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ORIGINAL RESEARCH

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# A four-pronged approach for evaluating e-learning modules with a newly developed instructional design scale

Kadriye O. Lewis[1], Erdem Demiroz[2], Haiqin Chen[3], Cheryll Albold[4], John D. Mahan[5]

[1]Children's Mercy Hospital, Department of Pediatrics, University of Missouri Kansas City School of Medicine, Kansas City, MO

[2]Trakya University, School of Applied Sciences, Edirne, Turkey

[3]Department of Testing Services, American Dental Association, Chicago, IL

[4]Mayo Clinic School of Graduate Medical Education, Jacksonville, FL

[5]Nationwide Children's Hospital, The Ohio State University College of Medicine, Columbus, OH

## ABSTRACT

**Objective:** We evaluated the instructional design properties of interactive e-learning modules using a four-pronged approach. The elements assessed in this method included: 1) module objectives, 2) pedagogical strategies, 3) instructional design properties measured by the instructional design scale (IDS), and 4) level of interactivity.

**Methods:** This descriptive study exemplifies the evaluation process of 18 previously developed e-learning Pediatric Nutrition Series (PNS) modules with the involvement of educators from six academic institutions. Using multiple tools, including Bloom's taxonomy, IDS, and interactivity scale and templates, we examined and synthesized the four elements of the module properties as mentioned above. Data were analyzed using qualitative thematic and interpretive content analysis, descriptive statistics, and intraclass correlations.

**Results:** All 18 PNS modules showed a consistent structure, including content with basic interactive components. Of 66 learning objectives, only three were vague/not measurable. A majority of the objectives were grouped in three cognitive levels: knowledge, comprehension, and evaluation. Six distinct pedagogical strategies were most frequently used in the PNS modules to support content and convey the message in a multisensory mode. Average evaluation scores for the modules across six instructional design domains ranged between 1.75 and 1.94 for the overall scale on the 50-item IDS. The results suggested that all modules were considered to be between "very good" with a score of 1.5 and "excellent" with a score of 2. All modules demonstrated either second- (limited interaction) or third-level interactivity (moderate interaction).

**Conclusion:** Instructional design is a critical component of any e-learning developments. Applying the science of learning and theory-driven instructional design, principles may dramatically increase instructional effectiveness, engaging learners in purposeful learning practices. The four-pronged approach can provide a valuable road map to determine the instructional design qualities and has the potential to be an evaluation model for other e-learning applications in any field of the study.

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## Introduction

Advanced technologies have expanded educational opportunities with the proliferation of e-learning modules that are uniquely constructed to keep learners educationally engaged in numerous ways on multiple levels of learning. Those modules are self-contained, independent learning units designed and developed for individualized instruction with the purpose of attaining projected/predefined instructional objectives [1,2]. They are also characterized as a curriculum package intended for self-study [1] that provides learners with self-direction

**Contact** Kadriye O. Lewis ✉ kolewis@cmh.edu Children's Mercy Hospital, Department of Pediatrics, University of Missouri Kansas City School of Medicine, Kansas City, MO.

and self-paced learning of the realm of content. This contemporary mode of learning has gained momentum in medical education due to learner demands for more self-directed and independent learning, as well as time constraints in training and regulated work hours that have resulted in decreased time for didactic and group education [3]. However, developing e-learning modules is a labor-intensive process and may be costly depending on the scope of a project. Although literature offers a variety of instructional design models [4–6] and concepts for developing e-learning modules, no single recipe fits all the purposes of this educational modality.

Although e-learning modalities are adaptable with many pedagogical approaches from self-directed independent learning to collaborative learning, designing digital instruction requires substantial effort and experience in utilizing effective instructional design principles during any module development [7,8]. In other words, designing instruction for an e-learning module does not involve simply putting together a collection of instructional materials or PowerPoint presentations online. Effective module design consists of incorporating multiple elements with the creative process [9]. These elements include, but are not limited to, learning objectives, educational content, teaching/pedagogical strategies, interaction (cognitive, content, and technology), assessment, feedback, user interface, and visual design [10–12]. The consistency and connection among all these elements, which are called instructional alignment, provide learners with maximum opportunities to develop the knowledge and skills necessary to achieve the desired learning outcomes.

