The Strategies Behind the PhD in Mathematics Education Graduates' Professional Growth: Insights from a Graduate Tracer Study (2016–2023)

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Abstract: This study explored the professional growth of PhD in Mathematics Education graduates from Don Mariano Marcos Memorial State University (2016–2023), focusing on the teaching strategies that contributed to their advancement. Motivated by the limited research linking doctoral training to practical classroom application, the study aims to identify which instructional approaches were most relevant to graduates' teaching practices and career outcomes. Using a descriptive tracer study design, data were gathered from all 16 program alumni through a structured online survey and analyzed using both quantitative and qualitative methods. Findings revealed that research-based instruction, problem-based learning, and digital tool integration were the most impactful strategies, contributing to improved teaching performance, increased confidence, job promotions, and professional recognition. Graduates reported high alignment between their doctoral training and real-world educational demands, particularly during the pandemic's transition to remote learning. Framed by Human Capital and Social Systems Theories, the results highlight how doctoral education functions as both a personal investment and an institutional lever for change. The study concludes that embedding flexible, research-informed pedagogies in doctoral programs strengthens instructional leadership and positions graduates as key agents of innovation in mathematics education.

Keywords: graduate tracer study, mathematics teacher education, professional growth benefits, teaching strategies

INTRODUCTION

What happens after the doctorate? In the high-stakes world of mathematics education, earning a PhD is often seen as the pinnacle of academic preparation, but what comes next is less frequently studied. While most tracer research ends at employment status, this study opens a new line of inquiry: How do doctoral graduates actually develop after graduation, and how do the teaching strategies they experienced shape their career trajectories? By tracing the professional paths and classroom practices of PhD Mathematics Education graduates over seven years, this study reveals not just where graduates work but also *how* they were taught, *why* certain strategies matter, and *what* makes their expertise relevant in today's educational landscape. This intersection of pedagogy and professional growth offers a fresh perspective on the true impact of doctoral education, one that moves beyond diplomas and dives into the heart of teaching.

In the evolving landscape of mathematics education, the role of doctoral programs has grown increasingly vital, not only in shaping scholarly research but also in transforming classroom instruction and educational leadership (Regan & King-Sears, 2023). Doctoral graduates are expected to serve as instructional innovators, research mentors, and curriculum leaders across diverse learning environments (Holewik et al., 2024). However, little empirical data demonstrates how doctorate-level training, especially in mathematics education, translates into real teaching methods and career advancement in the field, in spite of these expectations (Reys et al., 2019).

The Doctor of Philosophy in Mathematics Education program, which is in line with Level 8 of the Philippine Quality Framework (PQF), aims to produce graduates who exhibit advanced proficiency in curriculum design, research, teaching, and leadership (Atweh et al., 2023). Individuals are expected to lead professional practice, produce new knowledge, and use educational innovation to advance national development at this level. Yet, the real-world application and impact of these competencies, particularly in mathematics teaching, remain insufficiently documented (Chekulaeva et al., 2021). This gap presents an opportunity to examine how doctoral graduates apply PQF-aligned outcomes in their professional roles.

Several studies in higher education tracer research have historically focused on employment outcomes, income increases, or job satisfaction (Ferreras, 2023). While useful, such studies often overlook the pedagogical impact of doctoral programs, how teaching strategies developed during graduate studies are applied in practice, and how these strategies contribute to educators' professional growth, recognition, and leadership. Furthermore, in the wake of significant shifts in instructional delivery, especially during the COVID-19 pandemic, understanding which teaching strategies have remained relevant and impactful is more critical than ever (Bautista & Valtoribio, 2024; Koh & Daniel, 2022; Siani, 2024).

This study is grounded in the local context of the PhD in Mathematics Education program at Don Mariano Marcos Memorial State University (DMMMSU-SLUC). Between 2016 and 2023, the program produced graduates who entered or returned to roles in teaching, supervision, and administration. Yet questions remain: What strategies did these graduates take with them into their classrooms? And which strategies helped them advance professionally?

This research addresses those questions by tracing the teaching strategies employed with PhD Mathematics Education graduates and linking them to the benefits they reported after graduation, including improved job performance, increased confidence, promotion, and professional recognition. In doing so, the study moves beyond general tracer objectives and applies a pedagogical lens to graduate outcomes. It aims to contribute to the broader conversation on how doctoral programs can align teaching and research in meaningful, measurable ways.

Specifically, the study aims to answer the following questions:

1. What are the common teaching strategies employed with PhD in Mathematics Education graduates from 2016 to 2023 that are perceived as most relevant to their professional practice?
2. Which among these teaching strategies are associated with the greatest career-related benefits for graduates of the PhD in Mathematics Education program?
3. What specific career-related benefits have PhD in Mathematics Education graduates reported after completing the program?

This study draws upon empirical data to explore the relationship between instructional practices and professional growth among PhD Mathematics Education graduates. By linking applied teaching strategies to measurable professional outcomes, the research highlights the reciprocal nature of teaching and research in advanced mathematics education. The study's findings have implications for doctoral curriculum design, institutional development, and the cultivation of research-informed practitioners.

Rather than concluding with the attainment of a doctoral degree, this study begins at that pivotal moment, unfolding in four key parts. The Methodology section provides insight into how the study was designed, introducing the participants, data collection tools, and the analytical approach used to trace teaching strategies and professional growth. The Results section shares what the graduates revealed: the teaching practices they carried forward and the benefits they experienced in their careers. In the Discussion, these findings are brought to life through the lens of educational theory, including Human Capital and Social Systems Theory, and are situated within current national and global shifts in mathematics education. The paper concludes by synthesizing the implications in the Conclusion section, where recommendations are offered for improving doctoral programs, elevating instructional leadership, and informing future directions in research and practice. Each section builds toward a clearer understanding of how doctoral preparation can leave a lasting mark, not just on academic transcripts, but in real classrooms and careers.

Teaching Strategies in Graduate Studies

Effective teaching strategies are central to graduate education, particularly in fields like mathematics education, where instructional leadership and research competence are equally critical (Connolly et al., 2018). In doctoral programs, the emphasis often shifts from traditional content delivery to more complex forms of instruction, such as research-based teaching, problem-based learning (PBL), and inquiry-driven pedagogy (Öztürk et al., 2022; Wijnia et al., 2024). These strategies support the PQF Level 8 competencies, which include generating new knowledge, leading transformative practice, and addressing learning problems using innovative approaches (Erdem et al., 2025; Liu & Pásztor, 2022).

