



DEVELOPING PROFESSIONAL COMPETENCIES OF CHEMISTRY TEACHERS THROUGH CONSTRUCTIVE THINKING-ORIENTED INSTRUCTION: A SHORT EMPIRICAL STUDY

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Abstract

The growing emphasis on competency-based education has significantly reshaped expectations toward teachers' professional practice across different educational systems. In science education, particularly in chemistry teaching, professional effectiveness increasingly depends not only on subject knowledge but also on teachers' ability to analyze instructional situations, adapt pedagogical decisions, and critically reflect on their own practice. Chemistry teachers regularly face complex instructional challenges related to abstract concepts, experimental uncertainty, laboratory safety, and diverse student misconceptions. These challenges require a high level of cognitive flexibility and reflective judgment.

This study examines a constructive thinking-oriented instructional approach aimed at developing chemistry teachers' professional competencies. Using a qualitative-analytic methodology complemented by an empirical diagnostic component, a conceptual instructional model was developed and examined. Data were collected through a Likert-scale questionnaire designed to assess teachers' constructive thinking in instructional and laboratory contexts. The study involved in-service chemistry teachers participating in professional development activities. Descriptive analysis indicates that higher levels of constructive thinking are associated with stronger methodological planning, adaptive instructional behavior, and reflective practice. Although the study does not establish causal relationships, the findings suggest that constructive thinking-oriented instruction may serve as an effective framework for supporting sustainable professional development of chemistry teachers. The study contributes to teacher education research by offering an empirically informed, practice-oriented model suitable for in-service training programs in chemistry education.



Keywords: Constructive thinking; teacher competencies; chemistry education; reflective practice; professional development

Introduction

Contemporary educational reforms increasingly prioritize competency-based approaches as a means of improving instructional quality and learner outcomes. Within this paradigm, teachers are expected to move beyond the traditional transmission of subject content and actively design learning environments that foster analytical reasoning, problem solving, and reflective learning. Competency-based education emphasizes not only what teachers know, but also how they apply knowledge in dynamic instructional contexts.

This shift is particularly relevant in science education, where teaching involves complex interactions between theoretical concepts, experimental activities, and students' conceptual understanding. Chemistry education, in particular, poses unique challenges due to the abstract nature of chemical concepts, the symbolic language of the discipline, and the necessity of laboratory-based instruction. Chemistry teachers must simultaneously manage conceptual explanations, experimental design, safety procedures, and students' cognitive engagement. As a result, effective chemistry teaching requires a high level of professional competence that integrates subject knowledge, pedagogical skills, and reflective judgment.

In addition, laboratory instruction in chemistry is often characterized by unpredictability. Experimental outcomes may differ from expectations due to measurement errors, material quality, or environmental conditions. Teachers must be able to interpret these unexpected results constructively, transforming them into learning opportunities rather than instructional failures. This ability reflects a deeper level of professional thinking that goes beyond routine pedagogical actions.

Reflective pedagogy highlights that professional growth is closely linked to teachers' capacity to analyze their own instructional decisions and respond constructively to pedagogical challenges. Within this framework, constructive thinking can be understood as a meta-cognitive orientation that enables teachers to reinterpret difficulties, regulate emotions, and make adaptive decisions. Constructive thinking supports teachers in viewing challenges as opportunities for professional learning and instructional improvement.



Despite its relevance, constructive thinking is often addressed implicitly rather than systematically within teacher education and professional development programs. Many in-service training initiatives focus primarily on methodological updates or curricular changes, leaving limited space for the explicit development of reflective and constructive thinking skills. This gap is particularly evident in chemistry teacher professional development, where technical and content-related issues tend to dominate.

The present study aims to address this gap by examining a constructive thinking-oriented instructional approach designed to support the development of chemistry teachers' professional competencies. Specifically, the study seeks to conceptualize and empirically explore how constructive thinking may be integrated into instructional design and in-service teacher education. By combining conceptual modeling with empirical observation, the study contributes to ongoing discussions on sustainable and reflective professional development in chemistry education.

