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Transforming science education: A qualitative inquiry into empowering teachers through professional development for effective Claim, Evidence, and Reasoning (CER) integration

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Abstract

Integrating a Claim, Evidence, Reasoning (CER) framework into science education is an important shift to help develop students' critical thinking, inquiry, and scientific discourse. While previous research has indicated several benefits to student outcomes when employed CER, little research has considered how teachers might be systematically supported in implementing CER. This qualitative study examined the necessary components of a professional development program for secondary science teachers adopting the CER model. This research took place at Rancho High School in Las Vegas, Nevada, with ten science teachers participating in the study. Open-ended questionnaires and thematic analysis revealed significant components related to assessment, collaboration, implementation, inquiry, support of leadership, interdisciplinary practices, and application to the world outside of the school. Taken together, the findings identified an urgent need for ongoing, contextualized, collaborative professional development structures to assist teachers to meaningfully embed CER processes into their teaching practice. The study concludes that purposeful professional learning experiences are essential for supporting teachers' development of skills, confidence, and resources for deeper student engagement and critical reasoning in consideration of contemporary curriculum standards. This study contributes valuable insights to enhancing the connection between theory and practice in pedagogy to ensure science lessons remain productive and transformative.

Keywords: Claim Evidence Reasoning (CER); Science Education; Professional Development; Critical Thinking; Inquiry-Based Learning

1. Introduction

The Claim, Evidence, Reasoning (CER) framework is a structured approach designed to enhance critical thinking and scientific reasoning among students. It is one of the implemented practices in science classrooms that leads students to prove their free response answers based on evidence and logical reasoning that develops a deeper understanding of scientific concepts and promotes higher-order thinking skills. It involves students making a claim, supporting it with evidence, and providing reasoning that links the evidence to the claim. The integration of the CER learning tool into science education reflects a broader shift towards inquiry-based learning approaches that prioritize student engagement, exploration, and discovery with the aid of technology. The need to explore the CER framework arises from the growing emphasis on inquiry-based learning in science education, which aims to foster higher-order thinking skills and a deeper understanding of scientific concepts among students. This study focuses on investigating the key components of an effective professional development program for teachers aimed at integrating the CER framework into the science curriculum

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Various studies have highlighted the importance and benefits of the CER framework in science education. Research suggests that the CER framework promotes critical thinking, improves student engagement, and enhances understanding of scientific concepts. The emergence of CER (Claim, Evidence, Reasoning) as a tool in education represents a significant advancement in teaching scientific inquiry and argumentation skills [13]. This framework provides a structured approach for students to construct and evaluate scientific explanations, hypotheses, and conclusions based on evidence and logical reasoning. Furthermore, the CER tool fosters communication skills by requiring students to engage in scientific discourse and argumentation, learn how to communicate their findings, justify their conclusions, and involve in productive scientific discussions with their peers clearly and persuasively [4]. It encourages students to think more deeply about scientific questions, analyze data critically, and communicate their ideas effectively. The framework aligns with modern educational standards that emphasize the development of scientific literacy and critical reasoning skills.

Although previous studies have highlighted the advantages of the Claim, Evidence, Reasoning (CER) construct, which promotes scientific thinking and communicating, there is little research on how teachers can be effectively prepared to implement in the classroom. Much of the literature has been focused on student outcomes with little discussion of professional development that could ensure the teachers are prepared to incorporate CER strategies into their practice. There is even less discussion of the implementation challenges and related facets of a teacher instruction model. This study hopes to fill this gap by exploring how professional development could enable teachers to utilize the CER framework in science curriculum.

This research is significant as it aims to support educators in enhancing student learning through structured scientific reasoning and discourse. It can contribute to sustained improvements in science instruction that align with modern educational standards. It also provides insights into how the CER framework can be adapted and scaled in various educational settings, promoting inquiry-based learning. Ultimately, this study contributes to developing a more scientifically literate student population equipped with critical thinking and skills essential for academic and real-world success.

2. Materials and Methods

In exploring the key components of an effective professional development program for teachers focused on integrating the Claim, Evidence, Reasoning (CER) framework in science education, the researchers employed a qualitative approach. The study was conducted at Rancho High School in Las Vegas, Nevada, USA, with the participation of ten secondary science teachers from the Science Department who implemented the CER framework in their instruction throughout the academic year. Open-ended questions were used to gather comprehensive and substantial data on the teachers' professional development. Moreover, confidentiality and anonymity were maintained throughout the study, and informed consent was obtained from all participants.

3. Results and Discussion

Table 1 presents the findings from the qualitative responses of 10 participants on the key components of an effective professional development program for integrating the CER (Claim, Evidence, Reasoning) framework into the science curriculum. The responses were analyzed using thematic analysis to identify recurring patterns and themes. The findings are organized under seven major themes:

Table 1 Key Components of an Effective Teacher Professional Development

Theme	Key points	Respondents highlight
Assessment and Alignment	Creating aligned assessment and rubrics	1,4
Collaboration and Professional Learning Communities	Establishing PLCs to foster collaboration	1,3,6
Practical Implementation	Modelling and hands-on practice with CER strategies	6,10
Critical Thinking and Inquiry	Encouraging inquiry-based learning and reasoning	2,9

Leadership and Sustained Support	Providing guidance from instructional leaders and ongoing support	4,6
Interdisciplinary Integration	Collaborating with other departments, especially English	4
Real-Life Applications	Ensuring relevance by aligning standards and real-world contexts	5,10

3.1.1. Theme 1: Assessment and Alignment

Aligning assessments with the Claim, Evidence, Reasoning (CER) framework is essential to ensure that students' understanding aligns with learning objectives. Respondent 1 emphasized the need for detailed rubrics to provide clarity on expectations. This approach is supported by Eden [5], who discusses the use of CER for assessments across grade levels, highlighting the importance of structured rubrics in guiding both teachers and students. Respondent 4 highlighted the value of shifting towards phenomenon-based approaches, which are advocated in recent educational research for fostering inquiry and evidence-based reasoning. Adipat [1] explores the challenges and benefits of implementing phenomenon-based science education, emphasizing its role in enhancing student engagement and understanding.

