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Understanding Germane Cognitive Load Sustainability in Jigsaw-Based Collaborative EFL Tasks

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Abstract

Although collaborative learning is widely used in English as a Foreign Language (EFL) classroom, limited research has examined how repeated jigsaw-based collaborative tasks sustain students' germane cognitive load over time. Unlike previous studies focusing on learning outcomes or increases in cognitive load, this study investigates the sustainability of germane cognitive load as an indicator of productive cognitive engagement. An explanatory repeated-measures design was conducted with 20 eleventh-grade students participating in four jigsaw-based collaborative EFL sessions. Data were collected through an adapted germane cognitive load questionnaire, classroom observations, and interviews. Quantitative findings showed that germane cognitive load remained at a moderate-to-high level, with no statistically significant difference between the mid-task and post-task phases, $t(19) = -0.297$, $p = .770$, indicating sustained rather than increased productive cognitive engagement. Qualitative findings revealed that task familiarity, peer explanation, information organization, and teacher facilitation supported this sustained engagement. These findings extend collaborative EFL and cognitive load research by suggesting that instructional effectiveness may be reflected not only in improved learning outcomes but also in sustaining productive cognitive engagement. For EFL teachers, structured and recurring jigsaw-based collaborative tasks may help maintain meaningful learning throughout the instructional process.

1. Introduction

The growing demand for English proficiency in both educational and professional settings has led English as a Foreign Language (EFL) teachers to design learning activities that promote meaningful communication and active cognitive engagement. In Indonesia, English proficiency is particularly important as students are expected to use it for academic development, intercultural communication, and future professional opportunities (Khasanova & Mirzayeva, 2023; Gautam, 2022; Rahmah, 2023). However, successful language learning depends not only on learners' participation but also on how they allocate cognitive resources to understand, organize, and integrate new information. From the perspective of Cognitive Load Theory, effective instructional design should consider the limited capacity of working memory and support learners in directing cognitive resources toward meaningful learning processes (Sweller, 1988). Recent developments in Cognitive Load Theory further emphasize that effective instructional design should not only reduce unnecessary cognitive demands but also optimize learners' limited working-memory resources to support meaningful learning and schema construction (Paas & Van Merriënboer, 2020; Skulmowski & Xu, 2021).

Within collaborative EFL classrooms, learning becomes more cognitively demanding because students are required not only to understand content but also to interact, negotiate meaning, and coordinate ideas with peers. Collaborative tasks can promote explanation, elaboration, and shared knowledge construction, but poorly structured collaboration may impose unnecessary cognitive demands through unclear roles and ineffective coordination. Therefore, the central issue is not whether collaborative learning is beneficial, but how task design can support sustained cognitive engagement, particularly germane cognitive load, which refers to the mental effort devoted to schema construction and meaningful understanding. Recent research also supports the use of subjective cognitive load instruments as valid measures of learners' investment in productive cognitive processing (Leppink et al., 2013; Kastaun et al., 2021).

Although Cognitive Load Theory explains how learners allocate cognitive resources during learning, it does not fully explain how social interaction supports cognitive engagement. This perspective is complemented by Sociocultural Theory, which views learning as a socially mediated process. From a sociocultural perspective, learning is mediated through social interaction, scaffolding, and participation in collaborative activity within the Zone of Proximal Development (Vygotsky, 1978; Alkhudiry, 2022). Task-Based Language Teaching further emphasizes that meaningful language learning occurs through goal-oriented tasks that require learners to negotiate meaning and solve problems collaboratively (Ellis, 2003). These perspectives highlight that collaborative EFL tasks provide opportunities for learners to construct knowledge through interaction; however, they do not fully explain how cognitive effort is sustained during repeated task engagement.

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Recent research in Cognitive Load Theory provides additional insight into collaborative learning processes. Building on Cognitive Load Theory, Collaborative Cognitive Load Theory proposes that cognitive demands can be distributed among group members, enabling learners to engage in deeper processing through shared cognitive resources (Kirschner et al., 2018; Janssen & Kirschner, 2020). Empirical studies also indicate that well-structured collaborative tasks can promote germane cognitive load when learners actively participate in knowledge construction and explanation (Lange et al., 2020; Zhong & Wang, 2021). These findings suggest that collaboration can support meaningful cognitive engagement when instructional design and interaction patterns are appropriately managed.