Moeini (2020) emphasized that research-based instruction, when embedded in coursework and dissertation processes, empowers doctoral students to design lessons and learning environments that are both evidence-informed and adaptable to diverse contexts. Similarly, problem-based learning encourages graduates to approach instruction as inquiry, enabling the development of learners' critical thinking, collaboration, and problem-solving, key targets of PQF-aligned outcomes in mathematics education (Kozhoshov & Sakybekova, 2024; Kasemsap, 2021; Atmaja et al., 2024).

With the advent of distance education, technology-enhanced instruction has emerged as another key strategy at the graduate level (Mondragon-Estrada et al., 2023). The COVID-19 pandemic accelerated the integration of digital tools such as GeoGebra and LMS platforms, providing doctoral students not only with technological fluency but also with the ability to model flexible and resilient teaching (Engelbrecht & Borba, 2023; Assadi & Cretu, 2023). These competencies reflect the PQF's emphasis on lifelong learning, adaptability, and innovation in educational leadership.

Professional Growth Benefits Gained After Graduation

Graduate education, particularly at the doctoral level, is expected to result in a range of personal, academic, and institutional benefits. The PQF Level 8 descriptors emphasize that graduates should demonstrate advanced knowledge, independent research skills, and the ability to lead in their field. Studies have affirmed that PhD graduates frequently experience professional gains such as promotion, enhanced confidence, and expanded responsibilities, all of which align with these national qualifications benchmarks (Spronken-Smith et al., 2024; Cadilhe et al., 2023).

Painter and Clark (2015) noted that PhD holders often assume key roles in academic governance, faculty development, and curriculum innovation. These roles represent not just vertical advancement but evidence of applied leadership, a PQF-aligned outcome that doctoral programs aim to develop. Moreover, Spies et al. (2021) pointed out that teaching strategies gained through doctoral-level coursework often translate into leadership in classroom reform and research mentorship, further illustrating the intersection of academic preparation and practical influence.

The experience of navigating instruction during the pandemic also led to the development of digital literacy and pedagogical adaptability, reinforcing PQF objectives related to responding to national and global developments (Arissaputra et al., 2023). Graduates who completed their degrees during this period demonstrated not only instructional resilience but also the capacity to apply emerging tools and frameworks in ways that enhanced teaching effectiveness and program continuity (Schell, 2023; Marotta & Van De Laar, 2024).

Further, this study is anchored in two complementary theoretical frameworks: Human Capital Theory and Social Systems Theory.

Human Capital Theory (HCT), as articulated by economists such as Becker (1964), posits that investment in education enhances an individual's skills, productivity, and value in the labor market (Leoni, 2023). In the context of mathematics education, doctoral study represents a high-level educational investment that is expected to result in professional benefits, such as career advancement, teaching effectiveness, and institutional leadership (Rivas, 2024). The findings of this study, particularly the link between teaching strategy use and promotions, confidence, and recognition, demonstrate how human capital is not only accumulated during doctoral study but actively deployed through instructional practices that meet institutional goals and learner needs (Pozas et al., 2022).

Complementing HCT, *Social Systems Theory* views educational institutions as systems where individual components (students, faculty, programs) interact to achieve common goals (Vanderstraeten, 2023). In this framework, doctoral programs serve as developmental subsystems that shape graduates who, in turn, influence broader systems, such as schools, universities, and educational policy structures (Estrada et al., 2019). Graduates from the PhD in Mathematics Education program do not operate in isolation; their teaching strategies, curriculum development efforts, and leadership roles contribute to the functioning and transformation of the educational institutions they serve (Reys et al., 2008). As shown in this study, strategies like research-based instruction and curriculum alignment are mechanisms through which doctoral graduates exert systemic influence.

Together, these frameworks support the core proposition of this study: that doctoral training in mathematics education produces not only knowledge producers but also knowledge applicators, whose teaching practices carry both personal and institutional value.

METHODS

This section outlined the research design, participants, instrumentation, data collection, ethics, and analytical procedures employed in the study. Grounded in a tracer study framework, the methodology was designed to capture both the instructional strategies and professional growth benefits of PhD Mathematics Education graduates. By examining the teaching strategies employed during the program and the perceived benefits that followed, the study aims to provide a meaningful account of how doctoral-level preparation translates into professional impact in the field of mathematics education.

Research Design

This study employed a *descriptive* research design within a *tracer study* framework. As a tracer study, it aimed to monitor the professional trajectories and instructional practices of PhD in Mathematics Education graduates from 2016 to 2023. The descriptive approach was used to identify and summarize the teaching strategies most commonly employed by the graduates, as well as the career-related benefits they reported after completing the program.

This design was considered appropriate, as the study did not seek to manipulate variables or establish causal relationships. Instead, it focused on observing naturally occurring patterns, drawing on graduate feedback to document the perceived relevance of doctoral training, the alignment of program components with real-world teaching practices, and the reported impact on their professional growth and educational contributions. By using a descriptive tracer model, the study offers insights into how doctoral-level preparation in mathematics education translates into practical and career-enhancing outcomes.

Participants

The participants of the study were all 16 graduates of the PhD in Mathematics Education program at Don Mariano Marcos Memorial State University – South La Union Campus (DMMMSU-SLUC) from 2016 to 2023. A census approach was used due to the manageable population size, allowing for a complete set of feedback across all cohorts. The participants were employed in various educational institutions, including state universities, public schools, and private colleges, with most holding academic, supervisory, or leadership positions.

Instrumentation

The primary instrument used in this tracer study was a structured survey questionnaire, which was made accessible online via Google Forms to ensure ease of participation for respondents. The questionnaire was adapted from a standardized survey framework utilized by the university for all its tracer studies, thereby supporting the validity, consistency, and comparability of data across different academic programs at the graduate level. Consisting of 57 items, the survey was designed to gather information on several key domains: personal and demographic background, teaching strategies employed, current employment status, enrolment, the perceived relevance of the doctoral program to career development, and elements that contribute to employability and professional advancement.

The questionnaire incorporated a variety of item formats, including open-ended questions to elicit in-depth qualitative responses, a five-point Likert scale to measure levels of agreement or satisfaction, and multiple-choice items to capture specific categorical data. This design offers a comprehensive portrayal of alumni experiences following their completion of the PhD in Mathematics Education program.

