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A Realist Synthesis of Online Learning in Undergraduate Palliative Care Education: Contexts, Mechanisms, and Outcomes

Ahmed El-Kholy[1]*, Nour Abdelrahman[1], Karim Hassan[2]

[1]*Department of Integrative Nursing Sciences, Alexandria University, Alexandria, Egypt.*
[2]*Department of Palliative Clinical Care, Ain Shams University, Cairo, Egypt.*

Abstract

Even though palliative care (PC) training is now more commonly included in medical school curricula, several obstacles continue to limit the creation and rollout of high-quality educational initiatives. Internet-based distance learning supported by information technology (IT-DL) has the potential to build essential PC knowledge among students; however, questions remain regarding the most effective ways to design these curricula and to implement well-structured learning experiences that help students master the intricate skills needed in palliative care. To outline the application of internet-based education within undergraduate medical palliative care training through a realist theoretical lens. A realist review was performed, which generated a framework—or, using realist terminology, a program theory—designed to clarify what works, for whom, and under what conditions. These elements were articulated using the Context-Mechanism-Outcome configuration. An international panel of palliative care education specialists reviewed and judged the relevance of 256 articles obtained via systematic literature searches and expert recommendations.

The final synthesis, driven mainly by the 43 most pertinent articles, is organized into propositions addressing three main areas: (1) Educational theory, in which (a) Cognitivism (learning viewed as the acquisition of knowledge); (b) Constructivism (learning understood as a social, cultural, and negotiated activity); and (c) Behaviorism (learning seen as a measurable change in behavior) align well with the intended learning outcomes in PC. (2) Desired impact of the technology, which highlights that simply adopting IT-DL does not automatically add value; instead, it must successfully address the practical limitations of traditional face-to-face teaching. (3) Contextualization and length of the curricular activity, proposing that PC training should be embedded organically and legitimately into the broader medical curriculum. This area is projected to expand rapidly in the coming years. Both existing and upcoming studies could benefit from applying a realist approach of the kind presented here to better understand and integrate the multiple factors at play.

Keywords: Medical education, Palliative care, Realist review, Realist synthesis, Undergraduate education

Introduction

Palliative care (PC) is fundamental to human dignity and a component of the human right to health [1]. Nevertheless, many European countries experience a persistent shortage of physicians adequately trained in PC [2, 3]. To meet the rising demand for qualified PC professionals, education and training in this field have become vital parts of undergraduate medical programs. The European Association for Palliative Care released a White Paper that defines the essential competencies required for undergraduate PC education [4]. In 2020, the European Palliative Care Curriculum (EDUPALL) was created, drawing directly on these guidelines [5]. A continuing challenge is the limited number of faculty members with specialized expertise in PC, which restricts the development and delivery of robust educational programs in medical schools [6, 7]. Technology-enhanced learning approaches, particularly synchronous and asynchronous online formats, offer promising strategies for

Corresponding author: Ahmed El-Kholy
Address: Department of Integrative Nursing Sciences, Alexandria University, Alexandria, Egypt.
E-mail: ✉ ahmed.elkholy@outlook.com
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teaching PC's core competencies. One key advantage is their ability to bypass many of the logistical and resource-related barriers inherent in traditional classroom-based instruction. Although systematic reviews and meta-analyses already exist on the broader role of information technology in medical education, as well as on online learning specifically applied to PC, translating these findings into practical, theory-driven, feasible, and locally suitable teaching designs remains difficult for medical educators [8].

The present review aimed to develop a practical reference framework, along with concrete guidance, for creating and delivering online palliative care teaching and learning activities for undergraduate medical students.

This review represents the initial deliverable of the European project ELPIS (E-Learning on Palliative care for International Students), which received funding through the Erasmus+ KA220 scheme.

The project originated from educators' need to discover effective and sustainable methods for delivering PC education to large student cohorts. Consequently, the team chose to examine existing experiences and evidence through a systematic realist review.