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2. Literature Review

2.1 Constructive Thinking in Education

The concept of constructive thinking originates from broader discussions of cognitive, emotional, and reflective processes in professional practice. Constructive thinking refers to an individual's ability to interpret challenging situations in a flexible, solution-oriented manner, avoiding rigid, emotionally driven, or dysfunctional cognitive responses. In educational contexts, constructive thinking is closely associated with adaptive problem solving, emotional self-regulation, and reflective judgment, all of which are essential for effective teaching in complex learning environments.



Educational theorists have long emphasized the importance of reflective cognition in teaching. Dewey conceptualized reflection as an active, persistent, and careful consideration of beliefs and practices in light of their consequences, arguing that reflective thinking is fundamental to professional growth. Building on this foundation, Schön introduced the notion of the reflective practitioner, highlighting teachers' capacity to engage in reflection-in-action and reflection-on-action while dealing with real instructional situations. These theoretical perspectives underscore the idea that effective teaching requires ongoing interpretation, evaluation, and reconstruction of professional experience.

Contemporary research further suggests that constructive thinking supports teachers' ability to cope with uncertainty, ambiguity, and instructional complexity. Teachers who demonstrate higher levels of constructive thinking are more likely to reinterpret instructional challenges, experiment with alternative strategies, and maintain professional resilience in the face of difficulties. In contrast, limited constructive thinking may result in rigid instructional behavior, reliance on routine practices, and resistance to pedagogical change.

In teacher education, constructive thinking has been linked to the development of metacognitive awareness and self-regulated professional learning. Through constructive thinking, teachers learn to critically evaluate their instructional assumptions, recognize emotional responses to classroom challenges, and consciously adjust their pedagogical decisions. As a result, constructive thinking functions as a key component of reflective and competency-based teaching models, supporting both professional autonomy and continuous development.

2.2 Teacher Professional Competencies and Reflective Practice

Professional competence in teaching is widely understood as a multidimensional construct encompassing subject knowledge, pedagogical skills, methodological planning, classroom management, and reflective abilities. Competency-based models of teacher education emphasize not only the acquisition of knowledge, but also the ability to apply this knowledge effectively in diverse and dynamic instructional contexts.

Reflective practice is consistently identified as a central mechanism for developing professional competencies. Through reflection, teachers analyze instructional experiences, identify strengths and weaknesses in their practice, and refine



pedagogical strategies. Reflective practice supports professional autonomy and enables teachers to respond adaptively to changing curricular requirements, student needs, and institutional expectations. (Darling-Hammond et al., 2017).

Empirical studies on teacher professional development indicate that reflective activities—such as case-based discussion, reflective journaling, lesson analysis, and collaborative inquiry—contribute to deeper and more sustainable professional learning than transmissive training formats. These activities encourage teachers to engage with authentic instructional challenges and to construct personal and professional meaning from experience.

Constructive thinking plays a mediating role in reflective practice by shaping how teachers interpret and respond to instructional difficulties. Teachers with a constructive thinking orientation are more likely to view student errors, classroom disruptions, or unsuccessful lessons as opportunities for learning rather than as threats to professional identity. Consequently, constructive thinking supports the development of methodological, reflective, and adaptive competencies that are essential for effective teaching. (Schön, 1983; Brookfield, 2017).

2.3. Chemistry Education and In-Service Teacher Development

Chemistry education presents specific instructional and professional challenges that significantly influence teacher development. The discipline relies heavily on abstract models, symbolic representations, and experimental procedures, requiring teachers to continuously balance conceptual explanation with practical application. Additionally, laboratory instruction introduces safety concerns, time constraints, and technical limitations that demand careful planning and situational awareness.

Research in chemistry education highlights that teachers often encounter difficulties in addressing students' misconceptions, managing laboratory uncertainty, and implementing inquiry-based approaches. Unexpected experimental outcomes, limited laboratory resources, and heterogeneous student preparedness frequently require teachers to make rapid pedagogical decisions. These challenges underscore the need for professional development programs that move beyond content updating and explicitly address teachers' cognitive, reflective, and decision-making skills.

