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A Scoping Umbrella Review of Competency-Based Education: Part I– A Descriptive Analysis of Trends, Practices, and Gaps

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Competency-based education (CBE) has been increasingly adopted and popularized across diverse disciplines and professional fields. However, its implementation faces challenges due to the absence of a unified framework. Part I of this study aims to explore different theoretical approaches to CBE and to identify key approaches, emerging trends, and focal areas across diverse educational contexts, fields, and regions. A scoping umbrella review was conducted to synthesize evidence on CBE from systematic reviews, meta-analyses, and other reviews. Searches were performed across five databases by an experienced librarian, focusing on CBE frameworks and outcomes. Only peer-reviewed articles published in English were included. Four reviewers screened articles using Covidence software, resolving disagreements through discussion and collaboration. The umbrella review of 36 articles reveals key trends: (1) most are literature or systematic reviews, (2) published between 2017 and 2022, (3) primarily from the U.S. and Canada, and (4) focused on higher education and medical/health sciences. The review identifies three categories of theoretical approaches: theories, models, and frameworks. This review highlights the evolving theoretical foundations of CBE and its increasing application across various disciplines. The integration of various theories, models, and frameworks into a cohesive meta-framework emerges as a critical next step.

Keywords: competency-based education, taxonomy of theoretical approaches, scoping umbrella review

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Introduction

Competency-Based Education (CBE) represents a transformative shift in learning, prioritizing the mastery of skills and knowledge over a traditional time-based progression (Frank et al., 2024; Hamed et al., 2023; Ryan & Cox, 2017). The shift toward competency-based learning and instruction aligns with Farbman et al.'s (2015) recommendation to design educational programs that account for the varying time students need to achieve mastery-level skills and to base student advancement on demonstrated proficiency rather than time spent in the classroom. This transformative framework emphasizes personalized, learner-centered education, aligning closely with the evolving needs of diverse professional fields. This dynamic approach has become a cornerstone across diverse fields, including education, engineering, medicine, and nursing. In education, CBE empowers learners to progress at their own pace, accommodating different learning styles and individual needs while fostering a flexible and personalized experience (Sturgis & Casey, 2018). This shift from conventional classrooms to tailored learning environments not only improves knowledge retention but also builds confidence and autonomy, preparing students to excel in professional settings (Poh, 2024).

The value of CBE extends beyond general education into specialized fields. In engineering and medicine, it equips practitioners with practical, hands-on expertise essential for addressing complex challenges (Henri et al., 2017; Imanipour et al., 2022). This focus on applied learning enhances individual performance while elevating the quality of service and care. Similarly, in nursing, CBE emphasizes the development of critical skills necessary for patient safety and high-quality healthcare delivery. By integrating theoretical knowledge with practical application, nursing graduates emerge as competent and confident professionals ready to meet the demands of the real world (Lewis et al., 2022). The holistic nature of CBE, focusing on both knowledge acquisition and skill demonstration, ensures that graduates are well-equipped to navigate the complexities of their chosen fields and contribute meaningfully to their professions from the outset of their careers.

CBE holds significant potential, yet its advancement is hindered by the lack of a unified and comprehensive framework to guide its research, development, and implementation. Ryan and Cox (2017) observed that despite growing interest in CBE within the education sector, research has lagged behind its practical adoption and implementation. Similarly, previous studies investigating factors that influence CBE implementation have struggled to establish a cohesive body of scientific knowledge or effectively integrate existing literature. This gap has left critical questions unanswered about what is currently understood about CBE and how future research should advance (Açıkgöz & Babadoğan, 2021). The absence of a shared framework has also led to fragmented theoretical approaches, which undermine the scalability and effectiveness of CBE. Furthermore, without a robust theoretical foundation, it is difficult to analyze the mechanisms driving CBE's successes and failures, which limits the identification of predictive factors and the development of strategies to enhance its outcomes.

A well-defined framework is crucial to addressing these challenges and unlocking the full potential of CBE. First, it provides a clear structure for understanding the core components of CBE and their interrelationships. By fostering a shared language among researchers, practitioners, and policymakers, a robust framework minimizes ambiguity and ensures consistency across disciplines and applications (Açıkgöz & Babadoğan, 2021; Morrison, 2018). Second, a comprehensive framework facilitates the evaluation and comparison of CBE models. It enables the identification of effective strategies and the contexts in which they thrive, supporting evidence-based decision-making and enhancing the implementation and scalability of these strategies. A strong theoretical foundation also lends credibility to CBE, fostering greater acceptance among educators, employers, and policymakers by positioning it as a rigorous and reliable educational approach. Lastly, a unified framework promotes interdisciplinary collaboration by integrating insights from diverse fields, including education, psychology, engineering, and healthcare (Cravero et al., 2024). This convergence of expertise enhances CBE's adaptability and effectiveness, ensuring its relevance in a diverse range of contexts. Without such a framework, CBE risks stagnation and may fail to achieve its transformative potential in education and workforce development.

Objectives

This scoping umbrella review is structured in two parts. Part I examines the diverse theoretical approaches to CBE that have been employed across various disciplines, identifying key factors that influence CBE outcomes. Part I will be conducted through a descriptive and narrative analysis of selected reviews of reviews on CBE. Part II synthesizes these theoretical approaches into a unified meta-framework for CBE. The primary objectives of Part I are: (1) to propose a taxonomy that categorizes different theoretical approaches to CBE research and practice, and (2) to identify key approaches, emerging trends, and focal areas across the diverse educational contexts, fields, and regions. Part II synthesizes these theoretical approaches into a unified meta-framework for CBE by synthesizing existing theories, models, and frameworks. Part I aims to address the following research questions:

1. What are the key approaches, emerging trends, and focal areas across diverse educational contexts, fields, and geographical regions?
2. What theoretical approaches, including theories, models, and frameworks, are utilized in CBE across different contexts and disciplines?

Methods

A Scoping Umbrella Review

Rather than reviewing primary sources, we conducted a scoping umbrella review, also known as a 'review of reviews,' to synthesize review-level evidence on CBE (Brooks et al., 2023). This approach integrates findings from multiple review types, including systematic reviews, meta-analyses, and narrative, scoping, and thematic reviews, offering a comprehensive overview of theoretical approaches to CBE.