Rationale for review

There is a growing demand for training health professionals in palliative care (PC) for several key reasons: (1) the population is aging and the number of individuals with chronic illnesses is increasing [9]; (2) PC is progressively recognized as a more humane standard of care for seriously ill and dying patients, including those outside the onco-hematologic field [10]; (3) PC is now viewed as an integral component of simultaneous and supportive care starting from the time of diagnosis [11].

As PC has evolved into a distinct discipline, educators and policymakers have become increasingly involved in developing PC education for future health professionals. As a result, international and national curricula and standards have continued to emerge, and educational institutions have become more familiar with delivering structured PC training than in previous years [12]. For instance, Italy and Romania have nationally recommended the inclusion of formal PC training within undergraduate medical school programs [6].

When examining the content, certain PC educational learning outcomes—particularly those related to relationships and attitudes (learning to be)—cannot be adequately achieved through traditional classroom lectures. Moreover, teaching PC presents a clear practical challenge due to the unique nature of PC delivery, which often makes it impossible to provide sufficient hands-on training to every undergraduate student.

For these reasons, online learning has the potential to support students' development of appropriate PC knowledge. It is considered a viable approach for delivering effective education and training to large student groups. Nevertheless, uncertainty persists about the optimal way to design such curricula and to implement methodologically robust learning activities that allow students to develop the complex skills demanded in PC.

Objectives and focus of the review

This review seeks to explain how internet-based education can be applied in undergraduate medical PC education by creating a framework—or, in realist review terminology, a theory—of what works, for whom, and under which circumstances, grounded in the existing evidence.

To guide the process, the review was structured around the following research questions:

A. What key elements should be taken into account when designing online teaching for PC?

B. Which educational theories are relevant, and which theory is most suitable for specific contexts and outcomes? What are their advantages and limitations?

C. Which teaching methods are effective for particular learning outcomes?

D. What is the most appropriate way to tailor these methods to a specific context, considering its unique characteristics?

Materials and Methods

Changes in the review process

During the review process, the initial plan was to conduct a broader examination of internet-based education for PC for all health professionals. Once the realist synthesis approach was adopted, the scope was narrowed to studies focused on undergraduate students. This adjustment enabled a more manageable volume of articles and the development of a theory better aligned with the project's objectives. The team also discussed the precise definition of internet-based education and ultimately agreed on the term 'Information Technology-based distance learning' (IT-DL) as a more accurate description of the intended focus [13].

Rationale for using realist synthesis

IT-DL represents a rapidly evolving field and constitutes a complex intervention: factors such as available resources, characteristics of trainers and trainees, cultural influences, and numerous other variables can significantly alter its effectiveness [14-17]. PC education is itself a complex intervention, since even basic

competencies required of non-specialists demand the development of specific attitudes, critical thinking, and a holistic perspective, in addition to standard clinical knowledge and skills.

Realist theory aims to determine what might work, how it works, and for whom in relation to a particular intervention. It typically frames these elements using Contexts, Mechanisms, and Outcomes (CMOs) [17-19]. CMO configurations help explain why certain interventions succeed or fail and how they affect results.

Realist synthesis is a review method frequently employed to integrate diverse sources and types of evidence on complex subjects. It generates an evidence-based theoretical understanding intended to be practical for a targeted audience (in this case, educators involved in undergraduate PC teaching) who wish to replicate or adapt similar interventions. It follows a pragmatic research model in which knowledge is regarded as an ongoing, incremental process. Every intervention is viewed as a complex system embedded within another complex system (the broader social context). While the effects of an intervention can be described, each new implementation represents a unique situation in which both known and unknown factors may lead to different outcomes. Therefore, every intervention offers a fresh opportunity to generate knowledge about what works, for whom, and in what circumstances.

The realist review approach also permits the inclusion of relevant evidence from related fields of research [20] (for example, studies on internet-based education for health professionals in general), provided that its applicability can be logically justified.

In this manner, the more focused scope is expected to yield more actionable insights. At the same time, the flexible methodology helps minimize the chance of overlooking important evidence during the development of the final theory.

Scoping the literature

The early stage of mapping the existing literature followed an iterative and non-linear path. FC, a medical doctor with broad expertise in educational research, conducted the first comprehensive review of the literature. These findings were then reviewed and discussed with the rest of the authorship team—composed of specialists in the domain who were already familiar with the body of work—across multiple group sessions.