Previous studies have shown that the jigsaw technique promotes active participation, peer explanation, and shared responsibility by requiring learners to become "experts" on specific learning materials before teaching them to their peers. A recent systematic review and meta-analysis concluded that the jigsaw method consistently improves students' educational outcomes across a wide range of learning contexts (Drouet et al., 2023). In EFL classrooms, jigsaw-based learning has been associated with improvements in reading comprehension, speaking performance, collaborative interaction, and learner motivation. However, these studies have primarily examined language achievement and affective outcomes, with limited attention to the cognitive processes that occur during repeated jigsaw task implementation. Consequently, it remains unclear how jigsaw-based collaborative tasks sustain students' germane cognitive load over time.

In the context of Indonesian EFL education, previous studies have examined collaborative learning in relation to motivation, participation, creativity, and language performance. Research has shown that collaborative tasks can enhance student engagement and reduce perceived cognitive difficulty when tasks are meaningful and contextually relevant (Asfihana et al., 2022; Mulyani et al., 2024). Other studies have reported positive effects of collaborative activities such as peer feedback and group-based language production on students' communication skills and critical thinking (Silva et al., 2021; Tatlı et al., 2022). Collectively, these findings indicate that collaborative learning supports students' behavioral and affective engagement; however, considerably less attention has been given to how learners sustain productive cognitive engagement during repeated collaborative interaction (Abdullah et al., 2023; Wang et al., 2023). However, these studies largely emphasize learning outcomes and affective variables, while limited attention has been given to students' internal cognitive processes during collaborative learning.

Despite these contributions, important gaps remain in the literature. First, limited research has specifically examined germane cognitive load in senior high school EFL contexts, particularly in Indonesia. Second, most studies focus on learning outcomes, motivation, or general cognitive load rather than the sustainability of cognitive engagement during repeated collaborative tasks. Third, although Collaborative Cognitive Load Theory has explained how cognitive

resources may be distributed across group members, empirical research has focused primarily on higher education or non-language contexts, leaving the cognitive processes involved in repeated jigsaw-based EFL learning insufficiently understood (Kirschner et al., 2018; Janssen & Kirschner, 2020).

In this study, sustainability refers to the maintenance of students' germane cognitive load at a relatively stable level across repeated jigsaw-based collaborative learning sessions, rather than an increase or decrease over time. Based on this gap, the study addresses the following research question: How do jigsaw-based collaborative EFL tasks sustain students' germane cognitive load over time? The objective of this study is to investigate how germane cognitive load sustainability is manifested during repeated jigsaw-based collaborative EFL tasks in a senior high school classroom. The novelty of this study lies in extending Collaborative Cognitive Load Theory to repeated jigsaw-based EFL learning by conceptualizing germane cognitive load as a sustainable cognitive process rather than a variable expected to increase continuously. Instead of evaluating instructional effectiveness solely through learning outcomes or changes in cognitive load, this study examines how structured collaboration maintains productive cognitive engagement across repeated classroom learning experiences. By integrating questionnaire data with classroom observations and interviews, this study also provides a more comprehensive understanding of germane cognitive load than studies relying solely on self-report measures.

2. Method

Research Design

This study employed an explanatory non-experimental repeated-measures design to investigate how students' germane cognitive load was sustained during repeated jigsaw-based collaborative EFL tasks (Creswell & Clark, 2017). The design was considered appropriate because the study did not compare an experimental and control group, but observed students' cognitive responses across several task implementations in a natural classroom setting. The repeated-measures approach allowed the researcher to examine patterns of students' germane cognitive load over time, while the explanatory orientation helped interpret the quantitative results through classroom-based qualitative evidence. The qualitative phase was used to explain and contextualize the quantitative findings, following the logic of explanatory mixed-methods research (Creswell & Clark, 2017).

Participant

This study was conducted at SMAN 25 Bone, a public senior high school that integrates collaborative and project-based learning into its instructional practices. The school was selected due to its diverse student population and openness to innovation in English language education. The research was conducted from August 14th to September 15th, 2026, across four classroom meetings. The quantitative phase involved 20 eleventh-grade students who participated in structured jigsaw-based collaborative EFL tasks. For the qualitative phase, six

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students were selected purposively based on their questionnaire results, representing high, medium, and low levels of germane cognitive load. This sampling strategy was intended to capture diverse cognitive engagement experiences during collaborative learning (Creswell & Clark, 2017). The English teacher was also involved through informal interviews and classroom observation support to provide additional contextual information about task implementation and students' learning experiences.

Data Collection

Data were collected through a germane cognitive load questionnaire, classroom observation, and supporting qualitative notes from students' learning experiences. The germane cognitive load questionnaire was adapted from Leppink et al. (2013) to suit the context of repeated jigsaw-based collaborative EFL tasks. The adaptation involved contextualizing the wording of the items for senior high school learners while maintaining the original construct of germane cognitive load. The adapted questionnaire focused on students' cognitive effort in organizing information, integrating ideas, elaborating understanding, and explaining concepts during collaborative learning activities. The questionnaire was administered twice after task implementation during the 2nd meeting and 4th meeting to identify patterns of students' germane cognitive load across classroom meetings.