Data Collection Procedure and Ethics

Tracing the participants for this study posed notable logistical challenges, as the graduates were no longer concentrated in a single institution or geographic location – some are already outside the country. Having embarked on diverse professional trajectories across various provinces and regions, spanning state universities, public school systems, and private educational institutions, coordinating communication and encouraging participation required deliberate effort and flexibility. The dispersed nature of their employment rendered traditional face-to-face follow-ups impractical. As a result, the researcher employed multiple digital platforms, including email, mobile messaging, Facebook, and Messenger, to trace, reach out to, and engage the participants.

Each graduate received a formal invitation outlining the study's purpose, voluntary nature, and assurances of confidentiality. Informed consent was obtained electronically prior to participation. Despite the geographical dispersion, a complete census was successfully achieved through persistent communication, utilization of institutional networks, and the accessibility of online data collection tools such as Google Forms. Data collection was conducted over a four-month period in 2024. All responses were anonymized and securely stored.

Data Analysis

The collected data were analyzed using descriptive statistical techniques. Frequency counts and percentages were used to summarize the most commonly applied teaching strategies, their perceived usefulness, and the professional benefits reported by graduates. These metrics provided a comprehensive snapshot of patterns in instructional practice and career development across cohorts.

In addition to quantitative summaries, qualitative responses from open-ended survey items were subjected to thematic coding. Responses were grouped by recurring patterns and categorized under themes that reflected key areas of growth, strategy application, and program impact. Coding was done manually by the researcher, and categories were cross-validated through peer checking to enhance the trustworthiness of interpretation. This qualitative layer provided context and explanatory depth to support the quantitative findings.

Trustworthiness and Rigor

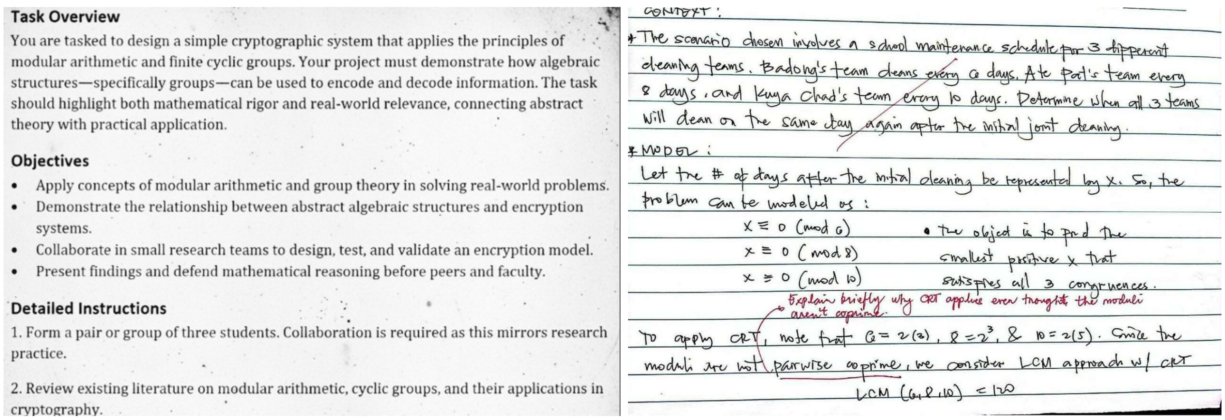
To ensure the credibility and integrity of the qualitative findings, the study observed strategies aligned with the criteria of trustworthiness: credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985; Ahmed, 2024). Credibility was supported by the use of a validated institutional tracer questionnaire and by triangulating data from responses. Participants' narratives were examined systematically through thematic coding to capture recurring patterns and meaningful insights. To enhance dependability, coding and interpretation were checked through peer debriefing with a senior faculty member, ensuring consistency in theme development. Confirmability was addressed by maintaining a clear audit trail of responses, coding decisions, and interpretive summaries. Although the study was context-specific, efforts were made to present detailed descriptions of participants and settings to support the transferability of findings to similar doctoral programs.

RESULTS

Inferred from Table 1, the teaching strategies applied to PhD Mathematics Education graduates evolved across time periods in response to both pedagogical developments and external factors such as the COVID-19 pandemic.

Table 1 shows that from 2016 to 2018, during traditional face-to-face instruction, strategies were largely grounded in constructivist approaches. Problem-based learning (PBL) and lecture-discussion with real-world modeling were dominant. Use of manipulatives, peer teaching, and oral defense formats supported communication, reasoning, and collaborative learning, core competencies emphasized during this period.

Course records show that one of their major tasks in Abstract Algebra involved developing a simple encryption model using modular arithmetic and cyclic groups (Figure 1a). Conducted as a problem-based project, the task required collaborative planning, literature review, and data validation, culminating in a class presentation and critique session.



(a) (b)

Figure 1. (a) Excerpt of the Abstract Algebra Task and (b) Student's output in Number Theory

Similarly, in the Number Theory course, lecture-discussion was complemented with modeling activities, such as applying the Chinese Remainder Theorem to real scheduling or synchronization problems in their workplaces (Figure 1b). Such experiences of the students became templates for how they later designed classroom investigations in their own teaching practice.

Further, in 2019, a shift toward research-integrated instruction became more evident. Graduates began to gain insights from their dissertations and coursework, particularly through action research, the use of formative assessment with rubrics, and early trials of the flipped classroom model. These emerging strategies reflect deeper engagement with curriculum design and student-centered learning. Faculty interviews indicated that dissertation findings were frequently used as case materials in research-related courses, reflecting the program's commitment to flexible and research-driven pedagogy. For example, one faculty of Qualitative Research required students to analyze data sets from completed dissertations to practice coding and thematic analysis, an approach that allowed learners to engage directly with authentic research processes rather than relying solely on textbook exercises. The faculty explained: *"I realized that many of our students find research abstract until they see how findings are derived. That's why I bring data from previous dissertations into class. We analyze them together, students practice coding, identifying themes, and connecting them to theoretical frameworks"*. In addition, Course syllabi and sample materials from 2018–2020 confirmed that many readings and examples were drawn from completed dissertation research within the program. This practice illustrates how flexible pedagogical approaches enabled faculty to adapt instruction to real research contexts, strengthening the integration of inquiry, reflection, and evidence-based learning in doctoral coursework and contributing to the institution's evolving culture of scholarly inquiry.