This initial exploration drew primarily on established systematic reviews addressing themes related to the central research question (such as the use of internet-based education in undergraduate medical PC training), as well as reports describing real-world experiences of delivering PC education to undergraduate learners.

Once this foundation was in place, the team constructed an Initial Rough Theory (IRT) in accordance with realist synthesis principles. The IRT functioned as an early conceptual outline capturing the broad Context-Mechanism-Outcome (CMO) patterns that appear to support internet-based education for undergraduate medical students. In the words of the methodology, the IRT represents ‘the initial sketch of a theory that is used to guide a realist synthesis’, because ‘to support the process of undertaking a review, it is at least useful to construct an initial rough theory of action (What is supposed to happen?) and an initial rough theory of change (Why is that supposed to work?)’ [21].

Searching process

Following the preliminary mapping phase outlined above, a rigorous systematic literature search was performed in 2020. The search was later refreshed in June 2022.

To evaluate the articles, the team adapted an appraisal guide based on established international realist synthesis recommendations and developed a standardized appraisal template, which was distributed to all researchers [14, 15]. A preparatory meeting was organized to align understanding of the appraisal procedure. Afterward, each team member independently reviewed 43–44 articles.

An additional set of relevant publications, identified through suggestions from domain experts and the research team, was incorporated. Several group meetings provided opportunities for collective reflection on the review’s aims and current knowledge, enabling the team to select further articles informed by their practical experience. The bulk of these expert-suggested articles originated from Drs. JP and CC are both co-authors on several of the works and recognized authorities in PC education.

Selection and appraisal of documents

Document selection unfolded through several distinct stages, as depicted in **Figure 1**.

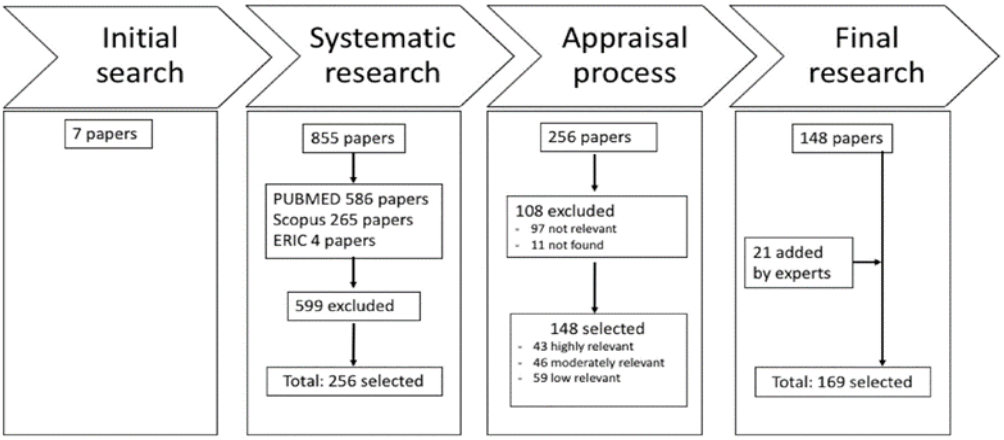

Figure 1. The process of document selection.

Appraisal relied on a structured form completed for every retrieved article. Reviewers were asked to judge the article's relevance to the research question and to document the grounds for that relevance, plus any valuable extracted information—ideally framed as CMO configurations. Given that the ELPIS project is a multinational collaborative effort, appraisal activities occurred at each partner's location, with all completed forms uploaded to a shared Google Drive® folder. Individual partners took responsibility for portions of the article set. Discussions and later stages of analysis and synthesis were conducted through online meetings. Each researcher then prepared a concise synthesis of the key data in the shape of 'if… then' statements. Articles were subsequently rated by the reviewer as high, moderate, or low in usefulness and relevance to the study, or marked for exclusion. To strengthen the reliability of the process in line with other mixed and qualitative review approaches, one author (JP)—an expert in distance learning applied to PC—was brought in only toward the end of the appraisal phase as an independent external reviewer. He examined the full set of materials and offered a second judgment on the relevance classification of each article. Any differences in judgment across the research subgroups were settled via both virtual and in-person group discussions.

