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Examining the Role of a Structured Seminar Course in Developing Research Readiness of Pre-Service Physics Teachers

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Abstract
The training of preservice physics teachers to participate in educational research is a long-standing issue in physics teacher education. This investigation seeks to understand the effectiveness of a focused seminar course in facilitating research readiness across time and by performance-based assessment and analysis of a research portfolio. Twenty-six preservice physics education students attended a semester-long seminar course focusing on research problem identification, critical response to SINTA and Scopus indexed journals articles, proposal development, and academic communication. The growth in students' development was studied using a phase-based analysis between the weekly assessment based on a Research Task Plan (RTM) and qualitative analysis of research portfolios. The answers provide evidence of a continuous development of students' research competencies with less variation in performance over the course levels. Analysis of the portfolios also suggests a shift away from mostly descriptive engagement with research literature toward more critical and comparative disciplinary analysis. These results indicate that seminars, designed as scaffolded learning environments that are authentic can be pedagogically effective in bridging between coursework taken by undergraduates and research done independently especially in the context of physics teacher preparation.

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INTRODUCTION

The cultivation of research competency closely associated with physics teacher education is becoming an increasingly prominent requirement. Today's education reforms align themselves with the principles of evidence-based decision making and reflective professionalism, in which teachers are no longer consumers trapped by research but rather they actively think about knowledge produced by scholars and, when applicable, shape their schools to a more enhanced version through research use for educational improvement (Kurti, 2023). In this context, pre-service physics teachers must be systematically prepared to master basic research competence beyond mere procedural knowledge towards one of disciplinary thinking.

Despite this increased focus, the level of research preparation within undergraduate physics teacher education is mixed. Research skills tend to be portrayed as secondary processes, to be dealt with mainly via discrete methodology modules or postponed until the latter part of an undergraduate degree programme. As a result, most students encounter major challenges moving from the structured courses to self-regulated learning especially in the areas of defining research problem, integrating literature and methodological thinking. In the field of physics education research (PER), substantial research has been conducted on students' conceptual knowledge, problem solving skills and scientific reasoning. Nevertheless, there is relatively

little work devoted to studying how undergraduate teaching approaches can systematically promote the development of research readiness in pre-service physics teachers (Gussen et al., 2023). Current studies frequently involve pre–post comparisons or focus on end products, not providing information on emergence and stabilization of research competencies in development.

Seminar programs are often framed as preparation for undergraduate research involvement. However, despite their promise for integrating coursework and independent research, their effectiveness is largely determined by the structure of instruction, design of assessment and degree to which learning activities mirror real-world disciplinary practices (Beka & Kulinxha, 2021). Without thoughtful scaffolding and consistent assessment systems, seminar courses simply become an exercise in procedure rather than a place for learning about research itself.

Informed by theories from cognitive apprenticeship (Herrington and Oliver, 2000), learning progressions (Rychen and Salganik, 2003) and authentic assessment (Gulikers et al., 2004; Farah-Franco et al., 2020; Zaabalawi, 2024), the following study seeks to investigate a well-structured seminar course aimed at enhancing research readiness of pre-service physics teachers over time. Through weekly performance assessment and continual engagement with peer-reviewed physics education research literature, the study provides an operationalization of research readiness as a growth-based rather than static construct.

Although seminar-type courses and portfolio-based learning have been widely used in teacher education, little empirical research has been conducted on how incrementality develops across such courses. This gap is here addressed by operationalizing research readiness in terms of a learning progression observed longitudinally through phase-based assessment and research portfolio analysis. In response, the research redirects focus from the attaining of end-points to developmental trajectories in research competence. The specific research questions are as follows, to what extent do students' research skills grow during the various instructional phases of a scaffolded seminar course and how does continued interaction with research portfolios facilitate the growth of disciplinary thinking within PER.

METHOD

Research Context and Participants

This research was conducted in the context of undergraduate Physics Department of a public university in Indonesia. The program trains preservice teachers for classroom teaching at the secondary physics level, and also has a required seminar to introduce students to educational research techniques. Participants were 26 pre-service physics teachers who took the seminar course for one semester. All instruction activities were integrated into normal class work, and the students' data were de-identified before analysis.

Seminar Course Design

The seminar course was developed as a scaffolding research apprenticeship setting. Rather than focusing on abstract research ideals in isolation, the course featured genuine research-oriented work that was consistent with disciplinary standards as described by physics education research. The main activities involved problem finding, critically analysing peer-reviewed journal articles that indexed in SINTA and Scopus, proposing research, oral presentations with structured peer discussion. Emphasis was placed on the importance of iterative feedback and increasing levels of student responsibility, reflecting principles of cognitive apprenticeship (Farah-Franco et al., 2020).