Period	Teaching Strategies	Description
2016–2018 (Classroom-Based Instruction)	Problem-Based Learning (PBL)	Used in teaching topics like number theory and abstract algebra.
	Lecture-Discussion with Mathematical Modeling	Integrating real-world applications in calculus or statistics.
	Use of Manipulatives and Visual Aids	Employed especially in geometry and combinatorics.
	Peer Teaching and Collaborative Group Work	Often used during group studies or as extension strategies.
	Oral Defense as an Instructional Tool	Frequent use of presentation and oral critique formats for fostering communication and logical reasoning.
2019 (Pre-pandemic Period)	Action Research-Driven Teaching	With more graduates conducting dissertation research, many PhD faculty members began integrating research findings into their classrooms.
	Use of Formative Assessment and Rubrics	Developed from coursework in curriculum and instruction.
	Flipped Classroom (Experimental Pilots)	Some started experimenting with this to increase student engagement and critical thinking.
2020–2022 (Pandemic and Distance Learning Period)	Synchronous and Asynchronous Online Teaching	Conducted via Google Meet or Zoom
	Video Lectures with Guided Practice	Pre-recorded math lectures followed by Google Classroom-based quizzes.
	Online Discussion Forums	For topics in educational philosophy, graduate seminars, and research methods.
	Digital Assessment Tools	Such as Google Forms and GeoGebra assessments.
	Modularized Instruction	Self-learning modules prepared in PDF/ print formats to serve learners with poor connectivity.
	ICT Integration in Mathematics	Applying ICT in teaching real analysis, statistics, and operations research.
2023 (Post-Pandemic/ Hybrid)	Blended Learning Strategies	A mix of online and face-to-face methods.
	Differentiated Instruction Using Data	Grounded in dissertation work focused on student profiling and performance tracking.
	Capstone- or Research-Based Instruction	Students work on mini-projects or papers as assessment tools.
	Technology-Supported Demonstrations	Incorporating math software like GeoGebra, or MATLAB in calculus and linear algebra.

Table 1: Common Teaching Strategies

The 2020–2022 pandemic period marked a significant transformation in instructional delivery. Teaching rapidly adapted to remote modalities, with widespread use of synchronous and asynchronous platforms like Zoom and Google Meet. Graduates implemented video lectures, online discussion forums, and Google Classrooms. The development of modularized instruction and ICT integration in mathematics also demonstrated a commitment to equity and continuity despite technological barriers.

By 2023, as schools transitioned to hybrid modes, a new blend of traditional and digital strategies emerged. Graduates reported learning through blended learning, data-driven differentiated instruction, and capstone or research-based projects to assess deeper learning. The increasing use of technology-supported demonstrations, such as GeoGebra and MATLAB, also illustrates how digital tools have become normalized in post-pandemic pedagogy.

Moreover, Table 2 revealed a clear hierarchy among the teaching strategies employed. The top-ranked strategy, Research-Based Instruction, consistently stood out as the most impactful. With 87.5% of graduates rating research activities as the most useful aspect of the program, this strategy was not only central to dissertation work but also translated into classroom practices such as action research, literature reviews, curriculum design, and research colloquium. Its consistent application in both face-to-face and distance learning settings highlights its versatility and alignment with doctoral-level competencies. To illustrate how research-based instruction and literature reviews were implemented in doctoral coursework, the following examples of instructional designs were drawn from the 2023 implementation of the Curriculum Development, Assessment, and Instructional Methodologies in Education and the 2019 midyear offering of the Special Topics in Abstract Algebra courses, as shown in Appendices A and B, respectively.

Next, Problem-Based Learning (PBL) was particularly effective in traditional classroom instruction, especially in subjects such as algebra, calculus, and number theory. This strategy was considered key to developing students' problem-solving and critical thinking skills, attributes they found most useful in their teaching and workplace settings. Its strong alignment with core mathematical thinking makes it a cornerstone of effective pedagogy in mathematics education. Third, the Use of Digital Tools such as GeoGebra, Google Forms, and learning management systems gained prominence during the 2020–2022 pandemic period. Graduates demonstrated a strong capacity to adapt these tools for assessment, content delivery, and engagement in both synchronous and asynchronous modes. While this strategy emerged in response to remote learning needs, it has persisted into the post-pandemic context, particularly in hybrid environments, signaling its lasting pedagogical value.

In contrast, the ninth- and tenth-ranked strategies were less widely adopted or had limited classroom application. The Flipped Classroom, while innovative, was only used by a small number of

Rank	Teaching Strategies	Context	Justifications From the Analysis of the Tracer Data
1	Research-Based Instruction	Face-to-face and Distance	87.5% rated research activities as most useful. Widely applied in dissertations and later translated to classroom strategies and professional development sessions.
2	Problem-Based Learning (PBL)	Face-to-Face	Frequently used in algebra, calculus, and number theory instruction. Promotes problem-solving and critical thinking skills, rated most useful in the workplace.
3	Use of Digital Tools (GeoGebra, Google Forms, LMS)	Distance Learning & Blended	Strong adaptation noted in 2020–2022. Widely applied in assessment and instruction during pandemic-era learning.
4	Collaborative/Group-Based Learning	Face-to-Face and Distance	Used across multiple years for promoting peer interaction, especially in teaching higher math and conducting research seminars.
5	Modular and Self-Paced Learning	Distance Learning ('20–'22)	Practical and widely adopted due to connectivity issues. Reinforced by institutional guidance during the pandemic.
6	Lecture-Discussion with Application Tasks	Face-to-Face	Especially effective in mathematics in finance, statistics, and linear programming. Combines concept delivery with real-world modeling.
7	Formative Assessment with Rubrics	Face-to-face and Distance	Tied to program coursework in curriculum and assessment. Rated highly relevant in linking instruction to performance-based evaluation.
8	Blended Learning (Post-pandemic Hybrid)	Hybrid	As classes returned to physical campuses, blended strategies offered continuity and flexibility. Still in the early reintegration phase among the graduates.
9	Flipped Classroom	Select Cases *(Experimental)*	Some 2019 and 2023 graduates reported using this in higher ed teaching, but adoption was not widespread.
10	Oral Presentation/ Defense as an Instructional Tool	Face-to-Face	Common in seminars and research subjects, but limited to academic assessments rather than direct classroom teaching.

Table 2: Ranked Teaching Strategies by Relevance and Usability in the Program

graduates (notably in 2019 and 2023) and remained in the experimental stage. It holds potential for increasing student autonomy and engagement, but lacks broad implementation during the study period. Meanwhile, Oral Presentation or Defense as an Instructional Tool, although common in research seminars and academic evaluations like dissertation proposals and final defenses, was rarely applied as a core teaching strategy in mathematics classes. Its use was largely limited to formal academic settings rather than everyday instruction.