Data extraction

A single researcher compiled a comprehensive matrix that gathered all pertinent information from the articles and organized it according to the CMO configurations supplied by the team. This matrix was distributed to the entire group through a comment-enabled Google Sheet®. The shared digital format enabled all researchers to easily review, compare, and navigate their colleagues' contributions.

Analysis and synthesis processes

GM took primary responsibility for synthesizing the data, while the full review team engaged in regular discussions to confirm the accuracy and internal consistency of the emerging findings. The team's focus was on detecting recurring patterns linking specific contexts to particular outcomes (demi-regularities). Once these patterns were identified, attention turned to uncovering the generative mechanisms that explained how and why they occurred.

Fresh insights produced during the review were integrated into the Initial Rough Theory (IRT) and shared as a collaborative, commentable Google document® with all authors. Team members were also encouraged to produce visual diagrams illustrating the synthesis. These visual aids were then examined collectively to support the construction of the final theoretical framework.

The revised narrative, shaped by author feedback and subsequent editing, served as the foundation for drafting the central results section.

As one illustration, the group explored the role of articulating a clear theoretical foundation (for instance, a constructivist orientation) within educational initiatives to enhance overall consistency. Although the original IRT highlighted this as a widely recommended practice, explicit theoretical statements were uncommon in actual program descriptions—even in highly effective cases. The IRT was therefore revised to account for this observation, noting that numerous interventions achieved positive results despite operating without a prominently declared theoretical basis.

Document flow diagram

An early rapid scan identified seven relevant articles [22-28]. These served as the foundation for the initial IRT.

Later, in June 2021 and January 2022, comprehensive systematic searches were conducted across PubMed, Scopus, and ERIC, yielding 855 records in total. Experts additionally contributed 21 more articles.
Following detailed screening and selection, the final set included 256 articles.
These articles were shared among five collaborating centers. Each center evaluated them for relevance to the final theory and categorized them as 'high', 'medium', 'low', or 'excluded'. In the end, 43 articles were judged highly relevant, 46 moderately relevant, 59 of low relevance, and 108 were excluded or unavailable.

Results and Discussion

The findings emerging from our theory-driven, systematic, and evidence-based iterative approach are summarized in three core sections. We began by clarifying the meaning of 'e-learning' before tackling the research questions directly. The ultimate synthesis of the literature and extracted CMOs appears as a set of propositions. These propositions address research questions B, C, and D through statements and practical examples organized into three areas: (1) educational theory, (2) intended technological impact, and (3) contextual factors and length of the learning activity.
Research question A ('What are the elements to be considered in the educational design of online teaching for PC?') is answered in a more direct and practical format: a checklist of guiding questions designed to support educators during the planning stage. This checklist is presented in **Table 1**.

Table 1. Key questions for educators.

Item	Reframed question	Explanation/Rationale
1	Can a primary theoretical framework underlying the educational intervention be identified?	Establishing a central theoretical foundation can support the development of a more coherent and structured educational program. Note: Even when not explicitly mentioned, an implicit guiding theory may still underpin the intervention.
2	Does the curriculum design align with the identified theoretical framework?	Certain educational theories are typically reflected through particular types of activities: (1) Cognitivism: Learning is viewed as knowledge acquisition; objectives and tasks may vary in complexity, and knowledge gains can be at least partly measured objectively. (2) Constructivism: Learning is understood as a socially and culturally mediated process; objectives, activities, and assessments are shaped through interaction among multiple stakeholders. (3) Behaviorism: Learning is defined as observable behavioral change, achieved through repetition and practice of tasks.
3	What specific purpose justifies the use of instructional technology? Does it enable outcomes that would not be achievable otherwise?	There is no definitive evidence that IT-based distance learning (IT-DL) is universally superior to face-to-face teaching. However, it may provide distinct advantages when addressing specific needs, such as enabling interprofessional education, facilitating exposure to specialized knowledge, or compensating for limited in-person resources.
4	Is the educational activity a standalone initiative, or is it embedded within a broader interdisciplinary palliative care curriculum?	Improved outcomes are more likely when palliative care (PC) is integrated across the undergraduate curriculum. Additionally, if IT-DL replaces rather than complements real-life clinical experiences, students may regard it as less desirable.
5	At what stage of the curriculum is the educational activity introduced?	Advanced, self-directed, and constructivist learning approaches may be challenging for early-stage (e.g., first-year) students, who often benefit from more structured and linear content. While not prohibitive, such approaches may require greater effort from less experienced learners.
6	Is the duration of the activity appropriate for achieving the intended learning objectives?	More complex goals (e.g., promoting cultural transformation) typically require longer engagement and practice, whereas simpler objectives can be achieved through shorter interventions. Additionally, designing content suited to online formats—such as keeping videos under 7 minutes—can enhance the overall learning experience.