In-service teacher development in chemistry is most effective when it is practice-oriented, collaborative, and reflective. Programs that incorporate problem-based learning, lesson study, classroom inquiry, and peer discussion have been shown to



support sustainable professional growth. Such approaches allow teachers to analyze authentic instructional situations, exchange professional experiences, and collectively construct solutions to pedagogical challenges.

Within these programs, constructive thinking can serve as a unifying framework that helps teachers navigate complexity, reinterpret difficulties, and sustain professional motivation. Teachers who develop constructive thinking skills are better equipped to treat laboratory uncertainty, student errors, and instructional setbacks as opportunities for learning and professional improvement.

Despite these insights, explicit attention to constructive thinking remains limited in chemistry teacher education literature. Most professional development initiatives focus primarily on methodological techniques or curricular reforms, while the cognitive and reflective dimensions of professional practice receive comparatively less emphasis. This study addresses this gap by proposing and examining a constructive thinking-oriented instructional model tailored to the specific demands of chemistry teaching.

2.4 Local Scholarly Context (Uzbekistan)

In the context of Uzbekistan, teacher professional development has increasingly emphasized competency-based and reflective approaches aligned with national education reforms. National studies highlight the importance of developing teachers' methodological, reflective, and adaptive competencies to improve instructional quality in general secondary education (Abdullaeva, 2021; Saidova, 2019).

Research in chemistry education conducted by Uzbek scholars indicates that inquiry-oriented and reflective instructional practices contribute to improved professional performance and classroom effectiveness (Iskandarov, 2020; Qalandarova & Rahmonova, 2022). These studies emphasize that chemistry teachers often face challenges related to laboratory implementation, student misconceptions, and curriculum adaptation, which require reflective judgment and flexible pedagogical decision-making.

In addition, national policy documents, including the State Education Standard and the National Curriculum for Chemistry, explicitly promote competency-based education, reflective teaching practices, and the integration of theory and practice in teacher professional development (Ministry of Preschool and School Education of the Republic of Uzbekistan, 2023a; 2023b). Within this framework, constructive



thinking-oriented instruction can be viewed as a pedagogically relevant approach that aligns international theoretical perspectives with local educational priorities.

3. Research Methodology

The study employed a qualitative-analytic research design supplemented by an empirical diagnostic component. This methodological combination was selected to enable in-depth conceptual modeling while also providing empirical insight into chemistry teachers' constructive thinking practices. The qualitative-analytic approach allowed for the systematic examination of theoretical perspectives and pedagogical concepts, whereas the empirical component offered descriptive evidence drawn from professional practice.

The research design reflects the exploratory nature of the study. Rather than aiming to establish causal relationships, the study seeks to identify meaningful tendencies and associations between constructive thinking and key aspects of teachers' professional competencies. Such an approach is appropriate for investigating complex cognitive and reflective constructs that are closely embedded in professional contexts. Research in chemistry education highlights persistent challenges related to abstract conceptualization, student misconceptions, and laboratory uncertainty (Taber, 2014; Van Driel et al., 2001). These challenges require teachers to engage in continuous reflective and adaptive decision-making.

3.1 Conceptual and Analytical Methods

A systematic analysis of international and national literature on constructive thinking, reflective practice, and teacher professional development was conducted. The literature review focused on identifying theoretical foundations, conceptual definitions, and empirical findings related to reflective cognition, professional competence, and adaptive teaching practices, particularly in science and chemistry education.

Pedagogical modeling was employed as a central analytical method to develop a conceptual instructional framework oriented toward constructive thinking in chemistry education. This method involved synthesizing theoretical insights with practical considerations derived from teaching practice. The resulting model emphasizes the integration of theoretical knowledge, practical experience, and reflective analysis as mutually reinforcing components of professional learning.



In addition, existing in-service training programs for chemistry teachers were examined to identify instructional practices that either support or limit the development of constructive thinking. Training materials, program structures, and commonly used instructional strategies were analyzed to determine the extent to which reflective and problem-oriented activities were embedded in professional development initiatives. The findings of this analysis informed the design of the proposed instructional model by highlighting the need for more explicit attention to constructive thinking processes within teacher training contexts.

