How the Family Resemblance Approach Improves Students' Understanding of Science and Pseudoscience

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ABSTRACT

The widespread use of seemingly scientific claims commonly known as pseudoscience poses a challenge to students' ability to critically evaluate information. Science education, particularly through the Nature of Science (NOS), can equip students to understand the unique characteristics of science from pseudoscience. The previous NOS models have been proposed, including the Consensus View model, which views science as having several rigid characteristics. However, this model presents a narrow portrayal of science, leaving no room for the unique features that distinguish one scientific discipline from another. The Family Resemblance Approach (FRA), on the other hand, offers a holistic framework for teaching NOS by emphasizing shared characteristics across scientific disciplines while also acknowledging disciplinary diversity (Erduran and Dagher, 2014). Following the previous teaching principle by Park and Brock (2022) on how to introduce NOS and address pseudoscience using FRA, this study will design an intervention to develop secondary school students' broader understanding of science and pseudoscience. Therefore, the research question of this study is *How does an intervention based on the Family Resemblance Approach (FRA) improve secondary school students' understanding of the characteristics of science and pseudoscience through their reasoning?*

This design-based research investigated how an FRA-based intervention influences students' reasoning about science and pseudoscience in a two-iterative cycle. This study involved 15 secondary school students aged 12–14 (grade 8): 10 from SMP Labschool Kebayoran, Indonesia, and 5 from the Indonesian School of The Hague (SIDH), Netherlands. The decision to include students from two countries allowed evaluation of the FRA across diverse profiles and educational settings. The SIDH group was limited to five due to availability. Participants were expected to follow natural science courses, as the cases were science-related. Students meeting these criteria were recruited in collaboration with science teachers, with an invitation letter explaining the procedure, location, subject, parental consent, and voluntary participation.

This study was conducted as design-based research over two cycles. Cycle 1 took place in Indonesia with 10 secondary school students from SMP Labschool Kebayoran, divided into two groups: Group 1 (Cycle 1A) and Group 2 (Cycle 1B). Cycle 2 was conducted in the Netherlands with five students from the Indonesian School of The Hague (Group 3). Interventions were held at the respective schools, and students' written responses on worksheets were collected for analysis. Initially, each group was planned to have two meetings to avoid overburdening students or teachers. However, because not all tasks were completed in Cycle 1, Cycle 2 was extended to three meetings. Iterative adjustments were made in Cycle 2 based on the established design principles, with the core research steps, pre-test, intervention, and post-test remaining the same.

Due to the limited number of students in SIDH, data from both cycles were not compared. Instead, data from Cycles 1 and 2 were examined sequentially through two main stages of analysis. First, participants' worksheets were transcribed, translated into English, and converted into a readable format for NVivo. Second, pre-test and post-test responses, along with worksheet questions, were coded in NVivo to address the research question. Coding was conducted using a top-down scheme based on the five FRA categories from Erduran and Dagher (2014). This scheme was used to identify what students learned about the characteristics of science and pseudoscience, based on whether they applied FRA categories from the intervention, in their reasoning across both tests and worksheets. To ensure coding reliability, 25% of the data was independently coded by a second coder, and Cohen's kappa was calculated to assess agreement.

The findings from both Cycle 1 and Cycle 2 are presented in three sections. The first section evaluates students' reasoning before and after the intervention by analysing whether they referred to the FRA categories in their pre- and post-test responses. Based on the five FRA categories by Erduran & Dagher (2014), four students (26.7% of the total students) from Cycle 1 showed improvement in the post-test for either science or pseudoscience cases, while three from Cycle 1 and one from Cycle 2 (20.0% of the total students) improved in both. Only one Cycle 1 student (6.7% of the total students) improved across all cases, whereas two others from both cycles showed displacement, maintained, or even declined in their FRA categories.

The second section assesses students' understanding of the characteristics of science and pseudoscience by examining whether FRA categories emerge in the worksheets and examining how these relate to post-test results. The lack of improvement in students' pre-test reasoning does not imply that their understanding of science and pseudoscience cannot be enhanced through FRA. In Cycle 1, some students who did not demonstrate certain FRA categories in the pre-test were able to present them in the worksheet and maintain them in the post-test, suggesting gains in understanding. However, others showed FRA categories in the pre-test and worksheet but later shifted to different categories or did not show them at all in the post-test. In Cycle 2, some students consistently exhibited only one or two FRA categories across all stages, indicating limited additional knowledge from the intervention. Nevertheless, most students from both cycles were able to identify resemblances between pseudoscientific and scientific cases, consistent with the FRA design principle by Park and Brock (2023).

The third section examines how the intervention design supports students' understanding, based on reflections, feedback, and a Likert-scale survey. The findings align with the design principle 1 (DP 1), where students were situated to analyse and compare the characteristics of three different cases using FRA categories from Erduran and Dagher (2014), and find which cases are more resemble to each other. These findings are significant because the aim of teaching with the FRA is not to impose strict rules about what counts as science. Instead, the FRA serves as a framework for exploring the distinctive features of different scientific disciplines and forms of pseudoscience (Park & Brock, 2023).

Other design principles, such as creating an environment where students could engage in discussion, also received positive feedback. In the case of Design Principle 2 (DP 2), nearly all tasks in the Cycle 2 worksheet were completed within the allocated three class sessions, suggesting that the alignment with DP 2 effectively balanced students' cognitive load with the content and available time. Most students in Cycle 2 also demonstrated their understanding of the Family Resemblance Approach in both the worksheet and the reflection activity, indicating some success in introducing the core concept through scaffolded support and task-based learning. Regarding the principle of aligning instructional materials with students' backgrounds and beliefs, no students reported accepting pseudoscientific claims based on personal belief. However, one student continued to believe in the health benefits of crystal healing in the post-test, citing a relative's personal experience as justification.

Keywords: *Family Resemblance Approach (FRA), Nature of Science (NOS), demarcation problem*