Abbreviations: IT-DL = Information Technology-based distance learning; PC = palliative care.

A first clarification: What is 'e-learning'?
The expression "e-learning" is frequently used as a synonym for several other terms, including web-based learning, online learning, computer-assisted instruction, computer-based instruction, internet-based learning, multimedia learning, technology-enhanced learning, and virtual learning [29]. This overlapping terminology has created ambiguity about whether e-learning refers to the tool itself or to the delivery method. To resolve this, we adopted the broad term IT-DL. It covers every type of distance education in which technology acts as the intermediary between teacher and learner. In this perspective, the true educational impact stems mainly from the learning activities, with technology serving to support or limit them.

Educational theory

Clearly stating the underlying educational theory is widely regarded as beneficial because it promotes consistency between intended learning outcomes and the chosen teaching strategies. The Theory-Technology Alignment Framework [22] is a well-known example of this structured planning approach. Although we originally considered explicit theory declaration essential, our team now recognizes that many effective initiatives in the literature do not openly name their theoretical foundation. Even highly successful programs rarely make their reference theories explicit. This may be because well-designed curricula can maintain strong internal consistency and deliver good results without formally declaring a specific theory.
As a result, we often had to deduce the underlying educational theory ourselves, since it was rarely stated directly in the publications or supporting materials.

Which reference theories and methodologies/techniques?
Learning theories, along with their number and variety, can feel overwhelming. For this reason, we must adopt a pragmatic approach when selecting and applying theories, models, or frameworks [22].
Given that many palliative care (PC) learning outcomes are clinical in nature, suitable reference theories often include cognitivism or social cognitivism. Consistent and effective methods aligned with these theories include clinical problem-solving, case-based learning, and virtual case simulations. These approaches work best when conducted in small synchronous groups supported by tutors.
Cognitivism: E-learning aligns well with cognitive constructivism. Active learning stimulates higher-order thinking in students, which supports the retention and real-world application of knowledge. This method involves rethinking learning by combining instructor-guided teaching with the flexibility of collaborative participation [30].
Constructivism: Because PC also involves communicative and relational learning outcomes, constructivist approaches are highly relevant. Effective techniques encourage reflection on experiences—even indirectly through films or narratives—and are strengthened when these reflections are shared socially [31].
Examples of the methodologies described include:

- Virtual Standardized Patient Contact; e-lectures; patient case vignettes [32]; reflective study questions with experts' answers [33];
- Standardized patients to develop verbal and nonverbal communication skills [34];
- In virtual patient experiences, students "can explore the consequences of their decisions in a more lifelike simulation". Including numerous end-of-life (EOL) psychosocial management issues can also help students handle emotionally difficult EOL situations with greater confidence [35];
- Flipped classroom model, where IT-DL delivers theoretical content and classroom time focuses on practical skill-building exercises [36];
- Simulation-based learning experiences, which can be used to teach communication skills (even though most evidence relies on self-reported outcomes) [37];
- Teleconferences, such as those in Project Extension for Community Healthcare Outcomes (ECHO©) [38], which successfully connect participants across different settings and disciplines;
- Blended learning pedagogy, which may be effective when grounded in an advanced constructivist approach [31]. New teaching methods can transform skill training into a more participatory and experiential process [39].