The data presented in Table 3 reflect the wide-ranging professional growth benefits experienced by graduates of the PhD Mathematics Education program. The most consistently reported gains occurred in the domain of Instructional Competence, where 87.5% of graduates indicated improved job performance and increased teaching confidence. In the domain of Career Advancement, 81.25% of graduates experienced promotion or received new professional designations, with half of them (50%) attaining such advancement within a year of completing the program.

Graduates also reported high levels of Research and Academic Engagement, with 87.5% finding research activities to be the most useful component of the program. This reinforces the centrality of research-based instruction in both academic practice and career progression, further supported by the high percentage (56.25%) of graduates recognized as resource persons or speakers.

Domains	**Premier Professional Growth Benefits per Domain**	**%**
Instructional Competence	Improved job performance	87.5
	Increased teaching confidence	87.5
Career Advancement	Promotion or new designation	81.25
	Promotion within 1 year post-graduation	50
Research and Academic Engagement	Found research activities most useful	87.5
Professional Recognition	Recognized as a resource person or speaker	56.25
Program Relevance	Reported program courses and strategies as highly relevant	100
Adaptability and Retention	Retained employment during the pandemic	100
	Successfully adapted to online/remote teaching	93.75
Leadership and Responsibility	Assigned greater roles/ responsibilities post-graduation	50

Table 3: Summary of professional growth benefits

Further, the domain of Program Relevance achieved the highest rating, with 100% of graduates affirming that the program's courses and strategies were highly applicable to their current roles.

This affirms strong curricular alignment with the real-world demands of mathematics education. Equally notable are the outcomes under Adaptability and Retention, where 100% of graduates reported retaining employment during the COVID-19 pandemic, and 93.75% successfully adapted to remote teaching. These findings highlight the program's role in fostering digital resilience and instructional flexibility.

Finally, Leadership and Responsibility were reported by 50% of graduates who assumed greater institutional roles post-graduation. These responsibilities likely stem from the research, mentoring, and curriculum development competencies cultivated throughout the program.

Table 4 shows a relationship between specific teaching strategies and the professional benefits gained by PhD Mathematics Education graduates. In the Table, three emerged as the most strongly associated with meaningful career advancement and performance outcomes: Research-Based Instruction, Problem-Based Learning (PBL), and the Use of Digital Tools. Research-Based Instruction was the most frequently cited strategy linked to career gains. Graduates credited it with enhancing their *confidence*, *improving work performance*, and enabling their *promotion to leadership roles* or *recognition as resource persons*. This aligns with tracer data showing that 87.5% of graduates rated research-related activities as the most useful component of their doctoral training. Its high relevance to program competencies, such as *critical thinking*, *instructional design*, and *leadership*, reinforces its transformative impact on practice. Further, Problem-Based Learning (PBL) also stood out, with graduates reporting improvements in *teaching performance, promotion* (due to the effect of the teaching effectiveness rating), and *overall job satisfaction*. This strategy's alignment with core doctoral courses such as Curriculum Development and Advanced Mathematics subjects underscores its direct application to content delivery and student-centered instruction. The focus on inquiry and critical thinking reflects a shift toward modern pedagogical approaches emphasized in graduate education.

Additionally, during the 2020–2022 pandemic period, the Use of Digital Tools played a crucial role in helping graduates retain their teaching roles and adapt to new instructional environments. Tracer data show a strong link between this strategy and enhanced *teaching confidence*, increased *innovation*, and sustained *employability*. Notably, there were no reports of job loss among graduates during this period, indicating the practical value of digital fluency in times of disruption.

Moreover, other strategies such as Collaborative Learning and Formative Assessment with Rubrics were linked to growth in areas like *leadership, mentoring*, and *instructional responsibility*. These approaches helped graduates build strong interpersonal and evaluation skills, key elements of educational leadership and reflective practice. Meanwhile, Lecture-Discussion with Application, Modular Instruction, and Blended Learning offered context-specific benefits, particularly in delivering complex mathematical content or maintaining instructional continuity during remote learning phases. However, their influence on career advancement was more limited compared to research-driven strategies.

Teaching Strategies	Graduate Benefits from Tracer Data	Support from Tracer Data
Research-Based Instruction	Promotions, increased confidence, expert/resource person roles, improved work performance	87.5% found research activities most useful; high alignment with program competencies like critical thinking and leadership.
Problem-Based Learning (PBL)	Improved performance, promotion, and job satisfaction	Linked to high-rated subjects like Curriculum Development and Advanced Math topics; aligns with critical thinking and problem-solving.
Use of Digital Tools (GeoGebra, Google Forms)	Improved confidence, innovation in teaching, and job retention	Strategies tied to pandemic-era instruction (2020–2022); sustained employability with no reported job loss; increased adaptability noted.
Collaborative/Group-Based Learning	Confidence in job, leadership roles, commitment to teaching, and peer mentorship	Aligned with reported gains in human relations and collaborative spirit, used in seminar-based and extension instruction.
Formative Assessment with Rubrics	Better performance feedback, greater responsibility in academic functions	Reflects skills in assessment and curriculum relevance; supports research and instructional effectiveness.
Lecture-Discussion with Application Tasks	Improved clarity in content delivery, effective math communication	Supports job performance in the core content area; aligns with improved communication and content mastery
Modular and Self-Paced Learning	Job retention during distance learning, flexibility in delivery	Particularly relevant in 2020–2022 for continued teaching and program completion; practical but less emphasized post-pandemic.
Blended Learning	Smooth transition post-pandemic, continuity of teaching	Applied mainly in 2023; supports sustainability and integration, but has limited long-term data on benefits.
Flipped Classroom	Encouraged learner independence and critical thinking, used in higher education settings	Used experimentally; relevant but not widely adopted (mentioned qualitatively, not strongly reflected in benefit frequency).
Oral Presentation and Defense as an Instructional Tool	Supports communication and confidence, but is limited to academic contexts	Mostly applicable in seminars and graduate-level presentations; less impact on broader teaching strategies or promotion.

Table 4: Teaching strategies by reported graduate benefits

Lastly, at the lower end of the benefit spectrum, Flipped Classroom and Oral Presentation/Defense as Instructional tools were acknowledged for their potential in developing student autonomy and communication skills, but were not widely adopted or reported as significantly impactful across graduates. Their use was mostly limited to experimental or academic settings, and did not strongly correlate with broader professional benefits like promotion or institutional leadership.