Assessment Structure and Instructional Phases

Students were evaluated on a weekly basis for their research skills with the RTM (Research Task Plan) that matched course goals. In order to investigate learning sequences, the assessment information was aggregated into three instruction phases: First Phase (Weeks 1–5): focus on identifying the research problem and an initial engagement with literature. Mid Phase (Weeks 6–10): review of literature; theoretically framing the study and designing research plan. Late Phase (Weeks 11–16): proposal redefining, presentation and thoughts on the process. The patients had the following assessment scores, which ranged between 80 and 100:

Table 1. Core research competencies assessed through the Research Task Plan (RTM) across instructional phase**s**

Instructional Phase	Core Research Competencies Assessed
Early Phase	Research problem identification; basic comprehension of journal articles
Mid Phase	Literature synthesis; theoretical alignment; methodological reasoning
Late Phase	Proposal coherence; methodological justification; scholarly communication

Research Portfolios

Each student compiled an individual research portfolio consisting of structured analyses of peer-reviewed physics education research articles indexed in SINTA and Scopus. Portfolio tasks required examination of research problems, theoretical frameworks, methodological approaches, and disciplinary contributions (Darman et al., 2024).

Data Analysis

Quantitative RTM data were analyzed descriptively to examine trends in mean performance and variability. Qualitative portfolio data were analyzed thematically to identify developmental shifts in students' engagement with research literature..

RESULTS AND DISCUSSION

Phase-Based Assessment Trends

RTM assessment scores revealed a systematic progression across instructional phases. Mean scores increased from the Early Phase to the Mid Phase and further to the Late Phase, while score variability decreased, indicating increasing consistency in students' research-related competencies.

Table 2. Descriptive statistics of weekly RTM assessment scores across instructional phases

Instructional Phase	Weeks	Mean	SD	Minimum	Maximum
Early Phase	1–5	82.6	3.9	80	92
Mid Phase	6–10	87.8	3.1	82	96
Late Phase	11–16	91.5	2.3	85	100

This progressive pattern of performance development across instructional phases is visually illustrated in Figure 1, which highlights the longitudinal trend in students' research-related performance.

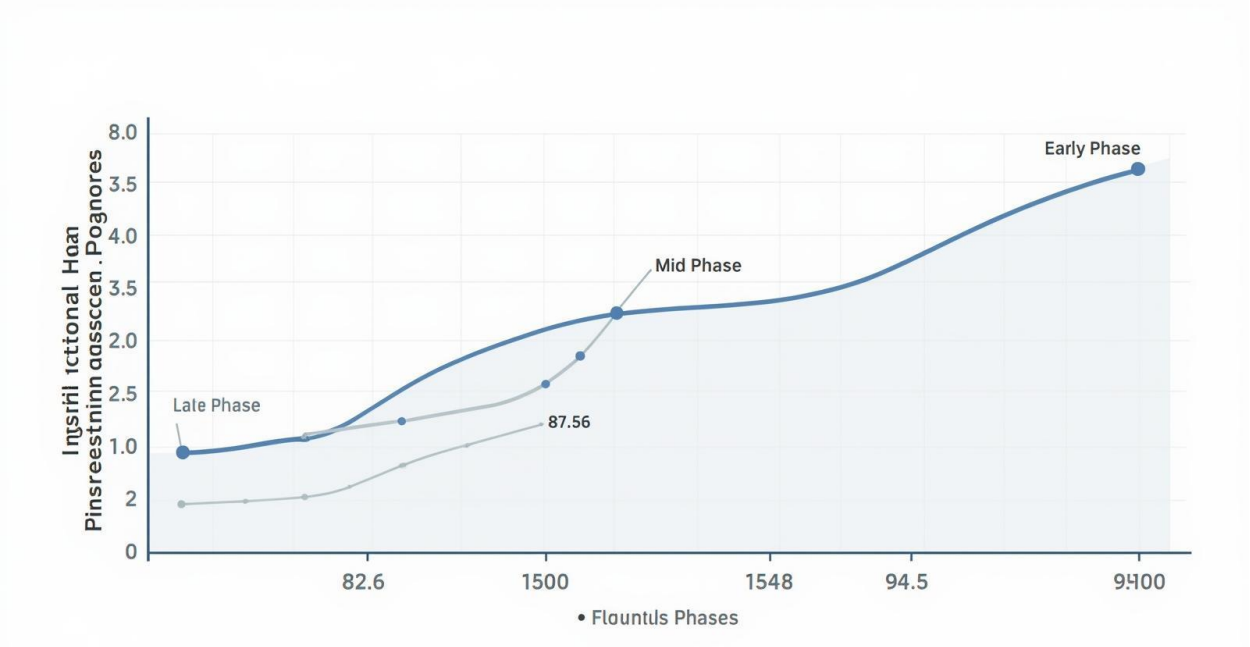

Figure 1. Mean RTM assessment scores across instructional phases of the seminar course, illustrating a progressive increase in pre-service physics teachers' research-related competencies over time.