Classroom observations were conducted during each learning session using a structured observation checklist developed from the indicators of germane cognitive load. The observations focused on students' cognitive engagement, including organizing information, elaborating ideas, integrating knowledge, asking clarification questions, and explaining concepts to peers. Observation notes were coded according to these indicators and were subsequently used to explain the quantitative findings. And semi-structured interviews were conducted after the completion of the classroom implementation. The interview protocol explored students' perceptions of their cognitive effort, collaborative experiences, and learning strategies during the jigsaw activities. Each interview was audio-recorded with participants' permission, and was transcribed for thematic analysis.

The jigsaw-based collaborative tasks were implemented through several stages. Students first worked with assigned materials individually or in expert groups to understand specific parts of the learning content. They then returned to their home groups to explain their assigned information, exchange ideas, and integrate the information into a more complete understanding of the task. During this process, the teacher provided instructions, monitored group interaction, clarified task procedures, and supported students when they experienced difficulties. This task structure was used to examine how repeated peer explanation, shared responsibility, and information integration contributed to sustaining students' germane cognitive load.

Ethical principles were observed throughout the study. Permission to conduct the research was obtained from the school administration, and all participants

were informed about the purpose of the study before data collection. Participation was voluntary, and students' identities were anonymized to ensure confidentiality.

Data Analysis

The quantitative data were analyzed using descriptive statistics and paired simple t-test analysis. Descriptive statistics were used to identify the overall pattern of students' germane cognitive load across task sessions, including mean scores and score tendencies. Inferential analysis was then used to determine whether there were statistically significant differences in students' germane cognitive load across repeated task implementations. In addition, item-level analysis was used to identify which aspects of germane cognitive load were more strongly or weakly reflected in students' responses.

The qualitative data were analyzed thematically to identify patterns related to students' cognitive engagement, peer explanation, information integration, and teacher facilitation (Braun & Clarke, 2006). The analysis focused on identifying patterns related to students' cognitive engagement, peer explanation, information organization, knowledge integration, and teacher facilitation during the jigsaw-based collaborative tasks. The qualitative findings were then connected with the quantitative results to provide a more comprehensive explanation of how germane cognitive load was sustained over time. The quantitative and qualitative findings were integrated to provide a more comprehensive explanation of how germane cognitive load was sustained during repeated jigsaw-based collaborative EFL tasks (Creswell & Plano Clark, 2018). Through this integration, the study aimed not only to measure students' germane cognitive load, but also to explain how jigsaw-based collaborative EFL tasks supported productive cognitive engagement in the classroom.

3. Result

This section presents the findings related to the research question: How do jigsaw-based collaborative EFL tasks sustain students' germane cognitive load over time? The results are presented in three parts: students' germane cognitive load across repeated jigsaw tasks, classroom evidence of cognitive engagement, and students' explanations of sustained cognitive engagement.

Germane Cognitive Load across Jigsaw Tasks

The quantitative data were used to examine students' germane cognitive load during repeated jigsaw-based collaborative EFL tasks. The questionnaire was administered twice, during the mid-task phase after the second meeting and during the post-task phase after the fourth meeting. The analysis focused on whether students' germane cognitive load changed significantly across the repeated task implementation.

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Table 1. Descriptive Statistics of Students' Germane Cognitive Load

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Average GCL Score T1	20	4.33	6.33	5.3333	.55672
Average GCL Score T2	20	3.67	6.33	5.3750	.68798
Valid N (listwise)	20				

The descriptive results showed that students' germane cognitive load remained relatively high across the two measurement phases. The mean score increased slightly from the mid-task phase (M = 5.33, SD = 0.56) to the post-task phase (M = 5.38, SD = 0.69). The relatively small difference between the two means and the low standard deviations indicate a generally consistent response pattern across participants.

To determine whether the difference between the mid-task and post-task scores was statistically significant, a paired-samples t-test was conducted. The result is presented in Table 2.

Table 2. Paired-Samples t-Test of Students' Germane Cognitive Load

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Average GCL Score T1 - Average GCL Score T2	-.04167	.62799	.14042	-.33557	.25224	-.297	19	.770

The paired-samples t-test indicated no statistically significant difference, t(19) = −0.297, p = .770, with a negligible effect size. This finding suggests that students' reported germane cognitive load remained statistically stable across the repeated implementation of the jigsaw-based collaborative EFL tasks.