Although a systematic review and meta-analysis of Internet-based learning by Cook et al. [13] showed that few studies reported on the instructional design principles used to guide the development process, there is not much information in the literature regarding a standardized approach or instructional alignment to assure instructional design quality for the development of medical education modules. The systematic review by Lewis et al. also found that many e-learning initiatives in the literature have failed to incorporate the intentional instructional design principles in educational e-learning module development [14]. Utilizing an instructional design framework seems to be neglected in the creation of educational modules or curricula. However, module evaluation has been a common practice to seek the views of learners on their satisfaction or perceived learning and/or overall assessment of the effectiveness of modules during or at the end of an educational intervention. Unfortunately, this indirect evaluation format provides little evidence of the effectiveness of the instructional design methodologies that have been applied to instructional applications or materials.

In brief, effective learning is dependent on several factors including how meaningful are the educational mediums or design of materials. Therefore, it is crucial to examine the instructional design properties of any learning solutions. Recognizing the existing gap of instructional design deficiency in the literature, we developed an instructional design scale (IDS) that will aid both module developments and/or closely examine the instructional design characteristics of rich media-enhanced medical training modules. Gaining a deeper understanding of the instructional design properties of educational modules is critical for developing any e-learning modality as well as determining the alignment between objectives, learning activities, and assessment methods. Thus, the purpose of this study was to introduce a four-pronged approach that was created based on the key components of effective module design mentioned above for examining the presence of desirable, intentional, and systematic instructional design properties of interactive e-learning modules. The key elements of this four-pronged approach included: 1) level of cognition related to the module objectives, 2) pedagogical strategies, 3) instructional design properties measured by the IDS, and 4) level of interactivity.

## Methods

For this descriptive study, we developed the following four-pronged approach as a conceptual framework for evaluating interactive e-learning modules that would help us gain a deeper understanding of the important variables in module design and constructive alignment [15], illustrating the interrelationship between learning objectives, pedagogical approaches, and assessment of learning or evaluation strategies (Fig. 1).

Each element of the four-pronged model above is described in detail in the "study tools and measures" section.

This study was approved as non-human subject research by the Institutional Review Board Expedited Committee at Nationwide Children's Hospital, Columbus, Ohio, in 2017.

