emphasizing the importance of support in the work environment. Scaffolding provides a structure that helps startup process information and complete tasks more efficiently [3].

The study also found that task complexity significantly affects the cognitive load of startup; the more complex the tasks faced, the higher the cognitive load experienced. Startups often encounter various tasks requiring deep data analysis, strategic decision-making, and effective operational management [5]. As these tasks become increasingly complex, must allocate more mental resources to understand, plan, and execute them, which can increase levels of stress and mental fatigue [4]. High task complexity also necessitates intensive critical thinking and multitasking, increasing the risk of errors and reducing decision quality [16]. This study shows that complex tasks can cause to feel overwhelmed and experience increased cognitive load due to having to consider many different variables and scenarios. Additionally, the pressure to complete these tasks within a limited time further exacerbates cognitive load, hindering their ability to work efficiently and effectively. Therefore, managing task complexity becomes crucial for the cognitive load of startup.

Simplifying tasks, providing appropriate scaffolding, and effectively prioritizing are some strategies that can help manage cognitive load due to task complexity. This research emphasizes the importance of a holistic approach to task management to ensure that can better cope with challenges in a dynamic and high-pressure work environment. The study found that the interaction between scaffolding and task complexity significantly affects the cognitive load of, with results indicating that scaffolding is more effective in reducing cognitive load for complex tasks. In the startup context, complex tasks often require deep information processing, careful analysis, and quick strategic decision-making, all of which can increase cognitive load. However, applying scaffolding through structured guidance, timely feedback, and ongoing support can help break down complex tasks into more manageable steps [4]. This not only helps understand and complete tasks more efficiently but also reduces the mental strain experienced. This interaction shows that when face complex tasks, scaffolding can serve as an essential tool for reducing cognitive load, allowing them to focus on key task elements without feeling overwhelmed by overall complexity. This study underscores the importance of providing adequate scaffolding, especially for complex tasks, to help manage their cognitive load more effectively in a challenging work environment.

The findings of this study offer several contributions. First, the research extends the explanation of cognitive load theory, particularly in a business context. Second, it provides practical contributions for startups and training organizers. Startups should consider implementing scaffolding strategies in task execution, especially for complex tasks. Training organizers should be aware of the task complexity given to and ensure that they are equipped with adequate support to manage their cognitive load. Training programs should be designed with task complexity in mind and provide appropriate scaffolding to ensure their effectiveness.

Despite its contributions, this research has some limitations that suggest potential for future studies. Research adding moderation or mediation variables, such as motivation or engagement, could be conducted to further explore how scaffolding and task complexity affect cognitive load. Additionally, involving participants from various types of startups (not just service-based) could improve the generalizability of the findings. Furthermore, a longitudinal design could be used to examine the long-term effects of scaffolding and task complexity on the cognitive load of startup.

This study responds to the need for effective training for startups, which aligns with SDG-8 (Decent Work and Economic Growth) by promoting sustainable economic growth through enhanced cognitive support. By demonstrating that scaffolding can significantly reduce cognitive load, especially for complex tasks, the research highlights a practical strategy to improve productivity and efficiency in startup environments. This contributes to creating decent work conditions and supporting economic growth, as better-managed cognitive load can lead to improved decision-making, reduced stress, and overall enhanced performance in startups. Thus, the findings support the broader goal of fostering sustainable economic development through effective training and support mechanisms for new and growing businesses.

4 CONCLUSION

This study found that scaffolding significantly reduces cognitive load for startup, while task complexity increases cognitive load. The interaction between scaffolding and task complexity indicates that scaffolding is more effective in reducing cognitive load for complex tasks. These findings emphasize the importance of adequate support in helping manage their cognitive load, and training organizers should consider implementing scaffolding strategies in task execution, especially for complex tasks.

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