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Students' Interaction With Mathematical Content in an Informatics Logic Course: A Gadamerian Hermeneutic Phenomenology Study

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Abstract

Informatics logic is foundational for computational thinking, yet students often experience its symbols and formal structures as abstract and disconnected from everyday reasoning. This issue is urgent in higher education, particularly in Informatics Engineering programs, where limited understanding of logic can hinder the development of essential problem-solving skills in the digital era. Therefore, this study aimed to explore the essence of students' interaction with mathematical content in an Informatics Logic course through Gadamerian hermeneutic phenomenology. The study was conducted at Universitas Cokroaminoto Palopo, Indonesia, involving five Informatics Engineering students selected purposively to represent diverse academic backgrounds. Data were collected through in-depth interviews, written reflections, participatory observation, and learning documents. Analysis followed a cyclic process of repeated reading, initial noting, emergent theme development, within-case interpretation, and cross-case synthesis in line with the hermeneutic circle. Four themes emerged. First, students perceived logical symbols as a "foreign language," leading to confusion and alienation. Second, they constructed interpretive bridges using analogies and everyday language. Third, they experienced meaning conflicts when intuition contradicted formal logical rules, especially in implication and equivalence. Fourth, some reached "aha" moments, reflecting a fusion of horizons and deeper understanding. The findings indicate that learning informatics logic is a dialogic and interpretive process shaped by prior understanding, language, and reflection rather than a linear transfer of rules. This study implies that instruction should integrate dialogic, contextual, and reflective approaches. It also highlights the need for curriculum designs that connect formal logic with students' everyday reasoning to enhance conceptual understanding and reduce cognitive barriers.

Keywords: *Informatics Logic, Gadamerian Hermeneutics, Hermeneutic Phenomenology, Student Experience, Conceptual Understanding.*

Introduction

Informatics logic is one of the main foundations of informatics education because it helps students develop systematic, analytical, and consistent ways of thinking. Through logic, students learn to construct arguments, evaluate premises, infer conclusions, and recognize formal relations that later support algorithmic thinking, programming, data structures, artificial intelligence, and computer-based decision making (Okeke et al., 2023; Yusuf & Noor, 2024; Omeh et al., 2025). However, the instruction of logic is frequently experienced as difficult, abstract, and emotionally demanding because students must work with unfamiliar symbolic structures such as conjunction, disjunction, implication, equivalence, and quantifiers (Ponomareva, 2021; Dewi & Surur, 2021).

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Informatics logic is also foundational for computational thinking, yet students often experience its symbols and formal structures as abstract and disconnected from everyday reasoning (Cihan, 2024). This issue is increasingly urgent in higher education, particularly in Informatics Engineering programs, where limited understanding of logic can hinder the development of essential problem-solving skills in the digital era. These conditions indicate that difficulties in learning logic are not merely technical but also relate to how students construct meaning when interacting with formal representations (Al-khowarizmi et al., 2023). The challenge does not lie only in the content itself, but also in the representational moves required to make sense of it (Dagiene et al., 2021). Students need to connect concrete experience, ordinary language, diagrams, and formal notation in order to understand logical relations meaningfully (Pereira & Seabra, 2023; Rajiman & Samsinar, 2022).

Research on reasoning and representation shows that learning is strengthened when students can move gradually from concrete and visual forms toward symbolic forms rather than being placed directly in abstraction (Milton et al., 2023; Prosser & Bismarck, 2023; Bronkhorst et al., 2021). In mathematics education, comprehension is also shaped by concept images, abstraction processes, and semiotic transformations, all of which may create tension between what students intuitively think and what formal systems require (Presmeg, 2022; Arcavi & Nachlieli, 2021).

In Indonesian higher education, studies on logic learning have more often emphasized instructional products and outcomes, for example web-based learning media or the effectiveness of problem-based learning in improving logical reasoning (Muhammad et al., 2025; Akramunnisa et al., 2023). Such studies are valuable, but they do not fully explain how students actually build meaning while encountering formal logic. Learning is not simply a transfer of completed knowledge but an active construction process shaped by prior knowledge, language, social mediation, and the learner's search for coherence (Nurhayati et al., 2022).