The scoping umbrella review in this study consolidates key theories, models, and frameworks into a unified meta-framework to inform the effective design, development, and implementation of CBE. This method allowed us to identify and synthesize foundational elements of CBE into a meta-framework for broad application.

Data Sources and Search Strategy

Searches for reviews were developed and conducted by an experienced research librarian (SRM) in five electronic bibliographic databases. These databases included: PubMed, Web of Science Core Collection, ProQuest PsycINFO, Academic Search Complete, and ProQuest ERIC. The search string for PubMed was developed and then translated as appropriate for each of the other databases (see Supplementary 1). The search consisted of both controlled vocabulary and natural language terms that would represent the three primary concepts of the study: 1) competency-based education, 2) a theory, model, or framework, and 3) an evidence synthesis in the form of a published review.

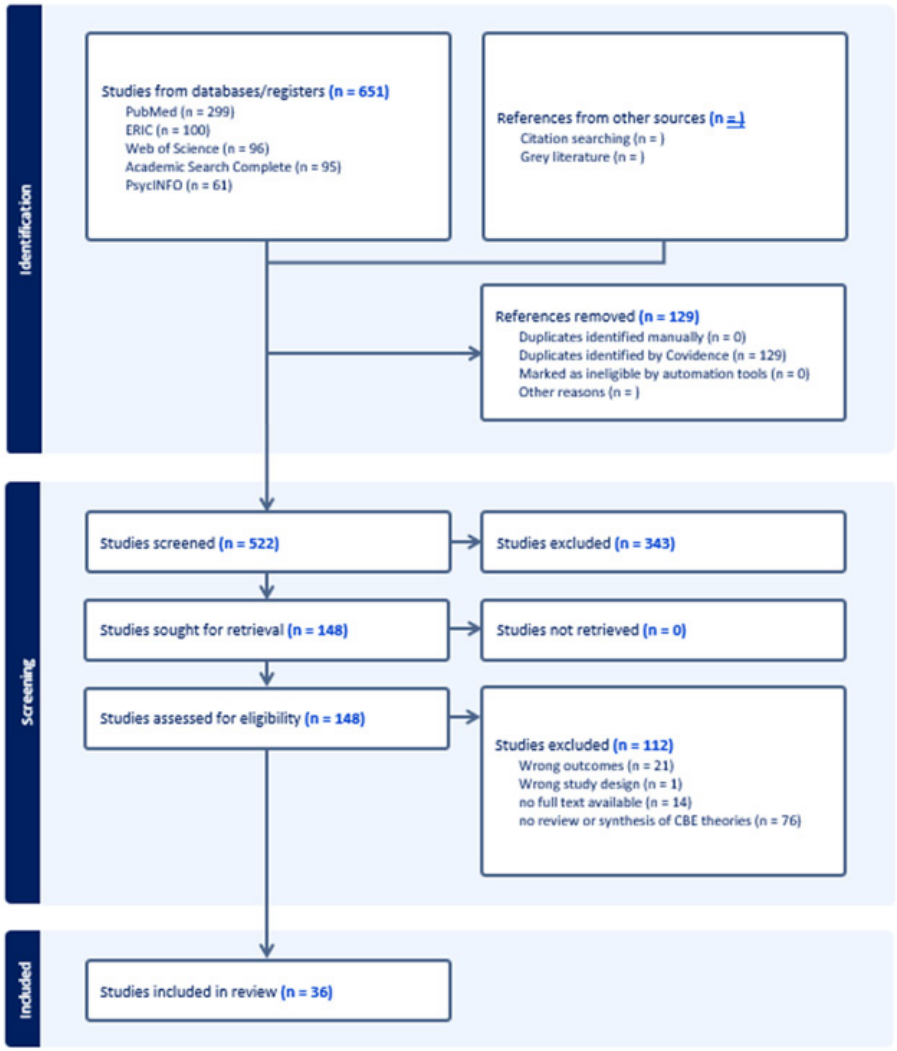
The inclusion criteria were that the articles had to present theoretical or conceptual frameworks related to CBE, include factors, elements, or processes within theories, models, or frameworks that may impact CBE outcomes, be published in peer-reviewed scholarly conference proceedings or academic journals, and be available in English. Exclusion criteria included articles that were book chapters, textbooks, handbooks, reports, dissertations, study proposals, discussion forums, trade magazines, abstracts only, or those unavailable in full text, or written in a language other than English.

The decision to limit the review to English-language publications was based on feasibility and resource constraints (e.g., translation capabilities) and to maintain consistency in the interpretation of theoretical constructs. While this approach may limit the ability to capture perspectives from non-English sources, it ensured methodological rigor in data extraction and analysis. Consequently, findings regarding country-level contributions should be interpreted with caution, as they primarily reflect English-language scholarship.

Screening and Quality Assessment

Potential reviews were imported into Covidence software (Veritas Health Innovation, 2024), where duplicates were identified and removed. Four reviewers, working in pairs, conducted an initial title and abstract screening, followed by a full-text review. Articles advanced to the next review stage only when both reviewers agreed on inclusion or exclusion criteria. Any unresolved questions were brought to the team for collaborative decision-making and resolution. Screening primarily excluded results that did not review theoretical and conceptual frameworks, with any ambiguities discussed among all reviewers.

Figure 1.
Flow Diagram of the Screening Process



Results

This section presents a comprehensive analysis of 36 carefully selected articles that form the foundation of our review of CBE. We provide a detailed examination of the key features of these articles, introduce a taxonomy of theoretical approaches to CBE, and offer an in-depth exploration of the theories, models, and frameworks addressed in the literature. Our findings delineate a rich and nuanced picture of the

theoretical landscape underpinning CBE, illuminating key approaches, emerging trends, and focal areas across diverse educational contexts, fields, and geographical regions. This synthesis aims to equip researchers and educators with a holistic understanding of the conceptual foundations that drive CBE implementation and research.