An item-level analysis was also conducted to identify which aspects of germane cognitive load were most evident during the task implementation. The strongest indicator was students' effort to make sense of the learning material. Among the questionnaire items, "I actively tried to make sense of what we were learning" consistently received the highest mean score in both phases (M = 5.70), indicating sustained cognitive effort toward understanding the learning material. The item "I tried to explain the material to others in my own words" increased from M = 5.05 to M = 5.40, suggesting greater engagement in peer explanation as students became more familiar with the jigsaw task structure. In contrast, the

remaining items showed only minor fluctuations, indicating relatively stable patterns of germane cognitive load across repeated task implementation.

Overall, the quantitative findings showed that students' germane cognitive load remained relatively stable across the repeated jigsaw-based collaborative EFL tasks. The descriptive statistics demonstrated only a slight increase in the mean scores between the two measurement phases, while the paired-samples t-test indicated no statistically significant difference. The item-level analysis further showed consistently high ratings for meaning-making and a modest increase in peer explanation.

Cognitive Engagement during Jigsaw Task Implementation

Classroom observations were conducted across four jigsaw-based collaborative EFL sessions to examine how students' germane cognitive load was manifested during task implementation. The observations focused on indicators of germane cognitive load, including elaboration, organization of ideas, knowledge integration, peer explanation, clarification questions, and connections between new and prior knowledge. The findings revealed three major patterns of cognitive engagement.

From Procedural Adjustment to Cognitive Engagement

At the beginning of the implementation, students devoted much of their attention to understanding the jigsaw procedure, including group formation, movement between expert and home groups, and task instructions. During this stage, observable indicators of germane cognitive load, such as elaboration, peer explanation, and conceptual integration, were still limited because students primarily focused on completing their assigned responsibilities. As students became increasingly familiar with the jigsaw structure across subsequent sessions, their cognitive effort gradually shifted toward processing the learning content. By the later meetings, students demonstrated greater elaboration, organization of ideas, and integration of information, suggesting that their attention had moved beyond understanding the task procedure to constructing meaningful understanding of the lesson content.

Increasing Peer Explanation and Collaborative Knowledge Construction

The observations also indicated that peer explanation became increasingly prominent throughout the repeated implementation of the jigsaw tasks. Students progressively asked clarification questions, explained concepts to group members, reorganized information obtained during expert-group discussions, and responded to peers' questions when returning to their home groups. These collaborative interactions became more frequent and more independent during the later sessions, reflecting greater engagement in elaboration and collaborative knowledge construction as students gained experience with the learning format.

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Teacher Facilitation Supporting Sustained Cognitive Engagement

Teacher facilitation consistently supported students' cognitive engagement throughout the implementation. The teacher provided structured instructions, examples, classroom monitoring, scaffolding, reflective questioning, and feedback that encouraged students to explain their reasoning and clarify their understanding. These instructional supports helped students manage the demands of the collaborative tasks while maintaining their attention on meaningful learning activities rather than procedural difficulties.

Students' Explanations of Sustained Cognitive Engagement

Interview data provided further insight into how students experienced germane cognitive load during repeated jigsaw-based collaborative EFL tasks. Although students demonstrated different levels of germane cognitive load, their experiences revealed three common patterns related to sustained cognitive engagement: (1) peer explanation as a strategy for understanding, (2) different ways of managing cognitive challenges, and (3) knowledge integration across learning activities.

Peer Explanation as a Strategy for Understanding

Students consistently described peer explanation as an important part of their learning process, although the depth of engagement differed across participants. Students with high levels of germane cognitive load explained that teaching their peers strengthened their own understanding. One student commented, *"When I explained things to my friends, I felt that I understood the material better."* Another participant described understanding not only the words but also the emotions expressed by speakers, indicating deeper interpretation during collaborative discussion.

Students with medium levels of germane cognitive load also participated in peer discussion but frequently relied on support from classmates and the teacher when encountering difficulties. In contrast, students with lower levels of germane cognitive load tended to contribute by listening before responding, suggesting that peer interaction served as an opportunity to build confidence before participating more actively.

Managing Cognitive Challenges through Collaboration

The interviews also revealed differences in how students managed cognitive demands during the jigsaw tasks. High-GCL students actively reorganized and clarified information while explaining ideas to others. Medium-GCL students managed cognitive challenges by rereading task instructions, consulting peers, and seeking clarification from the teacher when necessary. Meanwhile, students with lower germane cognitive load primarily managed task demands through careful listening and observation before attempting to contribute to the discussion. These

responses indicate that collaborative interaction provided different forms of cognitive support depending on students' readiness and confidence.