Although most reported experiences lean toward cognitivist or constructivist approaches, other theories have also proven successful. For instance, in a clinical and communication skills course, behaviorism was appropriate because students received feedback, rewards, and encouragement from instructors [40].

Technology's expected effect
Our findings indicate that simply using IT-DL does not automatically provide added value. Instead, it should produce a genuine "enhancement" effect or help overcome practical barriers present in traditional face-to-face training (such as limited resources or a small number of teachers/trainers).
Two important questions for decision-makers are: (1) What is the specific need that justifies the use of instructional technology? (2) Does it enable something that would otherwise be impossible?
A wide range of technologies exists, so selection should be based on their individual strengths and limitations, the learners' needs, and the availability of appropriate equipment [41].
Advantages of IT-DL include consistent content delivery, convenience, flexibility, the ability to cover topics lacking local expertise, and "just-in-time" content review. Learners can bypass familiar material and focus on new content at their own pace. E-learning proves particularly valuable when faculty resources are limited and can effectively supplement faculty-led teaching when instructors are available [42].
However, results are mixed. Schulz-Quach *et al*. [33] reported that their e-learning course did not show measurable effects on students' self-assessed competence in communicating with dying patients and relatives or in preparing to deliver PC. In contrast, many other studies reported positive effects on self-reported measures (for example, Shorey *et al*. [31] using the Communication Skills Attitudes Scale (CSAS) and the communication skills subscale

of the Nursing Students Self-Efficacy Scale (C-NSSES)). Clear improvements in learning outcomes were also observed in studies that explicitly referenced learning theories and employed validated assessment tools [22]. Several curricula demonstrated clear, specific benefits linked to IT-DL:

- Good results were achieved with subspecialist topics such as Children's Palliative Care [43] or communication with minority groups [32], although outcomes were mainly self-reported.
- Pulsford *et al*. [44] recommended interactive, student-centered methods over simply providing online material for asynchronous use.
- Artificial intelligence tools, such as chatbots, could theoretically increase personalization of training and help guide learners through multimedia content [45].
- Technology combined with reflective activities can play a vicarious role in learning, especially since students usually cannot attend hospices in large numbers [44].
- Web-based modules offer opportunities for interprofessional (virtual) training and interprofessional education [32, 46-48], while teleconferencing enables connections with professionals from various disciplines (potentially improving knowledge and self-efficacy [38]).

IT-DL also comes with limitations, as observed in the reviewed experiences:

- IT-DL should not replace hands-on experience in healthcare settings. Despite strong pedagogical design, students often still express a desire for more direct contact with real patients [33].
- Additional risks include lack of physical interaction with teachers, reduced emphasis on nonverbal communication, absence of social relationships, lack of peer presence, and potential decrease in student motivation when teachers are not actively involved [49].
- Systems that are difficult to access (for example, closed platforms not usable from home) can severely limit the effectiveness of e-learning, even in well-designed programs [50].
- In one study, students preferred passive lectures over constructivist activities, with learning outcomes varying across both groups [51].
- Even within a strongly constructivist setting that included peer and faculty discussions, some students failed to develop critical thinking skills when applying evidence to ongoing conversations [52].
- In Dietz *et al*. [53], students did not rate bedside teaching as more useful than a film-based teaching unit.

Contextualization and duration of training activities

PC training activities should be embedded naturally and meaningfully into the wider curriculum:

1. The more closely the overall curriculum relates to palliative care, the more effective and impactful the specific module becomes [54-56].
2. Designing each teaching or learning activity on solid theoretical grounds tends to yield stronger results [57].
3. Early-year medical students often favor learning that is more guided, less open-ended, and highly structured. This preference may support the use of more directive content, or it could instead emphasize the benefits of gradually introducing constructivist methods. Curriculum planners should carefully weigh this consideration [51].