Key Features of Studies

The key features of the 36 articles selected for this umbrella review on CBE are summarized, including review type, publication year, country, context, field, search period, and the theories, models, or frameworks addressed (see Appendix 1 for full details). The summary reveals a predominance of literature reviews (13 articles) and systematic reviews (7 articles) within the examined CBE literature. These review types account for over half of the reviewed articles, suggesting that the field is currently focused on synthesizing existing knowledge and establishing foundational concepts and frameworks rather than conducting primary research or experimental studies. This emphasis on synthesis indicates a collective effort to consolidate diverse perspectives on CBE, particularly given the array of theories, models, and frameworks that have been documented. The variety of review types, including scoping, narrative, meta-analytic, and thematic, demonstrates a multidimensional approach to exploring CBE. This diversity of perspectives offers a comprehensive understanding of CBE across different countries, contexts, and fields, contributing to a robust body of literature that informs future research and policy discussions. The concentration of literature and systematic reviews highlights both the maturation of foundational knowledge in CBE and a focus on synthesizing complex findings into coherent, applicable models. This approach provides a solid basis for advancing CBE research and implementation across various educational settings.

Publication years of the reviews span from 1987 to 2022, with a notable increase in the number of publications in recent years. Most of the reviews were published between 2017 and 2022, indicating a growing interest in synthesizing CBE-related theories, models, and frameworks in the past few years. Geographically, the reviews originate from a diverse set of countries, with a significant concentration in North America, particularly the United States and Canada. European countries, such as the United Kingdom, Germany, and the Netherlands, as well as Australia, also make substantial contributions to the body of CBE review literature. This distribution reflects the volume of English-language publications originating from these regions; however, it does not necessarily indicate that these regions are leading in CBE research and implementation globally, as publications in other languages were not included in this review.

In terms of educational contexts, the reviews predominantly focus on higher education and medical/health sciences education. This concentration suggests that CBE has been actively employed in these sectors, possibly due to their emphasis on professional competencies and outcome-based learning. The field of study closely aligns with educational contexts, with medical and health sciences, as well as general education, dominating the landscape, further reinforcing the prominence of

CBE in healthcare-related disciplines and broader educational settings. The search periods covered by the reviews vary widely, with many spanning more than two decades. This approach allows for a comprehensive historical perspective on CBE development, capturing its evolution over time. Some reviews focus on more recent literature, reflecting the rapid developments in the field.

The articles reviewed reveal a diverse range of approaches and concepts related to CBE. CBE models are the most frequently addressed, appearing in multiple reviews and focusing on core principles and implementation strategies across various educational contexts. Closely related frameworks such as outcomes-based education (OBE) and mastery learning (ML) are also prominently discussed alongside CBE. OBE emphasizes the importance of defining and assessing specific learning outcomes, while ML focuses on achieving a mastery level of skills and knowledge through individualized learning (Bisgaard et al., 2018). These approaches share common elements with CBE, contributing to a rich theoretical landscape. The reviews encompass a variety of additional theories, models, and frameworks, reflecting the multifaceted nature of CBE and its adaptations across different disciplines and educational contexts. This diversity highlights the ongoing development and refinement of CBE-related approaches in response to evolving educational needs and challenges. Overall, the literature demonstrates a complex and interconnected web of educational theories and practices, with CBE at its center, continually evolving to meet the demands of modern education and professional training.

Taxonomy of Theoretical Approaches to CBE

Through an umbrella review of the literature on CBE, we developed a taxonomy that distinguishes between various theoretical approaches, including theories, models, and frameworks. Table 1 provides a summary of the definitions and descriptions of the three distinct theoretical approaches in CBE.

Theories provide the conceptual foundation for CBE, explaining why learning occurs and why certain instructional strategies are effective. They include general learning theories, such as behaviorism, cognitive learning, and social learning, as well as educational approaches aligned with CBE principles, such as OBE and ML. Models are process-oriented representations that operationalize theories into structured steps, stages, or cycles, illustrating how learning and skill acquisition occur. Stage-based, pedagogical, and cyclical models guide learners and instructors in progressing toward mastery, designing learning experiences, and engaging in iterative reflection and improvement.

Frameworks provide practical structures that define what learners need to achieve and how to measure their progress. They specify competencies, learning outcomes, and assessment strategies. Examples include assessment frameworks, competency frameworks, and curriculum implementation frameworks, which support the design, evaluation, and operationalization of CBE programs and ensure measurable, observable outcomes. Based on the definitions and descriptions of the three theoretical approaches, we developed a taxonomy of theoretical approaches to CBE. Table 2 presents these three approaches, including theories, models, and frameworks, along with their respective sub-categories.

Table 1
Definitions and Descriptions of Theories, Models, and Frameworks in CBE

Theoretical Approach	Definition	Description
Theories	General explanations of learning or behavior that underpin CBE practices.	Theories in CBE describe core factors, elements, or components of CBE or CBE-related approaches (i.e., mastery learning, outcome-based education), or explore underpinnings of CBE (e.g., behavioristic learning theory, cognitive learning theory, social cognitive and learning theory, psychological theory, and motivational theory).
Models	Process-oriented representations specifying steps, stages, or phases in learning or skill acquisition within CBE.	Models specify steps, stages, and phases in individual learner development and growth, focusing on knowledge, skills, and competency, or describe curriculum development or evaluation. Note that most models employ stage-based or phase-based approaches, which are aligned with the novice-to-expert continuum.
Frameworks	Structured approaches that guide the design, implementation, and assessment of CBE programs and competencies.	Frameworks offer a structured approach to developing and assessing competencies through observable and measurable professional practices, as well as designing and implementing CBE programs.