Knowledge Integration across Learning Activities

Another recurring pattern concerned students' ability to connect new learning with previous classroom experiences. Students with high germane cognitive load demonstrated stronger knowledge integration by linking current listening activities with earlier lessons and reusing previously learned language expressions in new contexts. Students with medium germane cognitive load made simpler connections by drawing on familiar examples, whereas students with lower germane cognitive load tended to focus primarily on the immediate learning task and experienced greater difficulty recalling previous materials. These differences suggest variation in the extent to which students organized and transferred knowledge across repeated collaborative learning activities.

Overall, the interview findings indicate that repeated jigsaw-based collaborative EFL tasks supported sustained germane cognitive load through peer explanation, collaborative problem-solving, knowledge integration, and teacher support. While all students demonstrated meaningful cognitive engagement, the depth of their engagement varied according to their level of germane cognitive load. Students with higher germane cognitive load showed greater elaboration and knowledge integration, whereas those with medium and lower levels relied more heavily on peer interaction and teacher scaffolding to sustain their engagement.

Integrated Summary of Results

Table 3. presents a joint display that integrates the questionnaire, observation, and interview findings to illustrate how the qualitative evidence complements the quantitative results in explaining the sustainability of students' germane cognitive load during repeated jigsaw-based collaborative EFL tasks.

Table 3. Joint Display of Quantitative and Qualitative Findings

Research Aspect	Quantitative Findings	Observation Findings	Interview Findings
Germane Cognitive Load	Mean GCL remained stable from T1 (M = 5.33) to T2 (M = 5.38); no significant difference (p = .770).	Students gradually shifted from procedural participation to elaboration and knowledge integration during repeated jigsaw tasks.	Students reported sustained cognitive engagement through peer explanation, clarification, and collaborative learning strategies.
Peer Explanation	Mean score for explaining material to peers	Peer explanation became increasingly frequent and	High-GCL students described explaining to peers as strengthening

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	increased from 5.05 to 5.40.	independent during later sessions.	their understanding, while medium- and low-GCL students relied on peer interaction to support comprehension.
Teacher Support	—	Teacher scaffolding, monitoring, questioning, and feedback supported students' cognitive engagement throughout the implementation.	Medium- and low-GCL students frequently described teacher guidance as helping them overcome cognitive difficulties.

Overall, the quantitative and qualitative findings consistently indicate that repeated jigsaw-based collaborative EFL tasks sustained students' germane cognitive load throughout the classroom implementation. The questionnaire results showed that students' germane cognitive load remained at a moderate-to-high level across the mid-task and post-task phases, with no statistically significant difference between the two measurements.

The qualitative findings provided complementary evidence that helps explain this quantitative pattern. Classroom observations showed that students gradually shifted their attention from understanding the jigsaw procedure to engaging more actively in elaboration, peer explanation, and knowledge integration as they became familiar with the collaborative learning structure. Teacher facilitation further supported this process through structured guidance, scaffolding, and reflective questioning that encouraged meaningful cognitive engagement.

Similarly, the interview findings revealed that students sustained their cognitive engagement through different collaborative learning strategies. Students with higher levels of germane cognitive load demonstrated deeper elaboration and knowledge integration through peer explanation, whereas students with medium and lower levels of germane cognitive load relied more on peer interaction, teacher guidance, and listening strategies to support their understanding. Despite these differences, all three groups demonstrated meaningful engagement with the collaborative learning process.

Taken together, the convergence of the questionnaire, observation, and interview findings indicates that repeated jigsaw-based collaborative EFL tasks supported the maintenance of productive cognitive engagement over time. Rather than demonstrating a substantial increase in germane cognitive load, the findings consistently suggest that students maintained meaningful cognitive effort throughout repeated collaborative learning experiences.

4. Discussion

This study investigated how repeated jigsaw-based collaborative EFL tasks sustained students' germane cognitive load over time. The findings showed that students' germane cognitive load remained relatively stable from the mid-task phase to the post-task phase. Quantitatively, the mean score slightly increased from M = 5.33 to M = 5.38, but the paired-samples t-test showed that this difference was not statistically significant, $t(19) = -0.297$, $p = .770$. Therefore, the alternative hypothesis was not supported, and the null hypothesis was retained. However, this result should not be interpreted as a failure of the jigsaw-based collaborative task. Instead, it indicates that students' germane cognitive load was sustained at a moderate-to-high level across the repeated task implementation. In other words, the task did not produce a sharp increase in germane cognitive load, but it maintained students' productive cognitive engagement throughout the learning process.