Hermeneutic phenomenology offers a strong basis for examining this meaning-making process. Understanding is always historical and dialogic, meaning that individuals interpret new knowledge through pre-understandings shaped by language, experience, and tradition (Wedman & Bennet, 2025). In the context of learning, students enter the classroom with prior assumptions about mathematics, symbols, truth, and reasoning. Their understanding of logic emerges through a dialogue between these prior assumptions and the formal horizon of the subject matter. This perspective aligns with phenomenological attention to lived experience in the lifeworld and the transformative nature of interpretation (Dahiberge, 2021).

Based on this gap, the present study asked: What is the essence of students' experience of interacting with mathematical content in an Informatics Logic course when viewed through Gadamerian hermeneutic phenomenology? The study was conducted at Universitas Cokroaminoto Palopo, Indonesia, involving five Informatics Engineering students selected purposively to represent diverse academic backgrounds. Data were collected through in-depth interviews, written reflections, participatory observation, and learning documents, and analyzed through a cyclic process of interpretation following the hermeneutic circle.

The findings revealed four main themes: students initially perceived logical symbols as a “foreign language” that caused confusion, constructed interpretive bridges through everyday analogies, experienced conflicts between intuition and formal rules, and eventually reached moments of deeper understanding characterized by a fusion of horizons. These findings indicate that learning informatics logic is not a linear transfer of rules but a dialogic and interpretive process shaped by prior understanding, language, and reflection. Therefore, this study contributes by emphasizing the importance of designing instruction that is dialogic, contextual, and reflective, as well as developing curricula that connect formal logic with students' everyday reasoning to enhance conceptual understanding and reduce cognitive barriers.

Method

This study used a qualitative design with a hermeneutic phenomenology approach. The design was chosen because the study sought to understand lived experience and meaning formation rather than test relationships among variables or quantify achievement (Creswell & Poth, 2018; van Manen, 2016). The study was conducted in the Informatics Engineering program of Universitas Cokroaminoto Palopo during the odd semester of the 2025/2026 academic year.

Five students who were taking or had recently completed the Informatics Logic course were selected purposively as research participants. The selection process emphasized variation in academic achievement, ranging from high to lower-performing students, in order to capture a broad spectrum of learning experiences and perspectives. This approach allowed the study to explore diverse horizons of understanding, particularly in how students interpret and engage with abstract logical concepts. Such variation is important to reveal differences in reasoning processes, conceptual difficulties, and meaning-making strategies that may not emerge in a more homogeneous sample. To ensure ethical considerations, including confidentiality and anonymity, all participants were assigned pseudonyms labeled P1 through P5.

In this study, the researcher functioned as the primary instrument, consistent with qualitative research traditions that prioritize the researcher's interpretive role in understanding participants' lived experiences. Data collection was supported by several complementary instruments, including a semi-structured interview guide to elicit in-depth narratives, self-reflection sheets to capture participants' personal meaning-making processes, and field notes to document contextual observations during the research process. In addition, learning documents such as student assignments and lecture notes were analyzed to provide further insight into how students constructed and represented their understanding of informatics logic. The combination of these instruments enabled data triangulation, thereby enhancing the credibility and richness of the findings.

Data were collected through multiple qualitative techniques to ensure depth and richness of understanding, including repeated in-depth interviews, written reflective tasks, participatory observation during several class meetings, and document review. The use of repeated interviews allowed the researcher to trace the development of participants' understanding over time and to revisit emerging themes for clarification and elaboration. The interviews were designed to be semi-structured, beginning with questions about participants' prior knowledge of logic and gradually moving toward their concrete learning experiences. Particular attention was given to moments of confusion, the ways students interpreted abstract concepts, the strategies they used to make sense of formal representations, and how their understanding evolved throughout the learning process.

In addition to interviews, written reflective tasks were employed to capture participants' personal and introspective accounts immediately after engaging with specific topics in logic. These reflections provided insight into the students' internal meaning-making processes, including how they negotiated between intuitive thinking and formal reasoning. Participatory observation conducted during classroom sessions enabled the researcher to document real-time interactions, instructional practices, and student responses within the natural learning environment. Furthermore, learning documents such as assignments and lecture notes were analyzed to complement and validate the data obtained from interviews and reflections. The integration of these data sources facilitated triangulation, thereby strengthening the credibility and contextual interpretation of the findings.