Table 2
Taxonomy of Theoretical Approaches to CBE

Taxonomy	Theories, Models, and Frameworks Addressed in the Literature
Taxonomy 1. Theory	
1-1. Similar Educational Approaches to CBE	• Mastery learning model [1, 2, 6, 11, 14, 15, 16, 17, 28, 29, 34] • Outcomes-based education [3, 15, 30, 33]
1-2. Theories of Supporting CBE	• Behaviorism [1, 4, 16, 17, 25] o Stimulus-response theory o Thorndike's transfer of learning theory o Functional contextualism ▪ Relational frame theory • Cognitive learning theory [7, 19] o Cognitive load theory o Meaningful Learning Theory o Jeannerod's motor simulation theory • Constructivism [10] • Social cognitive and learning theory [13, 19] o Bandura's theory of social learning o Social cognitive theory o Teunissen's experiences-trajectories-reifications framework • Psychological theory [13, 17, 19, 34] o Ericsson's deliberate practice model o Theory of Planned Behavior o Social identity theory • Motivational theory [23, 35] o Achievement goal theory o Self-determination theory
Taxonomy 2. Model	
2-1. Stage-Based Models	• Dreyfus and Dreyfus Stages of Learning [8, 21, 24, 33] • Fitts and Posner's three-stage model of motor skills acquisition [19, 31] • Simpson's and Harrow's Taxonomy of the Psychomotor Skill Development [24]

Taxonomy	Theories, Models, and Frameworks Addressed in the Literature
2-2. Pedagogical Models	• Six-step Pedagogical Framework [24] • Kovacs's psychomotor learning theory [24] • Gallagher and colleagues' 8-step model [31] • McClusky and Smith's 3-step model [31] • Aggarwal and colleagues' competency-based framework for systematic training and assessment of technical skills [31] • Concrete-representation-abstract (CRA) model [17] • Rodolfa's Cube model of development of foundational competencies [32]
2-3. Cyclical Models	• Kolb's experiential learning theory [6, 21] • Self-regulated learning [2, 11, 13, 23]
Taxonomy 3. Framework	
3-1. Assessment Framework	• Entrustable Professional Activities [8, 9, 12, 18, 27] • Miller's pyramid of clinical competence [10, 22, 26] • Informed self-assessment framework [13] • Framework for a system of assessment [36] • Mager model for learning outcomes [35]
3-2. Learning Framework	• Bloom's taxonomy [15]
3-3. CBE Competency Framework	• Cheetham & Chivers Models of Professional Competence [5] • International Pharmaceutical Federation (FIP) Needs-based professional educational model [8]
3-4. CBE Curriculum Development Framework	• Curriculum development framework [8, 16]
3-5. CBE Evaluation Framework	• Kirkpatrick / Phillips Model for Training Evaluation [1]
3-6. CBE Implementation Framework	• Robinson et al.'s Five Domains of School Improvement [20]

Note. Please refer to Supplementary Document 2 for a list of articles associated with each theory, model, and framework, along with the number of supporting sources [ ].

Theories in CBE

The first approach is *theories* in CBE. Theories are categorized into two sub-categories: similar educational approaches to CBE and the theories or theoretical underpinnings of CBE. First, two similar educational approaches to CBE were found in the literature: OBE and ML. Many scholars consider the term "outcomes-based education" synonymous with concepts such as "competency-based education," as both focus on learner performance in specific competencies and the demonstration and achievement of learning outcomes (Morcke et al., 2013; Tan et al., 2018). While ML has also been considered synonymous with CBE/OBE, Bisgaard et al. (2018) distinguish ML from CBE/OBE by defining it as "a more rigid form of CBE" (p. 2) in which a high level of proficiency is demonstrated by achieving 90% correct answers. These three terms have often been used interchangeably because they share common principles, such as a focus on learning outcomes, student-centered learning that considers individual needs and learning paces, and rigorous assessment.

Second, CBE practices are supported by various theories, including behaviorism, cognitive learning theory, constructivism, social cognitive theory, psychological theory, and motivational theory. Originating from OBE, which is rooted in behavioristic learning theory, CBE emphasizes observable behavioral changes as learning outcomes (Morcke et al., 2013). In CBE, behaviorism underlines the importance of rewarding learners for mastering competencies and assessing them through observable outcomes rather than subjective measures (Bisgaard et al., 2018). Cognitive learning theories, such as meaningful learning theory, assert that understanding and conceptualizing tasks or competencies are essential before performance, advocating for diverse learning activities to enhance understanding (Imanipour et al., 2022). Social learning theories, particularly Bandura's social learning theory, support CBE by emphasizing the role of observing experts or mentors in achieving mastery (Rajaratnam et al., 2021). Psychological theories, including Ericsson's deliberate practice model, the theory of planned behavior, and social identity theory, elucidate aspects of human behavior, learning, and social interaction pertinent to CBE (Martin et al., 2023; Wentzell et al., 2020). Motivational theories, such as achievement goal theory and self-determination theory, emphasize the importance of intrinsic motivation, personalized learning, clear goals, and regular feedback in CBE (Ross et al., 2022; Winget & Persky, 2022).

Models in CBE

The second category in CBE is *models*. We define CBE models as process models in this study, encompassing stage-based, pedagogical, and cyclical models. These models specify steps, stages, or phases in the progression toward mastery and the application of learning strategies. While they are informed by broader conceptual frameworks that support learning research on CBE in general, these models play a central role in structuring learning and skill acquisition processes within CBE programs.

First, stage-based models describe the progression through distinct stages or phases in the learning and skill acquisition process. Each model outlines a series of stages that learners pass through as they acquire new skills or knowledge in CBE (Rajaratnam et al., 2021; Roberts et al., 2012; Sawyer et al., 2015). Therefore, stage-based models align well with CBE because both emphasize a structured progression through levels of skill or knowledge acquisition.

Second, pedagogical models such as the six-step pedagogical framework, Kovacs's psychomotor learning theory, and Gallagher et al.'s 8-step model offer structured and systematic approaches to skill development (Parker & Roumell, 2020; Sawyer et al., 2015; Stefanidis, 2010; Stevens et al., 2017). These models help instructors articulate clear learning outcomes, design compelling learning experiences and assess mastery of competencies crucial for success in CBE.

Finally, cyclical models such as Kolb's experiential learning theory and self-regulated learning (SRL) emphasize the active, iterative process of learning. Learners continuously engage with experiences, reflect on them, and adjust their learning strategies (Cook et al., 2013; Henri et al., 2017; Lengetti et al., 2020; Roberts et al., 2012). Within this category, it is important to distinguish between SRL and self-directed learning (SDL). SRL refers to the internal cognitive, motivational, and behavioral processes learners use to monitor, control, and adapt their own learning. SDL, by contrast, emphasizes learners' broader role in planning, managing, and directing the overall learning process, including setting goals, selecting resources, and making strategic decisions about their learning. In CBE, SRL has been highlighted in the models because it directly supports the iterative mastery of competencies, allowing learners to continuously assess and adjust their strategies to achieve defined learning outcomes. SDL complements this by enabling learners to take an active role in organizing and directing their own competency development. Together, these concepts illustrate how cyclical models operationalize both the process and the broader strategic planning necessary for effective learning in competency-based frameworks. These cyclical models share common features with CBE, including a focus on mastery and competencies, personalized learning, and the importance of continuous improvement and feedback.