3.2 Empirical Component

As part of the empirical component, a diagnostic questionnaire was developed to assess teachers' constructive thinking tendencies in instructional and laboratory contexts. The instrument employed a five-point Likert scale, ranging from strong disagreement to strong agreement, and was designed to capture teachers' self-reported approaches to instructional challenges.

The questionnaire included statements related to:

- adapting lessons when experimental results are unexpected;
- using problem-based situations in laboratory instruction;
- treating students' errors as instructional resources rather than failures;
- reflecting on instructional decisions after lessons;
- adjusting pedagogical strategies in response to students' learning needs.

These items were formulated to reflect key dimensions of constructive thinking, including cognitive flexibility, reflective judgment, and adaptive decision-making. The instrument was reviewed for clarity and relevance to ensure its suitability for in-service chemistry teachers.

The questionnaire was administered to chemistry teachers participating in professional development activities. Participation was voluntary, and responses were analyzed anonymously. Given the exploratory nature of the study, data were analyzed using descriptive statistical techniques, such as frequency distributions and mean score comparisons, to identify general tendencies and patterns in teachers' responses. This analytical approach allowed for an initial empirical examination of constructive thinking within professional practice without making inferential claims beyond the scope of the data.



4. Constructive Thinking-Oriented Instructional Model

The proposed instructional model is grounded in the assumption that professional competencies develop most effectively when teachers actively engage in reflective and problem-centered learning processes. Rather than viewing professional development as the passive acquisition of methodological knowledge, the model conceptualizes teacher learning as an active, experience-based, and cognitively demanding process.

The model is designed specifically for the context of chemistry education, where instructional complexity, laboratory uncertainty, and diverse student learning needs require teachers to make continuous pedagogical decisions. By foregrounding constructive thinking, the model aims to support teachers in interpreting instructional challenges as opportunities for professional learning and adaptive practice.

Constructive thinking is positioned in the model as a central meta-competence that connects experience, reflection, and instructional action. Through structured engagement with authentic pedagogical problems, teachers are encouraged to examine their instructional assumptions, regulate emotional responses to difficulties, and develop flexible decision-making strategies. In this way, the model aligns with contemporary competency-based and reflective approaches to teacher education.

4.1 Core Principles

The model is based on four interconnected principles that collectively support the development of teachers' professional competencies.

Reflective analysis refers to the systematic examination of instructional decisions and outcomes. Teachers are encouraged to reflect both during instruction and after lessons in order to evaluate the effectiveness of pedagogical strategies, identify areas for improvement, and generate alternative approaches. Reflective analysis supports the development of professional self-awareness and continuous learning.

Problem-oriented learning emphasizes engagement with authentic pedagogical challenges derived from real classroom and laboratory situations. Instead of working with abstract or idealized scenarios, teachers analyze concrete instructional problems, such as unexpected experimental results or student misconceptions. This principle promotes active cognitive involvement and supports the transfer of learning to professional practice.



Integration of theory and practice involves linking conceptual knowledge with classroom and laboratory experiences. Teachers are guided to connect theoretical perspectives on learning, instruction, and assessment with their own professional experiences. This integration helps teachers construct coherent professional knowledge structures and avoid fragmented or purely procedural teaching practices.

Collaborative pedagogical dialogue highlights the role of professional interaction and peer reflection in teacher learning. Through collaborative discussion, teachers share experiences, compare interpretations of instructional challenges, and co-construct pedagogical solutions. Such dialogue fosters collective professional knowledge and enhances reflective judgment.

Together, these principles aim to transform professional development activities from passive knowledge acquisition into active cognitive engagement. By embedding reflective, problem-centered, and collaborative processes into professional learning, the model supports the sustainable development of chemistry teachers' professional competencies.

4.2 Model Components

The main components of the model and their expected outcomes are summarized below:

Competency Type	Developmental Activity	Expected Outcome
Constructive thinking	Work with practical problem situations	Adaptive decision-making
Methodological competence	Purposeful planning and analysis of practical lessons	Improved instructional effectiveness
Reflective competence	Post-lesson reflection	Professional growth

Table 1. Components of the constructive thinking-oriented instructional model

5. Findings and Discussion

5.1 Empirical Findings

Descriptive analysis of the questionnaire responses indicates that teachers who reported higher levels of constructive thinking also demonstrated stronger tendencies toward reflective analysis and methodological planning. In particular, teachers who perceived unexpected experimental outcomes as learning opportunities rather than instructional failures were more likely to report adaptive instructional strategies, such as modifying lesson flow, encouraging student hypothesis generation, and facilitating reflective discussion after laboratory activities.