DISCUSSION

The evolution of teaching strategies among PhD Mathematics Education graduates from 2016 to 2023 reflects a dynamic response to pedagogical shifts, institutional expectations, and external pressures such as the COVID-19 pandemic (Biehler et al., 2024). As shown across the tables, the most relevant and widely adopted strategies, Research-Based Instruction, Problem-Based Learning (PBL), and the Use of Digital Tools, correlate with the most impactful professional benefits reported by the graduates, including improved job performance, increased confidence, promotion, and recognition as resource persons. The examples above show how doctoral coursework has embedded flexible and research-driven pedagogies into instruction. The students engaged in collaborative, problem-based, and modeling activities that linked theory to authentic inquiry. Similarly, the use of dissertation data in research courses exemplified flexible pedagogy, enabling students to experience the actual research process. Collectively, these practices demonstrate how the program bridges theoretical learning with applied research, fostering scholarly engagement and reflective practice among doctoral students. This progression supports the notion that doctoral training not only imparts knowledge but fosters adaptable, forward-thinking educators equipped to lead in varied instructional contexts (Patterson et al., 2019; McAlpine & Inouye, 2021).

This alignment is best understood through the lens of Human Capital Theory (HCT). Becker (1964) posits that educational attainment and skill development serve as investments in one's productivity and future professional value. The tracer data affirm this, showing that a significant majority of the graduates rated research activities, the cornerstone of doctoral preparation, as the most useful part of the program. Their application of research-based instruction in their teaching, curriculum development, and professional development sessions is a direct manifestation of capitalized learning (Gerber et al., 2011). Furthermore, strategies like PBL and digital integration reflect the program's role in enhancing instructional capacity and increasing graduates' market value and employability, particularly during times of crisis (D'Elia et al., 2025).

The results also reveal substantial evidence of professional growth across multiple domains. Under Instructional Competence, a high percentage of graduates reported improved job performance and increased teaching confidence, indicating that the pedagogical training they received had an immediate and lasting impact on their classroom effectiveness (Li et al., 2025). In terms of Career Advancement, a very high number of graduates were promoted or received new designations, with half of them advancing within just one year of graduation. These outcomes underscore the practical return on educational investment and further validate HCT's core assertion that advanced qualifications enhance workforce potential (Mustafa & Lleshi, 2024; Thwin, 2023).

In addition, beyond individual advancement, these outcomes also reflect how doctoral graduates function within larger educational systems, as articulated in Social Systems Theory. Graduates are not isolated agents; they are subsystems functioning within broader educational ecosystems (Khuzwayo, 2020). Their adoption of collaborative learning, formative assessment, and modular instruction demonstrates how doctoral-level training enables them to contribute meaningfully to institutional goals (Schmidt et al., 2023). The integration of new strategies during pandemic-disrupted learning phases shows systemic adaptability; graduates acted as mediators of change within their departments and communities, ensuring continuity of education and modeling resilience (Harmey & Moss, 2021).

The tracer study further highlights the role of the program in supporting research and academic engagement, with the majority of graduates citing research activities as most beneficial. This not only aligns with core expectations of doctoral education but also reflects how graduates translated their research competencies into practice, leadership, and policy influence (Cunningham et al., 2023). Supporting this, more than half of their number were recognized as resource persons or speakers, reinforcing the program's contribution to their professional recognition and visibility within academic circles (Van Winkel et al., 2025).

Equally relevant is the alignment of the observed outcomes with the Philippine Qualifications Framework (PQF) Level 8, which outlines the expected competencies of doctoral degree holders. Graduates demonstrated outcomes such as critical thinking, innovation, leadership, and reflective practice. The use of research-based and differentiated instruction exemplifies the ability to generate new knowledge and lead professional practice, both of which are embedded in PQF descriptors. Notably, all of the graduates confirmed the relevance of program courses and strategies to their work, demonstrating curricular coherence with national standards (Cuoco & McCallum, 2017).

The program's responsiveness to external disruptions is further validated in the domain of Adaptability and Retention, where all the graduates retained their employment during the pandemic, and almost all successfully adapted to remote teaching modalities. These results highlight the role of the doctoral program in fostering digital resilience and innovation, particularly through the use of ICT and modular delivery. Such capabilities are essential in navigating uncertainty and reflect a future-ready approach to teacher preparation (Bakker et al., 2021).

Moreover, half of the graduates assumed greater institutional responsibilities, including roles in supervision, curriculum leadership, and research mentorship. This is consistent with PQF expectations and illustrates that graduates not only improve their personal capacities but also strengthen the systems in which they operate, serving as agents of institutional transformation (Ahl et al., 2025).

The prominence of Problem-Based Learning in traditional classroom instruction further supports literature highlighting its value in developing mathematical reasoning and higher-order thinking skills (Alreshidi & Lally, 2024; Purba et al., 2023; Aba-Oli et al., 2024). PBL's relevance to graduate-reported benefits: promotion, teaching confidence, and job satisfaction, emphasizes its practical and professional value, especially in core subjects such as algebra and number theory (Ahl et al., 2025; Mohamad et al., 2024).

The Use of Digital Tools during 2020–2022 was not merely a response to pandemic conditions; it signaled a pedagogical shift that has persisted into post-pandemic practice (Driskell et al., 2025). These tools, such as GeoGebra, Google Forms, and LMS platforms, supported not only content delivery but also graduate adaptability, innovation, and job retention. Notably, no job loss was reported during this period, which highlights the role of technological fluency as a protective factor for employment continuity and a marker of educational relevance (Razalli et al., 2025). However, some graduates experienced challenges during remote teaching, noting that limited internet access occasionally hindered full use of digital tools, especially in less connected regions.

Meanwhile, strategies like Collaborative Learning and Formative Assessment with Rubrics, though ranked slightly lower, were significant in fostering leadership, mentoring, and institutional engagement (De Paula et al., 2024). These reflect the human relations and evaluative skills expected of doctoral graduates who must lead curriculum implementation and support instructional improvement in their workplaces (Kaur et al., 2023). Such findings echo the work of Fadzil and Osman (2025) and Johnson and Williams (2023), who highlight the importance of research-informed, collaborative teaching in shaping effective educational leaders.

On the other hand, less widely adopted strategies, such as the Flipped Classroom and Oral Presentation as an Instructional Tool, were acknowledged for fostering student autonomy and academic discourse but were limited to experimental or academic settings. Their lower ranking and limited impact on career advancement suggest the need for more systematic support and training for these strategies to gain traction in mainstream instructional practice (Cevikbas & Kaiser, 2020; Baybayon & Lapinid, 2024).