Frameworks in CBE

In the final category of *frameworks*, various frameworks have been discussed in the literature. These frameworks offer a structured approach to developing and assessing competencies through observable and measurable professional practices, as well as designing and implementing CBE programs. For instance, CBE assessment frameworks such as entrustable professional activities (Kerth et al., 2022), Miller's pyramid of clinical competence (La Chimea et al., 2020), and Mager's model for learning outcomes (Winget & Persky, 2022) offer a structured approach to evaluating and measuring learners' achievement of specific competencies or outcomes.

Concerning CBE competency frameworks, they outline the specific competencies (i.e., skills, knowledge, attitudes) learners need to achieve in a particular profession or field (Guthrie, 2009; Katoue & Schwinghammer, 2020). These frameworks focus on measurable learning outcomes and provide a clear pathway for achieving those outcomes. Additionally, other frameworks, such as those for CBE curriculum development, evaluation, and implementation, have been discussed in the literature.

The taxonomy of three theoretical approaches to CBE can help researchers and practitioners understand and explain the factors that influence its outcomes. They also aid in guiding the implementation of interventions at appropriate developmental stages and assessing the outcomes of CBE initiatives. Consequently, this taxonomy aims to foster cross-disciplinary dialogue among researchers and practitioners in the field.

Theories Addressed in CBE Literature

Various theories and theoretical backgrounds that inform CBE are frequently cited in the literature. Table 3 presents these organized by the frequency of each theory's reference, along with a brief description of each.

19 different theories were referenced in the included literature. ML and OBE were two of the most commonly referenced theories (11 times and 4 times, respectively). Unsurprisingly, these two theories appear frequently, given that ML and OBE are often conflated with CBE or seen as similar approaches. While ML was referenced in articles about various fields (medicine, nursing, engineering, K–12 education, and vocational/technical education), the articles that mentioned OBE primarily focused on pharmacy and medicine.

Behaviorism was the second-most referenced theory, appearing in five articles (four in medical/health education and one in vocational/technical education). Behaviorism is a psychological approach that emphasizes observable behaviors and events (Schilling & Koetting, 2010). Deliberate Practice was also mentioned in multiple articles (two in medical education and one in vocational/technical education). Deliberate Practice describes how people progress from novice to expert performance through a repeated cycle of practice and feedback over many years (Ericsson et al., 1993). The remaining 15 theories encompass a diverse range of approaches to learning, drawing from both psychology and education. These 15 theories are mentioned in only one article each, demonstrating a lack of convergence in theoretical approaches associated with CBE.

Models Addressed in CBE Literature

Various models that inform CBE appear in the literature. Table 4 illustrates the frequency at which each model is referenced in CBE studies.

Table 3
Descriptives (by Theory)

Rank	Theoretical Approaches Addressed in the Literature	Taxonomy	Frequency
1	Mastery Learning Model	Theory	11 [1, 2, 6, 11, 14, 15, 16, 17, 28, 29, 34]
2	Behaviorism	Theory	5 [1, 4, 16, 17, 25]
3	Outcomes-based Education	Theory	4 [3, 15, 30, 33]
4	Ericsson's deliberate practice model	Theory	3 [17, 19, 34]
5	Stimulus-response theory	Theory	1 [25]
5	Thorndike's transfer of learning theory	Theory	1 [25]
5	Functional contextualism	Theory	1 [17]
5	Relational Frame Theory	Theory	1 [17]
5	Cognitive load theory	Theory	1 [10]
5	Meaningful Learning Theory (Ausubel)	Theory	1 [7]
5	Jeannerod's motor simulation theory	Theory	1 [19]
5	Constructivism	Theory	1 [10]
5	Bandura's theory of social learning	Theory	1 [19]
5	Social cognitive theory	Theory	1 [13]
5	Social identity theory	Theory	1 [13]
5	Teunissen's Experiences-Trajectories-Reifications (ETR) framework	Theory	1 [13]
5	Theory of Planned Behavior	Theory	1 [13]
5	Achievement goal theory	Theory	1 [23]
5	Self-determination theory of motivation	Theory	1 [35]

Note. Please refer to Supplementary Document 2 for a list of articles associated with each theory, along with the number of supporting sources [ ].

Table 4
Descriptives (by Model)

Rank	Theoretical Approaches Addressed in the Literature	Taxonomy	Frequency
1	Dreyfus and Dreyfus Stages of Learning	Model	4 [8, 21, 24, 33]
1	Self-regulated learning	Model	4 [2, 11, 13, 23]
2	Kolb's experiential learning theory	Model	2 [6, 21]
3	Six-step Pedagogical Framework	Model	1 [24]
3	Fitts and Posner's three-stage model of motor skills acquisition	Model	1 [19]
3	Simpon's and Harrow's Taxonomy of the Psychomotor Skill Development	Model	1 [24]
3	Kovacs's psychomotor learning theory	Model	1 [24]
3	Gallagher and colleagues' 8-step model	Model	1 [31]
3	McClusky and Smith's 3-step model	Model	1 [31]
3	Aggarwal and colleagues' competency-based framework for systematic training and assessment of technical skills	Model	1 [31]
3	Concrete-representation-abstract (CRA) model	Model	1 [17]
3	Rodolfa's Cube model of the development of foundational competencies	Model	1 [32]

Note. Please refer to Supplementary Document 2 for a list of articles associated with each model, along with the number of supporting sources [ ].