Data analysis was cyclical and interpretive. The researcher repeatedly read the transcripts and reflective texts, made initial notes, developed emergent themes, examined the relationships among themes within each participant, and then synthesized patterns across participants. This process followed the logic of the hermeneutic circle and was aligned with interpretative phenomenological analysis as well as recent Gadamerian guidance for qualitative analysis (Alsaigh & Coyne, 2021). Trustworthiness was strengthened through source triangulation, member checking, peer debriefing, and the maintenance of an audit trail.

Results

Across interviews, reflections, observations, and learning documents, the participants' experiences did not appear as a single uniform pattern. Nevertheless, cross-case analysis identified four superordinate themes that describe the essence of how students interacted with mathematical content in the Informatics Logic course. Table 1 presents the participant profile, and Table 2 summarizes the superordinate themes.

Table 1. *Participant profile*

Participant	Gender	Academic category	Learning note
P1	Male	High	Reflective and active in discussion.
P2	Male	Medium	Initially procedural.
P3	Female	Medium	Depended on analogy.
P4	Female	Low	Strong symbolic confusion.
P5	Male	Low	Needed contextual and visual support.

Rather than representing statistical variation, the participant profile provides contextual information that helps interpret the learning experiences discussed in this study. The five participants represent different levels of academic achievement and learning characteristics, ranging from high-performing students to those who experienced substantial conceptual difficulty. This variation was intentionally retained to capture a broader spectrum of how students encounter formal logical notation. Differences in learning notes also indicate diverse cognitive responses to the course material. for example, some students focused on reflective discussion and conceptual reasoning, while others relied on procedural approaches or visual supports. These contrasts offer an important backdrop for understanding the patterns that later emerged in the thematic analysis.

Before presenting the superordinate themes, it is important to note that the themes were derived through iterative coding and cross-case comparison. The analysis focused on identifying recurring experiential patterns across participants while still preserving individual nuances in how students interpreted logical symbols and structures. The resulting themes represent shared dimensions of students' encounters with formal logic during the course.

Table 2. *Superordinate themes identified in the study*

No.	Superordinate theme	General meaning
1	Foreign-language encounter	Logical symbols felt unfamiliar and difficult to interpret.
2	Interpretive bridges	Everyday language and analogy mediated formal meaning.
3	Meaning negotiation	Everyday intuition conflicted with formal rules.
4	'Oh, I see' moments	Understanding deepened through fusion of horizons.

Table 2 summarizes the four superordinate themes that characterize the participants' experiences when engaging with logical notation in the Informatics Logic course. These themes capture a progression in how students interpret and internalize formal symbolic representations. Initially, many students encountered logical notation as a form of unfamiliar language. Over time, their experiences evolved through stages involving interpretive challenges, the search for meaning within symbolic expressions, and eventually moments of conceptual clarity. Together, these themes illustrate how understanding formal logic develops through both cognitive struggle and gradual conceptual integration.

Encountering Logic as a 'Foreign Language'

At the beginning of the course, participants described conjunction, disjunction, implication, equivalence, and quantifiers as if they were a new language. Their first response to the symbols was not meaning, but recognition of form. Several participants stated that they initially focused on how to read the notation rather than what a statement meant within a logical system. In this phase, the notation functioned more as a cognitive barrier than as a carrier of meaning. This feeling of symbolic estrangement was strongest among the lower- and medium-achieving participants, but it was not limited to them. Even the participant categorized as high achieving acknowledged an early phase of uncertainty before the notation became conceptually meaningful. As a consequence, some students temporarily relied on memorizing truth tables, symbol names, or rules of inference without yet having a secure conceptual grasp of why those rules worked.

Building Interpretive Bridges Through Everyday Language

To reduce confusion, students actively translated symbolic logic into everyday situations. Statements such as 'if it rains, the road becomes wet' or 'I attend class and bring a book' helped them approach conjunction, implication, and other operators from familiar experience. In this sense, ordinary language and analogy functioned as interpretive bridges between abstract notation and lived reality. This theme shows that students were not passive recipients of formal knowledge. They negotiated meaning by mobilizing language, examples, and personal experience. Participants with moderate and low academic backgrounds depended most on contextual examples, while the higher-achieving participant used analogy more strategically to test and verify formal understanding. Across cases, however, analogy was not merely a supporting device; it was part of the meaning-making process itself.