The teaching strategies employed for the graduates were not only pedagogically sound but also career-shaping tools, reflecting the convergence of theory, policy, and lived experience. These findings affirm the doctoral program's success in producing mathematics educators who are research-informed, context-responsive, and professionally agile, educators who embody the outcomes prescribed by national qualification standards, and who are well-positioned to lead instructional innovation and institutional improvement across diverse educational contexts (Biehler et al., 2024).

CONCLUSIONS

This tracer study confirms that doctoral training in Mathematics Education serves as a transformative experience that significantly enhances both instructional competence and professional identity. Graduates reported learning from and applying a range of impactful teaching strategies, particularly research-based instruction, problem-based learning, and digital integration, which influenced how they taught, led, and adapted in their professional contexts.

A key finding is the strong alignment between the program's pedagogical design and its real-world application. This integration of theory and practice translated into a range of professional benefits, including enhanced teaching competence, increased confidence, career advancement, and institutional leadership. Graduates also demonstrated resilience in times of disruption, highlighting the program's role in fostering digital fluency and instructional adaptability, skills now essential in the post-pandemic educational landscape.

These findings offer important implications for teaching practice within and beyond the doctoral level. Doctoral programs should more intentionally embed research-driven, collaborative, and flexible pedagogies into coursework and instructional training. Doing so ensures that graduates are not only content experts but also reflective practitioners and transformational leaders. Post-graduation, institutions must continue to support professional development and recognize doctoral alumni as key contributors to innovation in education.

Ultimately, the study reinforces that doctoral education is not only a scholarly pursuit but a systemic investment, one that prepares educators to drive meaningful change in mathematics education, both in the classroom and at the institutional level.

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Appendix A

Sample Classroom Learning Design in the Course Curriculum Development, Assessment, and Instructional Methodologies in Education

Philo 306: Curriculum Development, Assessment, and Instructional Methodologies in Education (Mathematics)

Project Title: Designing and Implementing Data-Driven Lessons in Mathematics
Semester: 2nd Semester, Academic Year 2022–2023
Instructor: [redacted]
Learning Modality: Blended (online and face-to-face)
Duration: 6 weeks

I. Rationale

The course emphasizes the integration of curriculum theory, assessment strategies, and innovative instructional methodologies to enhance mathematics teaching. Consistent with these objectives, the activity provides students with authentic opportunities to connect educational theory with practice by investigating real classroom problems, developing data-informed interventions, and analyzing their instructional outcomes. Through this process, doctoral students engage in reflective inquiry, collaborative problem solving, and evidence-based decision-making—core competencies aligned with the course's aim of developing scholarly and adaptive mathematics educators capable of designing responsive and research-grounded learning experiences.

II. Learning Outcomes

By the end of the activity, students were expected to:

1. Apply research methodologies in analyzing actual mathematics classroom problems;
2. Design differentiated and data-driven instructional strategies to address identified learner needs;
3. Implement lessons flexibly across various modalities (face-to-face, online, or hybrid);
4. Analyze collected classroom data to draw conclusions on instructional effectiveness; and
5. Present research findings and reflections through scholarly discussion and written report.

III. Learning Design

Stage	Description of Activity	Pedagogical Feature
Stage 1: Problem Identification (Week 1)	*Students identify a learning issue in their mathematics classrooms, supported by classroom data or learner performance records.*	Research-driven (rooted in authentic problems)
Stage 2: Literature Review and Lesson Design (Weeks 2–3)	*Each student conducts a brief literature review on strategies addressing the issue, then designs a short lesson sequence or intervention (e.g., differentiated algebra tasks, problem-based geometry).*	Flexible pedagogy (students choose focus and context)
Stage 3: Implementation and Data Gathering (Week 4)	*Students implement the designed lesson in their schools, using formative assessments, observation checklists, or interviews to collect data on student responses and outcomes.*	Research-driven, context-based learning
Stage 4: Analysis and Reflection (Week 5)	*Students analyze the collected data using basic descriptive or qualitative techniques to evaluate lesson effectiveness.*	Inquiry-based reflection
Stage 5: Presentation and Peer Critique (Week 6)	*Results are presented in class through PowerPoint and a brief report. Peers provide feedback and suggest methodological improvements.*	Collaborative learning

Stage	Description of Activity	Pedagogical Feature
Stage 5: Presentation and Peer Critique (Week 6)	*Results are presented in class through PowerPoint and a brief report. Peers provide feedback and suggest methodological improvements.*	Collaborative learning

IV. Assessment Scheme

Criteria	4	3	2	1
Research Application	Demonstrates outstanding ability to apply appropriate research methods and analytical tools; collects valid, well-organized data directly linked to research questions; integrates literature effectively to support findings.	Applies suitable research methods with generally clear data collection and analysis; minor gaps in consistency or interpretation.	Attempts to apply research processes but shows limited methodological rigor; data collection or analysis is partially appropriate.	Shows minimal understanding of research processes; data are incomplete or unrelated to identified problem.
Instructional Design Quality	Designs a coherent, innovative, and context-responsive lesson or intervention; instructional activities are differentiated and well-aligned with identified learner needs.	Lesson design is clear and mostly aligned with learner needs; some differentiation and contextualization are evident.	Lesson design shows partial alignment with learner needs; limited evidence of differentiation or innovation.	Lesson design is unclear or disconnected from learner needs; lacks differentiation and coherence.
Data Analysis and Interpretation	Presents comprehensive data analysis with accurate interpretation; demonstrates clear linkage between results, theory, and implications for teaching practice.	Provides sound data analysis and interpretation with some connection to theory and practice.	Data analysis is basic or descriptive; interpretations are limited and only loosely connected to theory.	Minimal or inaccurate analysis; conclusions are unsupported or missing.
Reflection and Synthesis	Produces deep, evidence-based reflection showing critical insight into teaching practice, learning outcomes, and professional growth; connects results to broader educational theories.	Reflection shows awareness of insights gained and links findings to teaching improvement.	Reflection is superficial or descriptive with limited evidence of synthesis.	Reflection is absent or purely narrative, lacking analytical or theoretical connection.
Collaboration and Communication	Actively contributes to group discussions and peer critiques; communicates ideas clearly and scholarly both in oral and written form; demonstrates respect and responsiveness to feedback.	Participates constructively in group work and presentations; communicates ideas clearly with minor gaps in coherence or engagement.	Participates inconsistently in collaboration; contributions or communication need clarity and substance.	Shows minimal engagement in group collaboration; communication is unclear or incomplete.