The most frequently addressed models, the Dreyfus and Dreyfus Stages of Learning and the Self-Regulated Learning models, are each discussed four times. The Dreyfus and Dreyfus Stages of Learning, a stage-based model, is often used to guide the development of expertise among healthcare professionals in education and training within the medical field. It outlines five developmental stages of learning that describe the continuum of improving performance: novice, advanced beginner, competent, proficient, and expert. Learners at each stage have unique characteristics. In the earlier stages, novice learners employ imitation and trial and error when learning skills, while advanced beginners start to perform skills habitually with some confidence and proficiency. In the more experienced stages, competent and proficient learners demonstrate accurate and highly coordinated performance, possessing well-developed skills and modifying solutions to difficult situations. Expert learners create new patterns to solve specific problems (Sawyer et al., 2015). Through the developmental stages, scaffolding is a teaching process in which a supervisor assesses a learner's competency and provides appropriate feedback, gradually reducing it as the learner becomes more competent (Roberts et al., 2012). The Dreyfus and Dreyfus Stages of Learning model has been used to provide a structured approach to

healthcare professionals' skill development in competency-based medical education, ensuring the learners and practitioners progress through the stages in a manner that supports their growth and meets their developmental needs.

Self-regulated learning is also recognized as one of the most frequently discussed models in CBE literature. It encompasses the behaviors and strategies that learners utilize to acquire knowledge and skills within the CBE framework (Lengetti et al., 2020). These strategies are closely aligned with personalized learning, a fundamental characteristic of CBE, as they empower learners to monitor their progress and address their individual needs. For instance, Ross et al. (2022) characterize self-regulated learning as a cyclical process comprising forethought, performance, and self-reflection. Through this process, learners engage in planning, executing, and evaluating their learning progress relative to their goals, thereby enabling them to assess their mastery of the content within the context of CBE. In this regard, self-regulated learning has been integrated with CBE, serving as a foundational approach to facilitate learning activities and strategies that aim to achieve mastery.

In addition to the Dreyfus and Dreyfus Stages of Learning and the Self-Regulated Learning models, Kolb's Experiential Learning Theory is the second most frequently addressed model in the context of CBE. This theory has been widely adopted as a pedagogical approach within CBE and has been identified as the predominant instructional strategy for promoting mastery of competencies (Henri et al., 2017). In CBE, instructors intentionally integrate real-world tasks and direct experiences that require learners to apply theoretical knowledge and skills, thereby reflecting the experiential learning cycle proposed by Kolb. This alignment between CBE and Kolb's Experiential Learning Theory not only enhances engagement but also fosters the development of practical competencies that are essential for success in professional settings. By emphasizing active learning, reflection, and application, this approach equips learners with the tools necessary to navigate complex, real-world challenges effectively.

The remaining models are addressed only once in the CBE literature. Most of these models adopt a stepwise approach, guiding learners through distinct stages of skill acquisition. In Fitts and Posner's 3-Stage Model (Rajaratnam et al., 2021), learners progress from the cognitive stage (learning) to the associative stage (practice), and finally to the autonomous stage (mastery). Similarly, the Six-Step Pedagogical Framework (Learn, See, Practice, Prove, Do, Maintain) outlines a clear sequence from introduction to maintenance (Sawyer et al., 2015), while McClusky and Smith's 3-Step Model (Sequential, Progressive, Modular) supports this structured progression (Stefanidis, 2010). This sequential flow is also evident in Simpson's and Harrow's Taxonomy, which breaks down psychomotor skill development into increasingly complex stages (Guided Responses, Mechanism, Complex Overt Response, Adaptation, Origination) (Sawyer et al., 2015).

Nearly all models incorporate practice as a key component of skill development. Kovacs's Psychomotor Learning Theory emphasizes practice that bridges learning and real-world application (Sawyer et al., 2015), while Gallagher's 8-Step Model incorporates practice on simulators with iterative feedback, highlighting the competen-

cy-based education focus on skill mastery through repeated trials (Stefanidis, 2010). Both the Six-Step Framework and Simpson's Taxonomy stress the importance of hands-on practice before learners are evaluated or allowed to advance (Sawyer et al., 2015).

Assessment and feedback are embedded throughout the learning process. Gallagher's 8-Step Model and Aggarwal's Competency-Based Framework emphasize continuous, iterative feedback at every stage, ensuring learners identify and correct errors before moving forward (Stefanidis, 2010). In Fitts and Posner's Model, feedback during the associative stage helps improve performance (Rajaratnam et al., 2021), while Simpson's Taxonomy refines skill acquisition through feedback (Sawyer et al., 2015). The Six-Step Pedagogical Framework and Kovacs's Theory also emphasize assessment phases that occur before learners apply their skills in real-world contexts (Sawyer et al., 2015).

These models share common features in their structured progression, emphasizing practice and incorporating feedback and assessment to guide learner development. They all prioritize a learner-centered approach, allowing for gradual mastery of competencies with a focus on skill transfer from training environments to real-world application, underscoring the importance of iterative learning to ensure proficiency before advancing.

Frameworks Addressed in CBE Literature

Eleven theoretical approaches were identified in the reviewed CBE literature. They are presented in Table 5 according to their frequency in the literature.

These approaches had a range of different foci, including assessment, curriculum, training, and systems change. Of the eleven theoretical approaches, the one referenced most in the literature (four in medical and one in healthcare) was Entrustable Professional Activities (EPAs). EPAs are an assessment framework used in medical education that combines the necessary knowledge, skills, and attitudes for a specific task (Meyer et al., 2019). This finding speaks to the prevalence of CBE in medical education fields. Another assessment framework, Miller's Pyramid, was the second most referenced approach (two in medical and one in dental). Many of the theoretical approaches identified were mentioned only once in the literature, underscoring the wide range of frameworks employed in CBE research.

Discussion and Conclusions

The landscape of CBE research reveals an evolving field that is steadily laying its conceptual foundations while also expanding in scope and influence. The prevalence of literature reviews and systematic reviews among recent studies underscores a period of consolidation, where the focus is on synthesizing existing research to clarify CBE's foundational theories, models, and practices rather than generating new empirical findings. This trend suggests that the field is preparing for a future shift toward more empirical and intervention-based studies as its conceptual base strengthens. In this umbrella review, only a few meta-analyses were identified. Since

Table 5
Descriptives (by Framework)