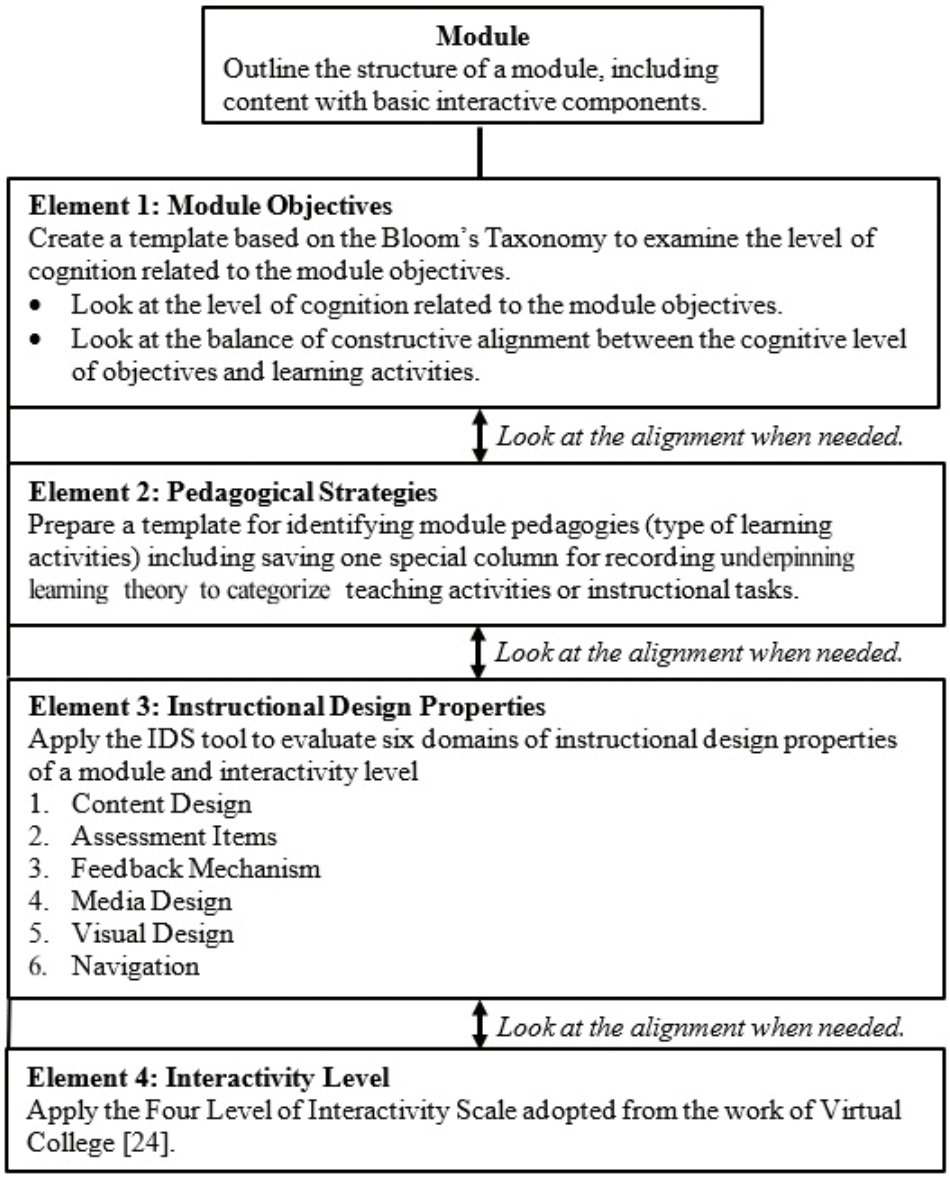


**Figure 1.** Conceptual framework: evaluating instructional design properties of an interactive e-learning module.

***Data (modules examined under the study)***

We decided to use a series of 18 interactive nutrition modules previously developed through an industry-sponsored grant project for the pediatric residency programs (postgraduate medical education programs) in the United States (US). A multidisciplinary work group from six institutions (faculty/nutritional content experts and an educational e-learning expert) collaborated to create those modules under the leadership of one co-author (JDM) as he was the principal investigator for the Pediatric Nutrition Series (PNS) project between 2008 and 2013. The previous publication reported the results of 10 nutrition modules that were used by pediatric residents (medical doctors in training) from 73 different US residency programs to determine their engagement, knowledge acquisition, and satisfaction with the modules delivered online in both interactive and noninteractive formats [16]. Thus, we had three valid reasons for using the PNS modules for this study: 1) the study mentioned above showed that the interactive modules resulted in higher satisfaction compared to noninteractive modules; 2) we had easy access to the modules without having any gatekeepers; and 3) we had sufficient background information about this large-scale project since the first and last authors (KOL and JDM) had been involved in developing those rich, multimedia-enhanced interactive training modules [16].

### *Module reviewers*

Except for the two reviewers for the piloting stage of the IDS tool for the 18 modules, we had a total of six reviewers for actual implementation of the four-pronged model. We recruited reviewers based on their instructional design knowledge and/or experience and familiarity with the topic of interactive educational modules. Using a random assignment method by drawing names, we formed two groups from these volunteers, and each group was assigned nine modules to review independently. Thus, we targeted three reviewers for each module. Along with individual meetings with reviewers, the first author of this paper (KOL) made two short videos to orient them for the review process and put both the videos on the Google Drive that was accessible at any time. The first video was to show how to create a free account to access the PNS modules. The second video illustrated how to access the RedCap™ survey to complete the module reviews. The video links and specific emails were sent to each individual with personalized directions.

### *Study tools and measures*

The following tools and methods were used to examine and evaluate the instructional design properties of the PNS modules applying the four-pronged approach.

#### Element 1: Module objectives

In this study, we used Bloom's taxonomy, originally created in 1956 under the leadership of educational psychologist, Dr. Benjamin Bloom [17], to measure the level of cognition related to the module objectives. The original taxonomy was organized into three domains: cognitive, affective, and psychomotor. The cognitive model consists of a six-level hierarchical classification of educational objectives that give direction to the learning process (knowledge, comprehension, application, analysis, synthesis, and evaluation). This model is designed to capture lower to higher-order thinking in education regarding observable knowledge, skills, attitudes, behaviors, and abilities.

The PNS module objectives were categorized based on the six cognitive levels of Bloom's taxonomy [17]. In this process, we used two online resources that provided the Bloom's taxonomy action verbs lists from Clemson University [18] and Fresno State University [19] since these lists complemented each other and together provided a more well-rounded resource.