Duration of the interventions: Several successful programs were intentionally designed to be substantial in length and included repeated sessions rather than one-off events (as seen in Kinghorn [54] and Sullivan *et al*. [58], who described effective undergraduate programs lasting 16 weeks and 6 months, respectively). While this longer format initially seemed essential for good results, our overall synthesis shows that brief modules can also be highly valuable. They adapt more easily to different settings and can be reused with minimal effort [59].

Regarding duration, cognitive learning theories (even outside PC-specific contexts) offer useful guidance for creating educational videos. Keeping videos short helps sustain residents' attention and interest. Engagement reached nearly 100% for videos under 6 minutes, dropped to about 50% for those lasting 9–12 minutes, and fell to roughly 20% for videos 12-40 minutes long [60].

Table 1 provides a summary of key guiding questions to support decision-makers and educators in designing PC curricular activities for undergraduate students, in line with the review's aims and realist approach.

Visual representation of the CMOs

Figure 2 presents an overview of the CMO configurations developed through our analysis.

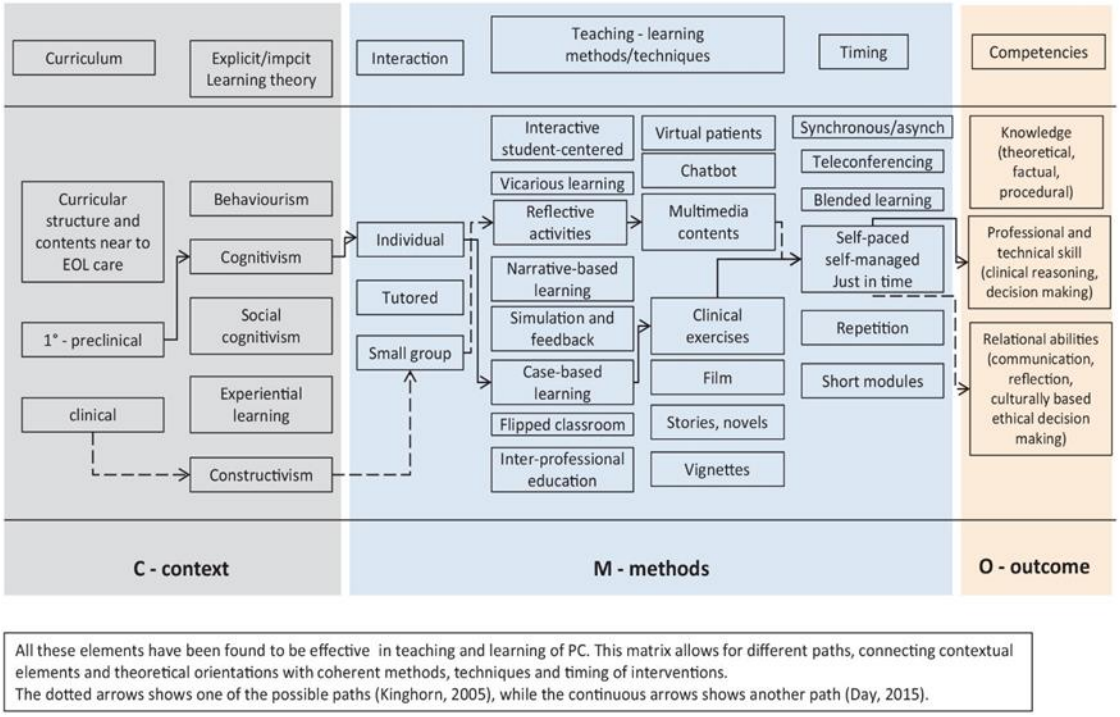

Figure 2. Examples of relevant CMOs found.

The literature reveals many possible pathways, with no single ideal model standing out. Drawing on the experiences examined, we highlighted several core factors (indicated by column headings in the figure). These include the module's place within the overall course of study, the chosen learning theory, the degree of interaction, the selected teaching and learning methods or techniques, the scheduling and length, and the targeted competences. Taking these elements into account greatly improves the chance of building a well-integrated educational offering and delivering a more effective learning experience.

As we will explore further, our findings align closely with previous reviews in the field. That said, the theory-driven methodology we applied offers fresh and practical guidance for those responsible for planning and managing education in palliative care.