Rank	Theoretical Approaches Addressed in the Literature	Taxonomy	Frequency
1	Entrustable Professional Activities (EPAs)	Framework	5 [8, 9, 12, 18, 27]
2	Miller's Pyramid	Framework	3 [10, 22, 26]
3	Curriculum development framework	Framework	2 [8, 16]
4	Informed Self-Assessment Framework	Framework	1 [13]
4	Framework for System of Assessments	Framework	1 [36]
4	Mager Model for Learning Outcomes	Framework	1 [35]
4	Bloom's Taxonomy	Framework	1 [15]
4	Cheetham & Chivers Models of Professional Competence	Framework	1 [5]
4	International Pharmaceutical Federation (FIP) Needs-based professional educational model	Framework	1 [8]
4	Kirkpatrick / Phillips Model for Training Evaluation	Framework	1 [1]
4	Robinson et al.'s Five Domains of School Improvement	Framework	1 [20]

Note. Please refer to Supplementary Document 2 for a list of articles associated with each framework, along with the number of supporting sources [ ].

meta-analyses quantitatively synthesize findings across individual studies, their scarcity suggests that empirical or quantitative investigations in CBE remain relatively limited. As the field's conceptual foundations continue to solidify, there may be an increasing opportunity and need for such empirical studies and intervention-based research. Notably, a marked increase in CBE publications from 2017 to 2022 signals escalating interest and recognition of its relevance, particularly in North America and Europe, with higher education and health sciences leading the way. This concentration is likely driven by the critical emphasis on professional competencies within these fields, where licensure and certification requirements create a strong demand for well-defined competency frameworks to ensure that future professionals meet established standards of practice.

The taxonomy of theoretical approaches to CBE, encompassing theories, models, and frameworks, adds significant value to the field by offering a structured approach to understanding its multifaceted landscape. This categorization aids not only in advancing cross-disciplinary dialogue but also in guiding the implementation and evaluation of CBE programs, underscoring factors that may shape outcomes. Within the theoretical domain, ML and OBE emerge as foundational pillars, frequently

associated with or intertwined in CBE principles. Behaviorism also has a significant influence, particularly in medical and health sciences education, aligning with the skills-based, practice-oriented approach of CBE. However, the theoretical landscape remains fragmented, with many theories cited only once, reflecting both the diversity and adaptability of CBE across disciplines and educational contexts.

In terms of models, CBE emphasizes structured skill acquisition, as seen in frameworks such as the Dreyfus and Dreyfus Stages of Learning model and the Self-Regulated Learning model. These models typically advocate for a sequential approach to mastering skills through practice and feedback, a hallmark of CBE's commitment to real-world competency development. Kolb's Experiential Learning Theory further enhances this approach, highlighting active learning and reflection as critical elements in fostering student competency.

Frameworks within CBE serve as guiding structures for developing and assessing competencies. Among these, EPAs stand out as a widely utilized approach, especially in medical education, where specific competencies are essential to patient care and professional trust. Similarly, Miller's Pyramid provides a hierarchical model of assessment, offering educators a scaffold to evaluate competency progression. The broad array of frameworks addressing diverse aspects such as assessment, curriculum design, and systems change illustrates CBE's adaptability and broad applicability across various fields. Together, these frameworks form a versatile toolkit that supports the customization of CBE to meet the unique demands of different disciplines and professional environments.

Overall, this synthesis of CBE theories, models, and frameworks reflects an adaptable, cross-disciplinary approach to education that prioritizes measurable outcomes and real-world readiness. As CBE continues to gain traction, these foundational elements are likely to catalyze further innovation, refining educational practices to align more closely with professional demands across diverse domains.

To integrate theories, models, and frameworks within a comprehensive meta-framework for CBE, a systematic approach is necessary. This approach should begin with the core principles of CBE, including focusing on outcomes, personalized learning, and mastery of competencies. It should incorporate key theories, such as behaviorism and cognitive learning theory, to explain the learning processes in CBE. Stage-based models, such as those developed by Dreyfus and Dreyfus, can be integrated to outline the progression of learner competency. Cyclical models, such as Kolb's Experiential Learning Theory, can describe the ongoing process of skill acquisition and refinement. Assessment frameworks, such as EPAs or Miller's Pyramid, should be included to guide the evaluation of competencies. Curriculum development and implementation frameworks can guide the design and execution of the program. Ultimately, embedding self-regulated learning principles can facilitate ongoing development and adaptation of learners and programs. This integrated meta-framework would provide a comprehensive approach to understanding, implementing, and assessing CBE across various educational contexts. It would combine the strengths of different theoretical approaches while maintaining the core principles of CBE, offering a robust foundation for research and practice in the field. Such a framework

could address the challenges identified in the literature, such as the need for more consistent theoretical underpinnings and the integration of diverse approaches across disciplines. The trends and issues identified in theories, models, and frameworks help understand theoretical approaches to CBE by highlighting the importance of structured skill development, emphasizing the role of practice, feedback, and assessment in competency acquisition, and demonstrating the adaptability of CBE across different disciplines and contexts. This understanding can inform future research and implementation efforts, ensuring that CBE programs are grounded in solid theoretical foundations and responsive to the diverse needs of learners and educational settings.

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Appendix 1
Summary of the Articles Included in the Review

No	Authors	Type of Review	Year	Country	Contexts	Field	Search Period	Theories/Models/Frameworks Addressed in the Articles
1	Bisgaard et al.	Narrative review	2018	n/a	Medical education - graduate medical education	Medical	January 1946 - August 2017	- Mastery learning model - Behaviorism - Kirkpatrick / Phillips Model for Training Evaluation
2	Cook et al.	Systematic review and meta-analysis	2013	Canada & United States	Medical education - clinical medicine	Medical	Through May 2011	- Mastery learning model - Self-regulated learning
3	Croft et al.	Literature review & thematic analysis	2019	Australia	Pharmacy education	Pharmacy	January 2000 to May 2019	- Outcomes-based education
4	Fernandez et al.	Systematic review & thematic analysis	2012	Canada & Belgium	Medical education	Medical	1948 to February 2011	- Behaviorism
5	Guthrie	Literature review	2009	Australia	Competency-based training packages and vocational programs in Australia	Vocational education and training (VET)	n/a	- Cheetham & Chivers Models of Professional Competence
6	Henri et al.	Systematic review	2017	United States	Higher education / Postsecondary education	Engineering	2005-2015	- Mastery learning - Kolb's experiential learning theory
7	Imanipour et al.	Systematic review and meta-analysis	2022	Iran	Health care training	Health care	January 1978 to July 2021	- Meaningful learning theory