This finding is important because meaningful learning is not necessarily reflected in continuous increases in germane cognitive load. According to Cognitive Load Theory, germane cognitive load represents the productive mental effort that learners invest in organizing, elaborating, and integrating knowledge into coherent schemas (Sweller, 1988; Leppink et al., 2013). Therefore, the relatively stable level of germane cognitive load observed in this study suggests that students consistently allocated cognitive resources to meaningful learning processes throughout the repeated jigsaw-based collaborative tasks. Rather than indicating stagnation, the stable questionnaire scores imply that students maintained productive cognitive engagement as they became increasingly familiar with the collaborative learning environment. This interpretation is further supported by the consistently high ratings for meaning-making and the increased engagement in peer explanation, suggesting that students continued to refine and reorganize their understanding during repeated task implementation.

The classroom observations provide further insight into the mechanisms underlying this sustained pattern of germane cognitive load. Rather than demonstrating a continuous increase in cognitive effort, students appeared to redirect their attention as they became more familiar with the jigsaw structure. Early in the implementation, cognitive resources were devoted to understanding task procedures and collaborative roles. As these procedural demands diminished, students increasingly engaged in elaboration, peer explanation, clarification, and knowledge integration. This progression suggests that repeated participation in structured collaborative learning enabled students to devote their cognitive resources more consistently to meaningful learning activities. Consequently, the stability observed in the quantitative findings reflects not a lack of cognitive development but a sustained pattern of productive cognitive engagement supported by increasing familiarity with the collaborative task structure.

This pattern suggests that task familiarity played an important role in sustaining students' germane cognitive load throughout the repeated jigsaw-based

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collaborative EFL tasks. During the initial implementation, students needed to understand the procedures of the jigsaw structure, including the organization of expert and home groups, role allocation, and collaborative task expectations. Although intrinsic and extraneous cognitive load were not directly measured in this study, the observation findings suggest that repeated exposure to the task structure may have reduced unnecessary procedural demands, allowing students to allocate greater cognitive resources to meaningful learning activities. As the jigsaw procedure became more familiar, students appeared to spend less mental effort managing task organization and more effort explaining ideas, integrating information, and constructing understanding collaboratively. From the perspective of Cognitive Load Theory, this shift suggests that reductions in procedural demands may have enabled students to sustain productive germane cognitive load without requiring a statistically significant increase in overall cognitive effort. Rather than generating continuously higher levels of germane cognitive load, repeated jigsaw implementation appeared to create a stable cognitive environment in which students consistently invested mental effort in schema construction and meaning-making. These findings highlight that effective collaborative learning depends not only on task design but also on learners' familiarity with the collaborative structure, which allows cognitive resources to be directed toward learning rather than task management.

The findings also support Collaborative Cognitive Load Theory, which proposes that collaboration can distribute cognitive demands among group members and facilitate collective knowledge construction when learning tasks are appropriately structured (Janssen & Kirschner, 2020). In this study, the jigsaw design required students to become responsible for different parts of the learning material, explain information to peers, and integrate ideas when returning to their home groups. These collaborative processes encouraged students to engage in elaboration, explanation, and knowledge organization rather than merely completing assigned tasks. This finding is consistent with previous studies reporting that collaborative learning promotes deeper cognitive processing through peer explanation, reasoning, and shared problem-solving (Lange et al., 2020; Zhong & Wang, 2021). However, unlike studies that have reported significant increases in students' cognitive load or learning performance following collaborative instructional interventions, the present study found that germane cognitive load remained relatively stable across repeated jigsaw sessions. One possible explanation is that the repeated implementation of the same collaborative structure gradually reduced procedural demands, allowing students to maintain productive cognitive engagement instead of exhibiting substantial increases in reported cognitive effort. In addition, differences in participant characteristics, educational context, task duration, and measurement timing may also account for these contrasting findings. Therefore, rather than viewing instructional effectiveness solely in terms of increasing cognitive load, the present findings

suggest that well-structured collaborative learning may be equally effective when it sustains students' productive cognitive engagement over time.

The interview findings provide further evidence that peer explanation was a central mechanism in sustaining germane cognitive load. High-GCL students reported that explaining ideas to friends helped them understand the material better. This suggests that explanation functioned as a process of cognitive clarification, not merely as a communication activity. When students explained content in their own words, they needed to reorganize information, check their own understanding, and make the content understandable to others. This process reflects germane cognitive load because students invested mental effort in schema construction and meaning-making.