Summary of findings

Our results indicate that when designing an undergraduate IT-DL module on palliative care (PC), adopting a Theory-Technology Alignment Framework or comparable structured approach is frequently recommended. However, we believe it is also important to recognize that numerous successful experiences in the literature do not explicitly state their underlying educational theory.

Many programs appear to rely on cognitivism implicitly, and approaches aligned with it — such as clinical problem-solving, case-based learning, and virtual case simulations — tend to yield valuable learning experiences. Similar observations apply to cognitive constructivism: active learning promotes higher-order thinking, practical knowledge application, and collaborative participation.

Technology should be expected to deliver a clear, specific benefit. This added value needs to be deliberately identified, articulated, and actively pursued during curriculum development, since IT-DL carries distinct drawbacks alongside its potential advantages.

Contextual integration is important — embedding PC consistently throughout the rest of the curriculum enhances outcomes. In the long run, many effective interventions favored longer formats, yet shorter modules offer greater adaptability and practicality.

Strengths, limitations, and future research directions

The quality of any systematic review depends directly on the strength of the primary studies. Both educational research and palliative care present unique challenges in generating high-quality, methodologically rigorous evidence.

The research team also notes several emerging topics not covered in our review, including artificial intelligence applications and telemedicine. The role of artificial intelligence in education remains largely unexplored and requires deeper investigation. Additionally, as certain PC services can now be delivered remotely, training programs could be adapted accordingly to respond to the rapid expansion of telemedicine.

Comparison with existing literature

Our findings align with the broader body of evidence, while also highlighting specific design features that may prove particularly useful for PC undergraduate education.

The Theory-Technology Alignment Framework [22] serves as one practical model for aligning training design, treating technology as an instrumental tool that supports learning.

Among the studies examined, the most frequently referenced educational theories were: problem-based learning (16/81, 20%), social learning theory (11/81, 14%), and cognitive theory of multimedia learning (10/81, 12%) [22]. Interestingly, as noted earlier, even successful programs rarely made their learning theory foundations explicit.

Other reviews confirm that additional elements influence the success of high-quality IT-DL. While IT-DL is not inferior to traditional face-to-face teaching for knowledge and skill outcomes [22, 25, 26, 28], factors such as sufficient practice opportunities and rigorous outcome assessment [28] have a positive effect. Meta-analyses [23, 24] further suggest that technology use in simulation (though not always within a full learning environment) proves more effective when:

- Interventions are repeated multiple times
- Feedback is intensive
- Practice occurs in groups

Although various overarching theories for distance learning exist, Picciano's framework [27] — which builds on Anderson's model — offers a comprehensive example. In this model, two main actors (student and teacher) interact with two resource systems (asynchronous/synchronous communication channels and structured content) to generate knowledge.

Learners may engage collaboratively in group-paced activities or independently in self-paced ones. Teachers can foster research communities or provide resources and structured tasks.

Self-paced, self-managed distance learning has shown strong acceptance and effectiveness in large-scale programs. However, much of this evidence comes from professional development courses, where such features may be especially valued [45].

Consistent with our review, other authors emphasize that the goal is not to identify a universally superior method, but to determine which approach works best for specific learners [42]. New technologies should encourage a fundamental rethinking of "what learning is about," prompting fresh strategies for how, where, and when learning occurs.

While these general principles apply well to our focus area, this review has distilled a clear, practical sequence of effective experiences and tools. Decision-makers in PC undergraduate education can use them directly. **Figure 2** (visual representation of CMOs) and **Table 1** (key questions for educators) offer concrete support for navigating the evidence.

Conclusion

This realist review was designed to assist educators in effectively implementing internet-based learning for medical undergraduates. We organized the main mechanisms identified in the literature into three categories: reference theory, expected technological effect, and contextualization of the educational intervention. We also developed a set of guiding questions to help educators and decision-makers concentrate on the essential aspects of intervention planning.

We anticipate substantial growth in this field in the coming years. Both current and future research could benefit from adopting a realist approach, similar to that used here, to deepen understanding of the complex interplay among the variables.

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