3.1.2. Theme 2: Collaboration and Professional Learning Communities

Collaboration through Professional Learning Communities (PLCs) fosters teacher growth and the effective implementation of CER strategies. Respondent 1 noted that PLCs facilitate discussions on aligned assessments, while Respondent 3 emphasized their role in strategy sharing. Recent studies underline that PLCs significantly enhance teacher collaboration, leading to improved classroom practices. For instance, Moulakdi and Bouchamma [8] found that elementary schools functioning as PLCs positively impacted student learning outcomes. Additionally, Nguyen et al. [9] conducted a comprehensive analysis of teacher PLCs, highlighting their pivotal role in fostering continuous professional development for educators. Respondent 6 highlighted the importance of sustained involvement in content development through collaborative efforts.

3.1.3. Theme 3: Practical Implementation

Practical implementation, including modeling and hands-on practice, emerged as essential for professional development. Respondent 10 stressed the importance of active learning experiences for teachers. Lichtenstein and Phillips [7] compared online versus in-person outcomes of a hands-on, lab-based teacher professional development program and found that experiential learning fosters effective strategy adoption. Respondent 6 emphasized the value of sustained application of CER strategies to bridge theory and practice, consistent with evidence suggesting that modeling promotes professional learning. Fies and Packham [6] discussed the benefits of interdisciplinary teams in teacher professional development, highlighting the importance of practical implementation in enhancing teaching practices.

3.1.4. Theme 4: Critical Thinking and Inquiry

Encouraging inquiry-based learning and fostering critical thinking are foundational to the CER framework. Respondent 2 identified the importance of professional development in equipping teachers to support inquiry. Rosado and Rebeiro [10] found that inquiry-based approaches improve student reasoning skills. Respondent 9 noted that CER prepares students for diverse fields, aligning with research linking inquiry-based learning to broader academic success. Qablan et al. [12] emphasized that inquiry-based learning prepares students for success in various fields, highlighting its significance in modern education.

3.1.5. Theme 5: Leadership and Sustained Support

Leadership plays a critical role in ensuring the success of professional development initiatives. Respondent 4 emphasized the need for instructional leaders to be well-versed in CER, while Respondent 6 highlighted the importance of ongoing support. Robinson et al. (2020) confirm that effective leadership and sustained professional development are critical to fostering impactful teaching practices. Additionally, Nguyen et al. [9] discuss the role of leadership in professional learning communities, emphasizing its importance in teacher professional growth.

3.1.6. Theme 6: Interdisciplinary Integration

The integration of CER with other disciplines, particularly English, enhances students' reasoning and communication skills. Respondent 4 suggested collaboration with English departments to strengthen students' abilities in writing evidence-based arguments. Arulsamy and Benjamin [2] highlight that interdisciplinary approaches enrich students' learning experiences by connecting concepts across subjects. Furthermore, Fies and Packham [6] discuss the benefits of interdisciplinary teams in teacher professional development, emphasizing the importance of integrating multiple disciplines to enhance teaching practices.

3.1.7. Theme 7: Real-Life Applications

Linking CER to real-life scenarios ensures greater teacher engagement and relevance for students. Respondent 5 recommended aligning CER strategies with NGSS standards to enhance its applicability, while Respondent 10 emphasized the use of real-world data to increase engagement. Studies show that real-world applications of CER foster deeper learning and motivation. Tapia [11] underscores that contextualizing science education with real-world examples not only makes concepts more relatable but also strengthens problem-solving skills. Similarly, the work by Basir et al. [3] highlights the integration of real-life problems in science curricula as an effective approach to engage students and improve their reasoning abilities.

Moreover, the findings from this study suggest several important implications for science education and teacher professional development. First, aligning instructional strategies with the CER framework allows educators to create a more structured and inquiry-driven learning environment, which fosters higher-order thinking and scientific reasoning among students. Second, fostering collaboration through PLCs and interdisciplinary partnerships enhances teachers' ability to implement innovative teaching approaches, ultimately improving classroom outcomes. Third, incorporating hands-on practices, real-life applications, and sustained leadership support ensures that professional development programs remain practical and relevant, addressing the diverse needs of educators and learners. These implications highlight the importance of a comprehensive approach to teacher training that integrates assessment, collaboration, and contextual learning to enhance both teaching efficacy and student engagement.

4. Conclusion

This study concluded that the integration of the Claim, Evidence, and Reasoning (CER) framework into the science curriculum significantly enhances both teaching practices and student outcomes. Teachers' prior beliefs, knowledge, and experiences were shown to play a critical role in their readiness and ability to adopt the CER framework. Professional development programs were identified as essential tools for building teachers' confidence and competencies, yet these programs need to be tailored to address specific classroom challenges and resource limitations. Thus, professional development programs should focus on equipping teachers with the necessary skills and tools to implement CER effectively. These programs must include ongoing training sessions that provide practical applications of CER principles and create avenues for teachers to collaborate and share experiences. Resources such as CER-aligned lesson plans, assessment templates, and instructional tools should be made accessible to teachers, ensuring that they are well-prepared to address diverse classroom needs.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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