#### Element 2: Pedagogical strategies

Instructional activities are one of the core components of a module. These activities use various pedagogical strategies or approaches that emerge from different educational theories of learning such as behaviorism, constructivism, cognitivism, and cognitive theory of multimedia learning [20,21]. Thus, pedagogical strategies can influence instructional design models that can translate the learning principles into effective teaching practices. In this study, we used specific templates to examine and synthesize the pedagogical strategies with respect to how the content was presented to evoke changes in the learner as well as to meet the targeted educational purpose.

#### Element 3: Instructional design properties

To determine the instructional design features and quality, we used a newly developed instrument called the "instructional design scale" (IDS) (Appendix 1). To develop this instrument, we conducted an extensive search of Google, MEDLINE, ERIC, PsycINFO, and Scopus to locate a checklist of validated instructional design properties for interactive modules. Although the literature offers some rubrics, checklists, and tools for quality assurance or development of online modules (Appendix 2), those tools were not specifically developed to assess interactive self-directed e-learning modules. However, as a result of this literature review and based on the best practices in instructional design in e-learning attributes and modalities, the first and the second authors of this paper (KOL and ED) developed the IDS that distinguishes the critical components of ideal instructional design features for a module in six key domains below:

1. *Content Design*: A defined domain of knowledge, skills, and concepts to be taught to fulfill a learner's need by presenting information in the best way for the learner to consume. The content design comes in various forms (audio, video, and text), uniting with the goals and objectives, and utilizes multiple teaching strategies to stimulate, engage, and motivate the learners. The content design also includes the organization and sequential relationship of materials, including visual illustration of specific examples with the right level of vocabulary and terminology for the learners.
2. *Assessment Items*: Any questionnaires, tests, or other activities/tasks to measure critical content elements embedded in a module.

The purpose is to evaluate whether a learner has achieved the objectives that have been established.

3. *Feedback Mechanism*: A system that provides a learner with specific, immediate feedback after completion of a task within a module whether the answers are correct or incorrect. The purpose is to guide learners toward understanding the content knowledge through questions or visual or textual clues.
4. *Media Design*: A design concerned with applying images, tactile–audio–visual elements, and videos to create a multisensory presentation of information that explains the core concepts of a selected subject to be taught. Media design also uses various structural forms to provide learners with a scaffolded, interactive, cognitive, and perceptual motivational learning experience.
5. *Visual Design*: A design that focuses on the aesthetic of a module and its related materials by strategically implementing images, graphics, colors, fonts, space, and other elements (screen titles, symbols or icons, audio narration, and videos) to improve the learner's experience during the learning process.
6. *Navigation*: A user interface of a module that allows learners to identify their learning path. It is like a road map to all the different areas and information contained within the module, so learners always know where they are in the module with a consistent *navigation* scheme.

The IDS was initially developed as a 72-item tool, but after much feedback from peers, we reduced the number of items after the pilot test implementation. Thus, the refined IDS had 50 items. Each item was evaluated by assigning scores ranging from 0.0 to 2.0, with 0 indicating "poor," 0.50 indicating "fair," 1.00 indicating "good," "1.50" indicating "very good," and 2.00 indicating "excellent." Then, the scores were rescaled to 0–100 points. The aim of this rescaling was to assess whether each module could have a minimum score of 80 points. Since there is no globally accepted standard score set for modules, we adopted this grading formula from the higher education system (80 points equate to a B, which is considered as "good"). Moreover, CITI training (Collaborative IRB Training Initiative) and many mandatory employee training course pass scores are set as 80 points. Content and face validity evidence for the IDS items was obtained through peer reviews (see acknowledgments). As mentioned earlier, RedCap™ was the data collection platform for this component of the study.

#### Element 4: Interactivity level

Interactivity is a fundamental aspect of the most effective educational module design. The term "interactivity" is described as the dialog that occurs between a human being and a computer program [22]. In the e-learning module setting, interactivity refers to the exchange of information, responsiveness, and some variation in user control over learning objects that increase learner engagement during the module review/study [23]. To determine the level of interactivity in the modules under the study, we adopted the four levels of interactivity metrics (Table 1), defined by the Virtual College [24].