Negotiating Meaning Between Intuition and Formal Rules

The most intense struggle appeared when students faced concepts that conflicted with everyday intuition, especially material implication and equivalence. In ordinary language, an 'if-then' statement is usually treated as causal or temporal. In formal logic, however, implication follows a stricter rule system that may validate statements students find counterintuitive. Participants moved back and forth between their prior intuitions and the formal demands of the subject. This conflict was not simply evidence of failure. Rather, it became the center of conceptual movement. Students revisited examples, questioned earlier assumptions, and tried to reconcile competing interpretations. The struggle of meaning therefore functioned as a productive tension that pushed students beyond surface familiarity toward deeper conceptual reorganization.

Reaching 'Oh, I See' Moments

Some participants eventually described moments when a previously confusing concept became intelligible. At this stage, they no longer treated logical rules merely as procedures to be memorized. Instead, they began to explain why a statement was valid or invalid within the structure of formal logic. Their language shifted from naming symbols to articulating relations, reasons, and logical consequences. These 'oh, I see' moments signaled a qualitative change in understanding. The participants did not abandon prior experience, but reinterpreted it within a wider conceptual horizon. In practical terms, this meant that symbolic notation became less threatening because it had been connected to an emerging structure of meaning rather than retained as isolated formalism.

Discussion

Learning Informatics Logic as a Hermeneutic Event

The findings show that students' interaction with mathematical content in informatics logic can be understood as a hermeneutic event rather than a one-way transfer of concepts. Students entered the course with pre-understandings shaped by ordinary language, prior mathematics learning, and personal expectations. When these horizons encountered the formal horizon of logic, initial confusion and a sense of alienation emerged because the two did not immediately align. This condition confirms that understanding is not a neutral process but is always historically and linguistically situated (Roberge, 2021). The students' early difficulty in interpreting symbols such as implication and equivalence reflects the gap between everyday reasoning and formal logical systems, which has also been identified in studies on students' misconceptions in logic and mathematics learning (Durand-Guerrier & Arsac, 2020).

From a hermeneutic perspective, this initial alienation should not be viewed as a failure but as a necessary stage in the process of understanding. The students engaged in a hermeneutic circle in which they moved back and forth between parts (symbols, rules, examples) and the whole (overall logical structure), gradually reconstructing meaning. This iterative interpretive movement aligns with the idea that learning involves continuous reinterpretation rather than linear accumulation of knowledge (Illweis, 2021). The emergence of "oh, I see" moments in this study represents a fusion of horizons, where students successfully reconciled their prior understanding with formal logic. Similar transformative learning experiences have been reported in studies emphasizing reflective and interpretive learning processes in higher education (Ryan, 2021). Thus, learning informatics logic can be conceptualized as an interpretive transformation in which students not only understand new content but also reshape their ways of thinking.

Representational Mediation and Relational Understanding

The second and third findings highlight that students relied heavily on analogies and everyday language to construct meaning. This indicates that conceptual understanding develops through processes of assimilation and accommodation, where learners integrate new knowledge into existing cognitive structures while modifying those structures when inconsistencies arise (Chi, 2021). The use of familiar contexts and verbal explanations demonstrates that language plays a central mediating role in learning, enabling students to externalize and negotiate meaning through interaction (Sfard, 2020).

Furthermore, the progression from concrete examples toward formal symbolic reasoning observed in this study is consistent with Bruner's stages of representation, which emphasize the importance of moving from enactive and iconic representations to symbolic forms in order to achieve deeper understanding (Milton et al., 2023). Empirical research also shows that students' ability to transition between different representations significantly enhances conceptual understanding and transfer of learning (Bronkhorst et al., 2021). In this study, students who were able to connect everyday reasoning with symbolic expressions demonstrated stronger conceptual clarity compared to those who relied solely on memorization of rules.

The difficulties encountered in understanding implication and equivalence further confirm that students' concept images often differ from formal definitions, leading to cognitive conflict during learning (Biza et al., 2021). This tension reflects the broader challenge of abstraction, where learners must shift from viewing concepts as processes to understanding them as objects within a formal system (Gray & Tall, 2021). In addition, the need to translate between ordinary language and symbolic notation illustrates the semiotic complexity of mathematical learning, where meaning depends on the ability to coordinate multiple representational registers. Students' success in explaining logical relationships indicates the development of relational understanding, in which they grasp the underlying structure of concepts rather than merely applying procedures (Hausberger, 2020).

Meaning Conflict as a Productive Learning Process

An important contribution of this study is the identification of meaning conflict as a productive rather than negative element in learning. Students frequently experienced tension when their intuitive reasoning contradicted formal logical rules (Sentence & Waite, 2021). Instead of hindering learning, this conflict encouraged deeper reflection and prompted students to question their assumptions. This finding aligns with constructivist perspectives that view cognitive conflict as a catalyst for conceptual change. When students are confronted with discrepancies between prior knowledge and new information, they are more likely to reorganize their understanding to achieve coherence (Anisa et al., 2025).

In the context of informatics logic, such conflicts are particularly significant because logical reasoning often requires abandoning intuitive but incorrect interpretations. Studies in mathematics education have shown that confronting and resolving misconceptions is essential for achieving conceptual understanding (Kapur, 2022). Therefore, instructional approaches should not avoid confusion but should instead facilitate structured opportunities for students to articulate, examine, and resolve their misunderstandings through guided discussion and reflection.

Pedagogical Implications for Informatics Logic Instruction

These findings suggest that instruction in informatics logic should move beyond a purely formal and procedural approach. Lecturers should design learning environments that acknowledge students' pre-understanding and actively bridge everyday reasoning with formal representations. This approach is supported by research emphasizing the role of representation and dialogue in developing higher-order thinking skills (Bronkhorst et al., 2021).

Practically, teaching strategies may include the use of analogies, contextual problems, collaborative discussion, and reflective writing activities. Such strategies allow students to articulate their thinking, confront conceptual conflicts, and gradually refine their understanding. In addition, instructors should provide opportunities for students to move flexibly between different representations, including verbal explanations, diagrams, and symbolic notation, in order to strengthen conceptual connections

The findings also extend previous studies in the Indonesian context that primarily focused on instructional media or problem-based learning outcomes. While those studies demonstrate improvements in performance, the present study highlights the importance of supporting students' meaning-making processes during learning (Wahyuni et al., 2025). This suggests that effective instructional design should not only aim for measurable achievement gains but also facilitate deep conceptual understanding through interpretive engagement.

Overall, this study contributes to the understanding of informatics logic learning by framing it as a dialogic, interpretive, and transformative process. It emphasizes that meaningful learning occurs when students actively engage with content, negotiate meaning through language and representation, and reflect on their own understanding. Therefore, curriculum and instructional design in informatics education should prioritize not only what students learn but also how they experience and interpret that learning process.

Conclusion

This study was grounded in the recognition that informatics logic, as a foundation of computational thinking, is often experienced by students as abstract and disconnected from everyday reasoning, creating significant challenges in higher education contexts. Therefore, the purpose of this research was to explore the essence of students' interaction with mathematical content in an Informatics Logic course through a Gadamerian hermeneutic phenomenological perspective. This study concludes that students' interaction with mathematical content in an Informatics Logic course is a dynamic hermeneutic process. The experience moved from initial alienation, to interpretive bridging through ordinary language and analogy, to conflict between intuition and formal rules, and finally toward possible fusion of horizons in moments of authentic understanding. The findings show that difficulty in logic is not merely cognitive; it is also interpretive and linguistic. The study contributes to the literature by showing how students experience the meaning-making process behind formal logic rather than focusing only on measurable learning outcomes. Its limitations should also be noted: the study involved only five participants from one program and one institutional context, so the results should be understood as context-bound rather than statistically generalizable.

Future studies can examine the hermeneutic development of understanding across semesters, compare different abstract courses, and investigate more specifically the role of classroom discourse, diagrams, and digital media. For teaching practice, lecturers are encouraged to design logic instruction that begins with students' language, supports gradual representational transitions, and values reflection as part of conceptual understanding.

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