However, the findings also show that students did not experience germane cognitive load in the same way. High-GCL students used collaboration for deeper elaboration, interpretation, and knowledge integration. Medium-GCL students were engaged but still relied on peers or teacher support to clarify deeper meanings. Low-GCL students mainly engaged through listening and observation before contributing verbally. These differences suggest that germane cognitive load is not a uniform experience across learners. Rather, it is shaped by students' readiness, confidence, prior knowledge, and ability to participate in collaborative interaction. This finding extends previous research by showing that collaboration may sustain germane cognitive load differently depending on learner profiles.

The role of teacher facilitation was also important in sustaining students' germane cognitive load. Observation data showed that teacher support developed through structured instructions, examples, monitoring, scaffolding, reflective questioning, and reasoning-oriented feedback. These forms of facilitation helped students manage task demands and gradually move from procedural adjustment to deeper cognitive engagement. This finding is consistent with sociocultural theory, which emphasizes that learning develops through guided participation and social mediation (Vygotsky, 1978). In the context of this study, teacher facilitation served as a scaffold that helped students maintain productive cognitive effort during collaborative learning.

The findings also align with the principles of Task-Based Language Teaching (TBLT), which emphasizes meaningful, goal-oriented communication as the foundation of language learning (Ellis, 2003). In the present study, the jigsaw task required students to communicate with a genuine classroom purpose by sharing information, explaining assigned content, negotiating meaning, and constructing a shared understanding within their groups. More importantly, the repeated implementation of the jigsaw structure appeared to support schema construction through successive cycles of collaborative learning. During expert-group discussions, students first organized and elaborated their understanding of specific content before re-explaining it in their home groups. This process required learners to reorganize knowledge, connect new information with prior understanding, and refine their explanations based on peer interaction and

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feedback. Across repeated classroom meetings, these cycles of explanation, reflection, and knowledge integration became increasingly familiar, allowing students to invest cognitive effort in deeper conceptual processing rather than procedural task management. Consequently, the jigsaw structure functioned not only as a communicative activity but also as a scaffold for sustained schema construction, supporting productive germane cognitive load through repeated opportunities for elaboration, organization, and collaborative meaning-making.

The principal theoretical contribution of this study lies in its interpretation of germane cognitive load sustainability within repeated jigsaw-based collaborative EFL tasks. Previous research on instructional effectiveness has frequently emphasized whether an instructional approach produces significant increases in cognitive load, learning outcomes, or academic performance. In contrast, the present findings suggest that meaningful learning may also be reflected in the sustained allocation of productive cognitive resources over time rather than continuous statistical growth. Since students' germane cognitive load remained at a moderate-to-high level from the mid-task to the post-task phase, the absence of a significant increase does not indicate reduced cognitive engagement. Instead, it suggests that students consistently invested mental effort in elaborating, organizing, and integrating knowledge throughout the repeated collaborative learning process. This interpretation is supported by the qualitative findings, which demonstrated continued peer explanation, knowledge integration, and teacher-supported elaboration across successive classroom meetings. From the perspective of Cognitive Load Theory, these findings suggest that sustainable germane cognitive load represents a stable pattern of productive cognitive engagement in which learners continuously devote cognitive resources to schema construction as collaborative learning becomes increasingly familiar and meaningful. Consequently, this study extends existing understandings of germane cognitive load by proposing that instructional effectiveness should not be evaluated solely by increases in cognitive load or achievement scores, but also by the extent to which learning environments sustain productive cognitive engagement across repeated learning experiences.

The practical implications of this study extend beyond classroom instruction to the design of collaborative EFL curricula. At the classroom level, teachers should not evaluate collaborative learning solely through immediate improvements in achievement or performance. Instead, they should also consider whether students consistently engage in productive cognitive processes, such as elaboration, peer explanation, knowledge integration, and reflective thinking. To sustain germane cognitive load, teachers need to provide clear role allocation, structured task sequences, guiding questions, scaffolding, and regular opportunities for students to explain and discuss ideas with their peers. Particular attention should also be given to students who participate less actively, as careful listening and observation may represent early stages of meaningful cognitive engagement that can gradually

develop into more active participation with appropriate instructional support. At the curriculum level, the findings suggest that jigsaw-based collaborative tasks should be implemented as recurring instructional experiences rather than isolated classroom activities. Repeated exposure to structured collaborative learning allows students to become familiar with task procedures, reducing unnecessary procedural demands while enabling greater cognitive resources to be directed toward schema construction and meaningful language learning. Consequently, EFL curriculum designers and educators should consider incorporating sequenced collaborative tasks across instructional units to promote sustained cognitive engagement and long-term language development rather than emphasizing short-term performance gains alone.