### *Data analysis*

The data analysis included both the qualitative and quantitative methods. The details of data analysis for each element of the four-pronged model were described as follows:

#### Analysis of element 1

As mentioned earlier, the level of cognition related to the module objectives was determined with Bloom's taxonomy. All objectives from the 18 modules were entered in a template to calculate the number of learning objectives under each cognitive level as well as the total number, average, and distribution of each cognitive group within modules (Appendix 3). To assess the measurability of the action verbs for the validation process, we analyzed the module objectives in three groups:

1. *Group A* represented the distribution of cross-loaded objectives that addressed more than one cognitive level in Bloom's taxonomy. For example, the action verb, "describe" was listed under the three different levels of cognitive learning: knowledge, comprehension, and evaluation;
2. *Group B* represented the distribution of cross-loaded items that were upgraded to the highest cognitive level and addressed by the learning objective (e.g., describe: evaluation level); and
3. *Group C* represented the distribution of cross-loaded items that were reduced to the lowest cognitive level and addressed by the learning objective (e.g., describe: knowledge level).

**Table 1.** Four levels of interactivity.

| Interactivity levels | Description |
|---|---|
| ***Level 1. Passive—no interaction*** | It is a linear design that consists of:<br>• Graphics, images, and simple animations<br>• Rollovers<br>• Test or basic quiz questions<br>The learner acts only as an information receiver and cannot interact with resources. |
| ***Level 2. Limited interaction*** | While the design is still basic, learners have more control over their learning with the content and resources such as:<br>• Clickable animated graphics<br>• Navigation menus, glossaries, and links to external resources<br>• Simple exercises (i.e., drag-and-drop, matching, and identification components)<br>• Audio and vide |
| ***Level 3. Moderate interaction*** | The module design is non-linear and includes<br>• Animated videos<br>• Customized audio recording<br>• Simulated exercises where the learners enter data into fields Scenario-based cases<br>• Custom flash animations where learners have the ability to investigate<br>The learner has more control over their learning and perceives the module as a participative and dynamic activity and not just a presentation of content. |
| ***Level 4. High-level interaction (Full immersion- simulation and game-based learning*)** | The module design includes all of the elements of Levels 1, 2, and 3, plus recharged interactivity with greater levels of sophistication to keep learners motivated. This nonlinear, multiple path design for real-time learning uses a variety of advanced multimedia presentations such as:<br>• Real-time learning<br>• Gaming technology<br>• 3D simulations<br>• Variety of multimedia (i.e., custom videos and interactive 3D objects)<br>• Digital avatars |

### Analysis of element 2

To better understand the pedagogical properties of each module, we used qualitative thematic and interpretive content analysis to categorize different themes regarding the structure of the learning activities within the modules [25,26]. For each module, we made brief notes about the pedagogical properties rooted in established theories and research in human learning to evaluate how the learning activities were structured within the module. In this way, we were able to create the coding framework and categories within specific themes. The following steps guided us during the process:

- We outlined all the segments of modules, including the objectives and purpose of the activity, and then looked at the modeling (e.g., how the activity is structured or illustrated to learn the new skill or content).
- We determined the levels of learners' involvement in a multisensory mode and then categorized them in groups using general learning theoretical concepts such as constructivist learning [27,28], problem-based learning [29,30], discovery learning [31], inquiry approach [32], case-based reasoning [33], and multimedia learning [21]. This process was a kind of slicing and dicing each segment of a learning activity with respect to a learner's engagement in a multisensory learning perspective. We prepared a cheat sheet to facilitate this process (Appendix 4) and grouped all learning activities to determine their theoretical roots as well as labeled them with a more formal activity name that would be used in further analysis.
- To assess the coding consistency and quantify the occurrence of certain types of learning activities, we created two templates: (1) to analyze the types and structure of the learning activities within each module based on their purpose and pedagogical properties (Appendix 5) and (2) to tally each type of pedagogical strategy to see the distribution across the modules (Appendix 6).
- We analyzed the most frequently used pedagogical strategies (teaching method) using the descriptive method and calculated the frequency and frequency percentage of each pedagogical strategy applied to modules.

### Analysis of element 3

Quantitative data from the module reviews were analyzed and interpreted using descriptive statistics (tables, frequencies, and percentages) and intraclass correlations for the six domains of instructional design features (content design, assessment items, feedback mechanism, media design, visual design, and navigation). We used SPSS version 21 (SPSS Inc., Chicago, IL) for all statistical analyses and intraclass correlations. Reliability analysis was determined by calculating intraclass correlation coefficient with two-way model and absolute agreement type with 95% confidence interval.

We calculated the scores for each IDS item (0.0–2.0) given by the reviewers in two steps:

1) