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FAREF: A Pilot Study of a Structured Approach to Teaching Argument Formalization and Evaluation

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Abstract: This study introduces FAREF (Formalization and Argument Reasoning Evaluation Framework), a novel instructional framework designed to support learners in formalizing and evaluating restricted informal arguments. FAREF integrates a flowchart-guided analysis process with the Triangular Logic Model (TLM) to provide a visually supported, step-by-step method for transforming informal arguments into formal logical structures. A pilot study was conducted with graduate students to evaluate the feasibility and effectiveness of the proposed approach using the Analyzing Arguments category from the Watson-Glaser Critical Thinking Appraisal (WGCTA). Results indicated improvements in learners' ability to evaluate arguments and a reduction in completion times. These findings suggest that FAREF holds promise as a structured instructional approach for enhancing argumentation skills in critical thinking education.

Keywords: FAREF, critical thinking, analyzing arguments, formal and informal arguments, reasoning.

1. Introduction

Critical thinking is a foundational cognitive skill important for academic success and professional competence. It encompasses the evaluation of information, the construction of logical arguments, and the making of reasoned judgments (Arthi & Gandhimathi, 2024). At the heart of this skill lies argument analysis, the ability to identify premises and conclusions and to understand the logical relationships that connect them. However, learners often struggle to analyze arguments effectively when required to shift from informal, everyday reasoning to the more structured processes of formal logical representation, a difficulty that undermines their capacity for higher-order thinking and rigorous evaluation (Bronkhorst et al., 2020; Teig & Scherer, 2016).

One widely used tool for assessing critical thinking is the Watson-Glaser Critical Thinking Appraisal (WGCTA), whose Analyzing Arguments section targets the evaluation of argument strength in constrained informal formats (Gadzella et al., 2005). Despite this emphasis, many instructional approaches do not adequately equip learners with strategies for formalizing arguments. Traditional logic instruction focuses on propositional logic and requires high levels of abstraction and prior symbolic knowledge (Polkowski, 2022), posing challenges for novices. Visual aids such as argument mapping help clarify relationships (Van et al., 2007), but often fall short in supporting formalization or evaluating logical validity. Similarly, while scaffolding tools like flowcharts and graphic organizers can reduce cognitive load in reasoning tasks (Stachel et al., 2013), they are rarely integrated into logic instruction.

To address these gaps, this study introduces FAREF (Formalization and Argument Reasoning Evaluation Framework), a pedagogical approach that combines a flowchart-guided process with the Triangular Logic Model (TLM). TLM organizes arguments through three core propositions: Ground, Reason, and Claim. When embedded in a step-by-step flowchart, this structure offers learners an accessible bridge between informal comprehension and formal representation. FAREF not only aids logical structuring but also

supports evaluation of argument strength based on validity. A pilot study was conducted to examine the framework's instructional potential in improving learners' abilities to formalize and assess arguments.

2. The FAREF Framework: Bridging Informal and Formal Argumentation

FAREF (Formalization and Argument Reasoning Evaluation Framework) is a structured instructional model that guides learners in transforming informal arguments into formal logical structures and evaluating their strength. This section introduces the key components of the framework and its pedagogical function.

- *Informal Arguments in the WGCTA Context:* The informal arguments come from the Analyzing Arguments section of WGCTA test. Each item provides a statement and a short argument; learners judge whether it is **strong** (providing relevant, sufficient support) or **weak** (failing to do so). These arguments are unstructured, lacking clear premises or conclusions.

- *Formal Arguments Based on Toulmin's Three-Clause Structure:* FAREF uses a structure inspired by Toulmin's model, framing each argument in three propositions: Basis (the issue), Reason (supporting justification), and Claim (the conclusion). With these components, learners apply deductive logic to assess an argument's coherence and support. This three-part structure underlies FAREF's process of transforming informal arguments into formal logical expressions.

- *The Triangular Logic Model (TLM):* The Triangular Logic Model (TLM) is a visual version of Toulmin's structure: a triangle with **Claim** at the top and **Basis** and **Reason** at the base. Learners recombine propositions as "movable cards" in this triangle to assess an argument's validity. TLM applies formal logic: if the connections between Basis, Reason, and Claim are coherent, the argument is valid. This visual formalization process makes abstract reasoning accessible and evaluable. (Hirashima, et al., 2021). Recent studies (Hirashima, et al., 2023; Rashid, et al., 2022;) suggest that TLM can improve learners' logical reasoning and encourage reflection. By manipulating an argument's structure, students examine reasoning. Thus, TLM functions as a visual and analytical tool that aligns closely with the goals of FAREF promoting awareness of reasoning.