Teachers with higher constructive thinking scores also tended to express greater confidence in managing laboratory uncertainty and student misconceptions. These teachers reported being more willing to adjust planned instructional procedures in response to situational factors, including time constraints, equipment limitations, and variations in students' prior knowledge. Such flexibility reflects an important dimension of professional competence in chemistry education, where rigid adherence to pre-planned procedures may limit meaningful learning opportunities.

Rather than suggesting causal relationships, the findings indicate a consistent tendency for constructive thinking to co-occur with enhanced professional competencies, particularly reflective and methodological competencies. Teachers who demonstrated constructive thinking were more likely to engage in post-lesson reflection, analyze instructional effectiveness, and consider alternative pedagogical approaches for future lessons. This pattern supports the conceptual assumption that constructive thinking functions as a facilitating mechanism within professional practice, enabling teachers to integrate experience-based learning into their instructional repertoire.

5.2 Discussion

The findings align with reflective pedagogy frameworks, which emphasize the central role of reflective cognition in teachers' professional growth. Constructive thinking enables teachers to reinterpret instructional challenges not as personal or professional shortcomings, but as opportunities for learning, experimentation, and improvement. This orientation is particularly significant in chemistry education, where laboratory work is inherently unpredictable and requires continuous pedagogical adjustment. From a theoretical perspective, the results support models of teacher professionalism that view competence as dynamic and context-dependent rather than static. Constructive thinking contributes to this dynamic understanding by supporting teachers' ability to make informed, situationally appropriate decisions. In this sense, constructive thinking serves as a cognitive bridge between experience and professional learning, transforming everyday instructional challenges into sources of professional insight.

From a professional development perspective, the findings suggest that in-service training programs should explicitly incorporate activities that promote constructive thinking. Such activities may include structured case analysis of laboratory incidents,



reflective journaling focused on instructional decision-making, and collaborative problem-solving tasks based on authentic classroom scenarios. These approaches encourage teachers to articulate their reasoning, examine alternative strategies, and develop shared professional knowledge.

Moreover, collaborative reflective activities appear particularly valuable in fostering constructive thinking. Through professional dialogue and peer feedback, teachers can compare interpretations of instructional challenges, broaden their pedagogical perspectives, and strengthen reflective judgment. Integrating such practices into chemistry teacher professional development may enhance the sustainability and transferability of learning outcomes.

5. Conclusion and Implications

This study highlights the importance of constructive thinking as a foundational element in the development of chemistry teachers' professional competencies. By proposing and examining a constructive thinking-oriented instructional model, the study contributes to contemporary discussions on reflective practice, competency-based teacher education, and sustainable professional development.

The findings suggest that integrating constructive thinking into in-service training programs may strengthen teachers' adaptive capacity, reflective practice, and methodological effectiveness. In the context of chemistry education, where instructional complexity and experimental uncertainty are common, constructive thinking supports teachers in maintaining professional flexibility and resilience.

While the empirical component of the study is exploratory and based on descriptive analysis, it provides initial evidence for the relevance of constructive thinking in professional competence development. The study does not claim causal relationships, but rather highlights meaningful associations that warrant further investigation.

Future research may expand this work by employing longitudinal research designs, larger samples, and inferential statistical methods to examine the impact of constructive thinking-oriented instruction on teaching quality and student learning outcomes. Additionally, qualitative methods such as interviews and classroom observations may provide deeper insight into how constructive thinking manifests in everyday chemistry teaching practice.

Practically, the proposed instructional model may serve as a methodological framework for designing and improving professional development programs in



chemistry education and related science disciplines. By explicitly addressing constructive thinking, such programs may better support teachers in navigating instructional complexity and sustaining long-term professional growth.

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