No	Authors	Type of Review	Year	Country	Contexts	Field	Search Period	Theories/Models/Frameworks Addressed in the Articles
8	Katoue & Schwinghammer	Narrative review	2020	International	Education/ training for health care professionals (with a focus on pharmacy)	Health care	1975-2019	- Dreyfus model for skills acquisition - Entrustable Professional Activities (EPAs) - International Pharmaceutical Federation (FIP) needs-based professional education model - Curriculum development framework
9	Kerth et al.	Systematic review	2021	Germany	Pediatric postgraduate medical education	Medical	2014-2020	- Entrustable Professional Activities (EPAs)
10	La Chimea et al.	Literature review	2020	Canada	Dentistry	Dental	2000-2019	- Constructivism - Miller's pyramid of clinical competence
11	Lengetti et al.	Literature review	2020	United States	Nursing education	Nursing	1968-2014	- Mastery learning - Self-regulated learning
12	Liu et al.	Scoping review	2021	China	Graduate medical education	Medical	2019-2020	- Entrustable Professional Activities (EPAs)
13	Martin et al.	Scoping review	2022	Canada	Medicine - workplace-based learning and assessment	Medical	Until September 2020	- Social cognitive theory - Theory of Planned Behavior - Social identity theory - Diffusion of innovation - Apprenticeship model - Self-regulated learning - Informed self-assessment framework
14	McGaghie et al.	Qualitative synthesis and critical review	2014	n/a	Medical education (simulation-based)	Medical	2006-2013	- Mastery learning model

No	Authors	Type of Review	Year	Country	Contexts	Field	Search Period	Theories/Models/Frameworks Addressed in the Articles
15	Mohieldein	Systematic review	2017	Pakistan	Medical education	Medical	through 2015	- Mastery learning model - Outcomes-based education - Bloom's taxonomy
16	Morcke et al.	Literature review	2013	Europe (i.e., Denmark, Netherlands)	Undergraduate and graduate medical education	Medical	1999-2010	- Mastery learning model - Behaviorism - Curriculum development framework
17	Parker & Roumell	Literature review	2020	United States	Vocational education and training (VET)	Technical and Vocational Education and Training (TVET)	n/a	- Mastery learning model - Functional contextualism - Relational frame theory - Deliberate practice model - Concrete-representation-abstract model
18	Pinilla et al.	Scoping review	2021	International (i.e., US and European Countries)	Undergraduate medical education (UME) clinical rotations	Medical	From 2005 (the introduction of EPAs) until 2019	- Entrustable Professional Activities
19	Rajaratnam et al.	Literature review	2021	n/a	Surgical skill training	Medical	From 2010 to February 2020	- Jeannerod's motor simulation theory - Bandura's theory of social learning - Ericsson's deliberate practice model - Fitts and Posner's three-stage model of motor skills acquisition
20	Reierson & Becker	Integrative, thematic literature review	2021	Canada	School improvement in secondary education	K-12 Education	n/a	- Robinson et al.'s Five Domains of School Improvement

No	Authors	Type of Review	Year	Country	Contexts	Field	Search Period	Theories/Models/Frameworks Addressed in the Articles
21	Roberts et al.	Literature review	2012	Australian and New Zealand	Vocational training in ophthalmology	Medical	n/a	- Dreyfus and Dreyfus stages of learning - Kolb's experiential learning theory
22	Robinson	Literature review	2021	United Kingdom	Fiberoptic endoscopic evaluation of swallowing (FEES) training	Medical	n/a	- Miller's pyramid of clinical competence
23	Ross et al.	Narrative literature review	2022	n/a	Fiberoptic endoscopic evaluation of swallowing (FEES) training	Medical	2015 to 2021	- Achievement goal theory - Self-regulated learning
24	Sawyer et al.	Nonsystematic literature review and critical synthesis	2015	n/a	Procedural skill training in medical training	Medical	n/a	- Dreyfus and Dreyfus Stages of Learning - Simpon's and Harrow's taxonomy of the psychomotor skill development - Six-step pedagogical framework - Kovacs's psychomotor learning theory
25	Schilling & Koetting	Literature review	2010	n/a	Professional health care programs in higher education	Education	n/a	- Reductionism - Behaviorism

No	Authors	Type of Review	Year	Country	Contexts	Field	Search Period	Theories/Models/Frameworks Addressed in the Articles
26	Shipton et al.	Systematic review	2019	International	Pain medicine	Medical	January 1997 to December 2016	- Miller's pyramid of clinical competence
27	Shorey et al.	Scoping review	2019	International	Health care education	Medical	Inception of each database to May 2018	- Entrustable Professional Activities
28	Siddaiah-Subramanya et al.	Analytical review	2017	n/a	Surgical practice	Medical	n/a	- Mastery learning model
29	Slavin	Meta-analysis and narrative review	1987	United States	Elementary and secondary schools	Education	1976-1986	- Mastery learning model
30	Spencer & Jordan	Literature review	2001	United Kingdom	CME continuing medical education	Health care	1983-2001	- Outcome-based education
31	Stefanidis	Literature review	2010	United States	Simulator-based education	Medical	1967-2010	- Fitts and Posner's three-stage model of motor skills acquisition - Gallagher and colleagues' 8-step model - McClusky and Smith's 3-step model - Aggarwal and colleagues' competency-based framework for systematic training and assessment of technical skills
32	Stevens et al.	Structured literature review	2017	Australia	Clinical psychology education	Psychology	n/a	- Rodolfa's Cube model of development of foundational competencies

No	Authors	Type of Review	Year	Country	Contexts	Field	Search Period	Theories/Models/Frameworks Addressed in the Articles
33	Torralba et al.	A historical review of outcomes-based medical education	2020	n/a	Medical education	Medical	n/a	- Outcomes-based education - Dreyfus and Dreyfus stages of learning
34	Wentzell et al.	Literature review	2019	North America	Ophthalmology residency	Medical	1995-2018	- Mastery learning model - Ericsson's deliberate practice model
35	Winget & Persky	Literature review	2022	n/a	Pharmacy education	Medical	n/a	- Self-determination theory - Mager model for learning outcomes
36	Young and colleagues	Literature review	2021	n/a	Psychiatric medical education	Medical	n/a	- Framework for a system of assessment

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