- *Flowchart-Guided Argument Formalization and Evaluation:* FAREF enhances the TLM by embedding it in a guided flowchart that scaffolds learners as they analyze, formalize, and evaluate informal arguments. The process is as follows:

1. **Proposition Identification:** FAREF first guides learners to extract underlying Basis, Reason, and Claim propositions from the argument part of each WGCTA item, without considering the statement yet. This step is crucial, as learners often struggle to identify arguments when logical components are hidden in natural language.
2. **Symbolization and TLM Recomposition:** If all three propositions are identified, they are symbolized and recomposed into the TLM structure to test logical connections. If any proposition is missing or cannot be integrated, the argument is considered weak and the process ends.
3. **Validity and Relevance Evaluation:** If the TLM structure is valid, the Basis is then compared with the statement's topic. A strong argument requires both logical validity and topical alignment; failure in either results in a weak classification.

This structured approach enables FAREF to consistently transition arguments from informal to formal logic, helping learners assess argument strength based on both validity and topical relevance, and making formal analysis more accessible.

3. Pilot Study Results and Conclusion

A pilot study was conducted with eight graduate students who had prior exposure to logic or critical thinking but were unfamiliar with FAREF. Participants completed a pre-test using 25 items from the *Analyzing Arguments* section of the WGCTA, followed by a 70-minute training session after a three-week interval. The training introduced the FAREF framework and included guided examples and nine practice exercises. A post-test using the same WGCTA

items was administered immediately after. Results showed an increase in mean test scores (from 0.61 to 0.68) and a reduction in completion time (from 33.45 to 22.25 minutes), though neither change reached statistical significance ($p > .05$), likely due to the small sample size. However, the effect size (Cohen's $d = 0.72$) suggested a moderate-to-large practical impact. A post-hoc power analysis indicated that a sample size of 20 would be needed for sufficient power in future studies. These preliminary findings suggest FAREF may improve argument analysis performance and efficiency, warranting further investigation with a larger cohort.

In summary, while the results did not reach statistical significance, the observed effect size and decreased response time are encouraging and suggest that FAREF may support improvements in critical thinking performance. These findings provide a strong rationale for conducting a follow-up study with a larger sample to confirm and extend these results.

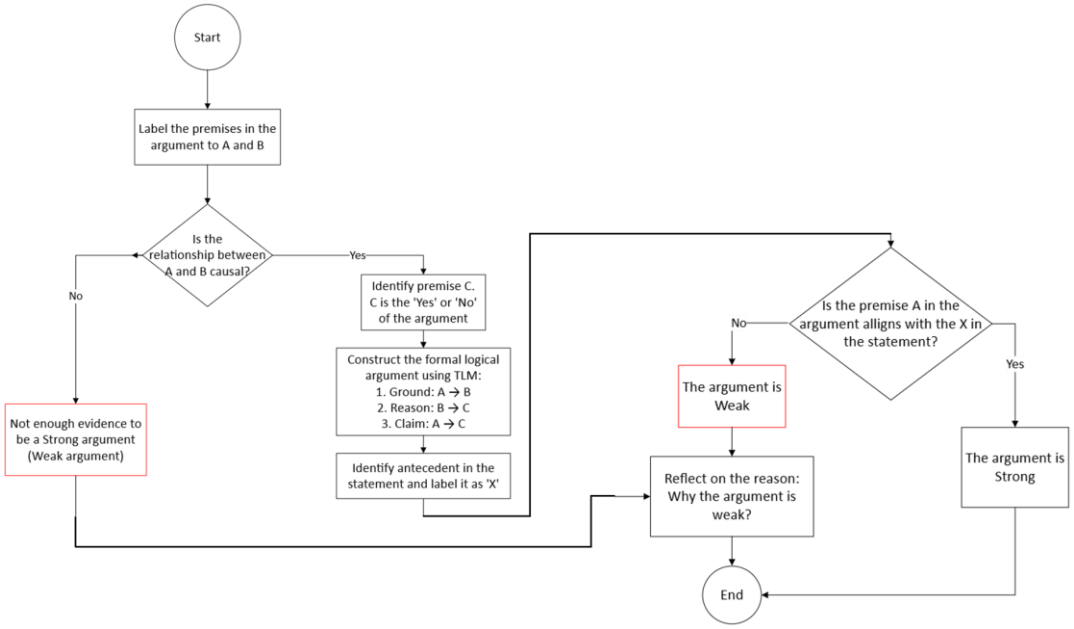

Figure 3. FAREF Flowchart.

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