Research Portfolio Analysis

Qualitative analysis of research portfolios revealed systematic developmental patterns. Early Phase portfolios were predominantly descriptive. Mid Phase portfolios demonstrated emerging synthesis across studies, while Late Phase portfolios reflected comparative analysis, identification of research gaps, and evaluative methodological commentary.

Table 3. Representative patterns of students' research portfolio development across instructional phases

Instructional Phase	Dominant Portfolio Characteristics
Early Phase	Descriptive summaries of individual studies
Mid Phase	Emerging synthesis and attention to theory and methods
Late Phase	Comparative analysis and identification of research gaps

Discussion

The findings provide empirical support for the effectiveness of a structured seminar course in fostering research readiness among pre-service physics teachers. From a learning progression perspective, research competencies are shown to develop gradually through sustained engagement with authentic disciplinary practices, rather than emerging as abrupt outcomes (Zaabalawi & Zaabalawi, 2024). The alignment between instructional design, assessment structure, and learning outcomes is conceptualized in Figure 2.

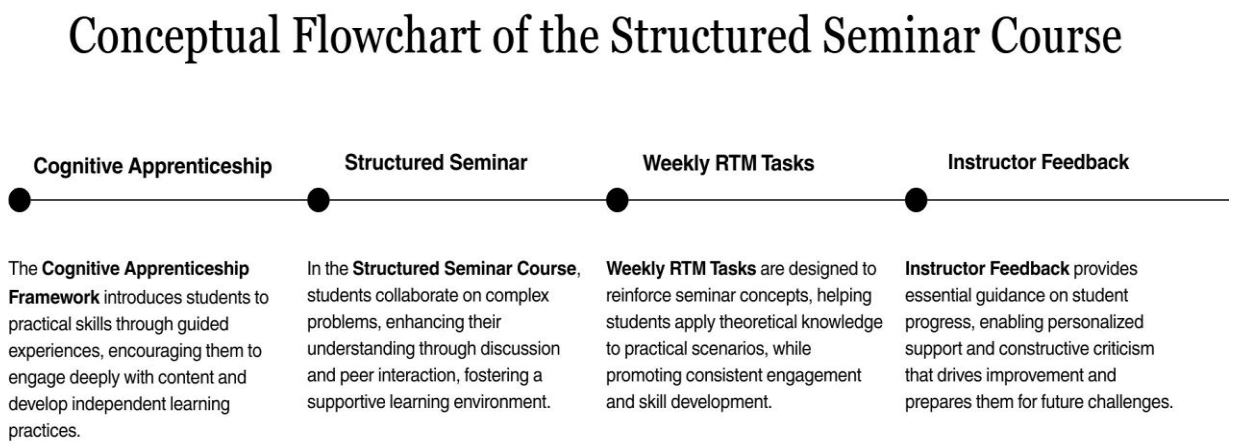

Figure 2. Conceptual model of the structured seminar course as a cognitive apprenticeship environment supporting the development of research readiness through iterative assessment, feedback, and portfolio-based learning.

These findings align with prior studies emphasizing the importance of scaffolded instructional environments in supporting the development of higher-order academic competencies. By situating research preparation within an authentic seminar context, the course enabled students to engage iteratively with core research practices, including problem formulation, literature synthesis, and methodological reasoning. This design reflects principles of cognitive apprenticeship, wherein complex practices are made visible through modeling, guided practice, and feedback (Farah-Franco et al., 2020).

Beyond empirical performance gains, this study contributes theoretically by conceptualizing research readiness as a progressive and assessable construct within physics teacher education. The integration of performance-based assessment and longitudinal portfolio analysis demonstrates how research competencies can be examined through process-oriented evidence rather than through final products alone. Such an approach addresses limitations of assessment practices that rely exclusively on summative evaluations and aligns with broader calls for authentic and formative assessment in teacher education (Guo, 2020).

Although conducted within an Indonesian institutional context, the instructional principles and assessment structures described in this study are not context-bound. Seminar courses are widely implemented across teacher education programs internationally, and challenges related to undergraduate research preparation are commonly reported. Accordingly, the structured seminar model presented here may offer transferable insights for physics teacher education programs seeking to strengthen students' research readiness through sustained, scaffolded engagement with disciplinary practices.

CONCLUSION

This study provides longitudinal empirical evidence that a structured seminar course can support the progressive development of research readiness among pre-service physics teachers. Through authentic assessment, scaffolded instructional design, and sustained engagement with peer-reviewed literature, the seminar course functioned as an effective pedagogical bridge between undergraduate coursework and independent research practice.

RECOMMENDATION

This study was conducted within a single institutional context with a relatively small cohort. Future research could replicate this design across multiple institutions and examine relationships between seminar performance and subsequent thesis quality. Further work may also explore applicability across other STEM disciplines.

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