4 – Excellent (3.50–4.00): Exceeds expectations; demonstrates mastery of research-driven pedagogy and reflective practice.
3 – Proficient (2.50–3.49): Meets expectations; shows strong understanding with minor areas for refinement.
2 – Developing (1.50–2.49): Partially meets expectations; requires further development of research and instructional integration.
1 – Beginning (1.00–1.49): Does not meet expectations; limited evidence of understanding or application.

V. Instructions for Conducting the Research Activity

A. Preparation and Permission

1. **Select a Focus:** Identify a teaching or learning issue in mathematics relevant to curriculum, assessment, or methodology.
2. **Prepare a 1–2 Page Proposal:** Include title, objectives, description of intervention, data plan, and ethical considerations.

3. **Secure Permission:** Submit the proposal for instructor approval, then request authorization from your school head or supervisor using a signed letter of permission.
4. **Ensure Ethical Compliance:** Maintain confidentiality, voluntary participation, and data anonymity at all times.

B. Conduct of the Research

1. **Design the Intervention:** Develop a short lesson or strategy (e.g., differentiated task, blended module, modeling activity).
2. **Collect Baseline Data:** Administer a pre-assessment or diagnostic tool to identify learner needs.
3. **Implement the Lesson:** Apply your design in your class or simulated setting; document engagement and observations.
4. **Gather Post-Data:** Conduct a post-test or reflection interview to evaluate results and learning gains.
5. **Analyze and Reflect:** Use simple statistics or thematic analysis, then interpret results in relation to theory and practice.

C. For Non-Teaching Students

If not currently teaching, choose one:

- **Collaborate** with a teaching colleague as co-researcher.
- **Simulate** a lesson with volunteer learners or peers.
- **Analyze Documents** such as anonymized lesson plans or assessment data.

D. Report Format

1. **Title and Objectives**
2. **Description of Intervention**
3. **Methodology (Participants, Data, Tools)**
4. **Results and Reflection**
5. **References and Appendices**

Formatting: Times New Roman 12, 1.5 spacing, 1-inch margins, 5–7 pages.
Filename: *LastnameFirstname_RA_MathEd2023*

Appendix B

Sample Literature Review Task in the Special Topics in Abstract Algebra

Med 317 – Special Topics in Abstract Algebra
Midyear Term, School Year 2018-2019
FINAL Requirement
Literature Review

I. Objectives

By the end of the term, the students should be able to:

1. Conduct a systematic and scholarly literature review on a self-selected topic under *Abstract Algebra*;
2. Demonstrate research-driven inquiry by locating, analyzing, and synthesizing peer-reviewed sources;
3. Collaborate in scholarly discussions to critique, refine, and present findings; and
4. Identify research gaps and propose possible directions for future study in mathematics education or abstract algebra research.

II. Activity Overview

This activity was developed to integrate the literature review process into the PhD in Mathematics Education coursework as a means of cultivating authentic scholarly practice. It engages students in independent inquiry, collaborative critique, and reflective synthesis—core elements of advanced research training. Flexibility is embedded in the design by allowing students to select their specific subtopic within Abstract Algebra and determine their preferred synthesis framework (thematic, chronological, or theoretical). Through structured consultation sessions, students engage in critical dialogue and peer evaluation, replicating the iterative knowledge-building process characteristic of the research community.

III. Scope and Considerations

1. **Topic and Focus:**
   Students select any research area under *Abstract Algebra* based on their academic or professional interests.
2. **Time Frame:**
   Sources should primarily cover studies from the last **10 years (80% recent literature)** to ensure relevance.
3. **Sources:**
   Use at least **10 scholarly references** (peer-reviewed journals, conference proceedings, books, or theses).
4. **Inclusion and Exclusion Criteria:**
   Students set criteria based on methodology, relevance, or scope. Criteria must be justified in the Introduction.
5. **Synthesis Approach:**
   Choose a synthesis type — **thematic**, **chronological**, or **theoretical** — as appropriate to your topic.
6. **Gap Identification:**
   Conclude with the identification of **research gaps** and implications for further study.

III. Learning Flow

Time Frame	Stages	Student Tasks
Week 2	Topic Proposal	Submit a one-page proposal identifying the chosen subtopic in Abstract Algebra, its rationale, and initial keywords for literature search. This establishes the foundation for a research-driven inquiry.
Week 3	Guided Search Workshop	Attend a guided database search workshop (onsite or online) on accessing research databases such as Scopus, ERIC, and JSTOR. Students practice constructing search strings and evaluating scholarly sources, demonstrating flexible, technology-enhanced learning.

Time Frame	Stages	Student Tasks
Week 5	Peer Consultation	Participate in a peer consultation session to present preliminary findings, discuss challenges, and refine inclusion and exclusion criteria. This stage fosters collaborative learning and critical academic dialogue.
Week 7	Draft Submission	Submit a partial draft of the literature review (Introduction and initial synthesis). Receive formative feedback from both instructor and peers to refine analysis and organization. This promotes iterative, research-based improvement.
Week 10	Final Submission and Presentation	Submit the final version of the literature review and deliver a short oral presentation summarizing findings, identified gaps, and future research directions. This stage emphasizes reflective synthesis and scholarly communication.

V. Output Format

Length: 5–7 pages (excluding references)
Format: Trebuchet, 12pt, 1.5 spacing, 1-inch margins
File name: *Lastname_LitReview_AbsAlgebra.docx*
Reference Style: APA 7th edition
Submission Deadline: Week 10, Saturday
Presentation: Week 11 (10-minute summary face-to-face)

VI. Assessment Criteria

Criteria	4 - Excellent	3 - Proficient	2 - Developing	1 - Beginning
Research Rigor	Comprehensive review using diverse, credible sources; clear inclusion/exclusion justification.	Adequate review with some methodological clarity.	Limited justification or uneven source selection.	Incomplete or poorly justified review.
Synthesis and Organization	Insightful and coherent synthesis showing clear conceptual patterns or theoretical linkages.	Logical synthesis with minor organizational lapses.	Partially organized or descriptive synthesis.	Disconnected or unstructured review.
Gap Identification	Clearly identifies gaps and proposes meaningful future research directions.	Gaps identified but with limited elaboration.	Minimal attempt to discuss gaps.	No discussion of gaps.
Collaboration and Feedback Use	Actively engaged in peer discussions and used feedback effectively in revision.	Participated in discussions; feedback somewhat integrated.	Limited collaboration or reflection.	No collaboration or feedback evidence.
Writing and Scholarly Style	Academic tone, accurate citation, and logical argumentation throughout.	Minor lapses in style or citation accuracy.	Several style or citation inconsistencies.	Poor academic tone and missing citations.