This study has several limitations. First, the study involved a small number of participants from one senior high school, so the findings cannot be generalized to all EFL contexts. Second, the implementation was limited to four classroom meetings, which may not fully capture long-term changes in students' germane cognitive load. Third, the study focused only on germane cognitive load and did not measure intrinsic and extraneous cognitive load in detail. Future studies could involve larger samples, longer implementation periods, and more complete cognitive load measurement. Future researchers may also compare jigsaw tasks with other collaborative task types to examine whether different task structures sustain germane cognitive load in different ways.

Overall, the findings indicate that repeated jigsaw-based collaborative EFL tasks sustained students' germane cognitive load by supporting peer explanation, task familiarity, information organization, and teacher-guided interaction. Although the quantitative results did not show a statistically significant increase, the integration of questionnaire, observation, and interview data shows that students maintained meaningful cognitive engagement throughout the learning process. This provides a new understanding that the value of jigsaw-based collaborative EFL tasks lies not only in increasing cognitive load, but in sustaining productive cognitive effort over time.

5. Conclusion

This study examined how repeated jigsaw-based collaborative EFL tasks sustained students' germane cognitive load over time. Based on the findings, students' germane cognitive load remained at a moderate-to-high level from the mid-task phase to the post-task phase. Although the quantitative result showed only a slight increase in mean score and no statistically significant difference, this finding does not indicate the absence of cognitive engagement. Rather, it suggests that students' germane cognitive load was sustained throughout the repeated implementation of the jigsaw-based collaborative tasks.

Qualitative evidence consistently demonstrated that repeated participation in jigsaw tasks supported students' transition from procedural participation to sustained cognitive engagement through collaborative explanation and knowledge

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integration.

Therefore, the study concludes that jigsaw-based collaborative EFL tasks can support the sustainability of germane cognitive load when the task is structured, repeated, and supported by teacher facilitation. The principal theoretical contribution of this study is the proposition that instructional effectiveness in collaborative EFL learning should be evaluated not only through increases in cognitive load or learning outcomes, but also through the sustainability of productive cognitive engagement over repeated learning experiences. This study conceptualizes germane cognitive load sustainability as the continuous allocation of cognitive resources to schema construction through elaboration, organization, peer explanation, and knowledge integration during repeated collaborative learning.

However, this conclusion should be interpreted carefully. The study was conducted in one senior high school with a limited number of participants and only four classroom meetings. Therefore, the findings cannot be generalized broadly to all EFL classrooms. In addition, the study focused specifically on germane cognitive load and did not measure intrinsic and extraneous cognitive load in detail. Accordingly, the educational value of repeated jigsaw-based collaborative EFL tasks lies not merely in improving short-term achievement, but in creating learning environments that sustain students' productive cognitive engagement and support long-term schema construction.

Beyond individual classroom practice, EFL teachers are encouraged to integrate jigsaw-based collaborative tasks across multiple instructional units rather than using them as isolated activities. Repeated implementation allows students to internalize collaborative procedures, reduce unnecessary procedural demands, and consistently allocate cognitive resources to meaningful language learning. Designing collaborative learning as a recurring instructional strategy may therefore better support sustained cognitive engagement than occasional group activities.

Suggestions

Based on the findings, EFL teachers are encouraged to design collaborative tasks that provide clear roles, structured stages, and opportunities for peer explanation. In jigsaw-based tasks, students need sufficient time to understand their assigned materials, discuss them in expert groups, and explain them clearly in home groups. Teacher facilitation is also important, especially through clear instructions, examples, guiding questions, monitoring, and feedback that encourages reasoning. These supports can help students move from procedural participation toward deeper elaboration and knowledge integration.

Teachers should also pay attention to students who participate less verbally during collaborative tasks. Silent or receptive participation does not always indicate disengagement. Some students may still be processing information

through listening and observation before they are ready to explain ideas. Therefore, teachers should provide gradual scaffolding to help these students participate more actively, such as giving sentence starters, guiding questions, peer support, or smaller explanation roles.

Future research should replicate this study with larger and more diverse participant groups across multiple schools and educational contexts to examine the generalizability of germane cognitive load sustainability. Longitudinal studies involving more classroom meetings may also provide deeper insights into how productive cognitive engagement develops over extended periods of collaborative learning. In addition, future studies are encouraged to measure intrinsic, extraneous, and germane cognitive load simultaneously to better understand how these three dimensions interact during repeated collaborative EFL tasks. Future researchers may also compare jigsaw-based collaborative tasks with other collaborative task types, such as role play, problem-solving tasks, or project-based tasks. In addition, future studies should consider measuring intrinsic, extraneous, and germane cognitive load together to provide a more complete understanding of how collaborative EFL tasks influence students' cognitive processes.

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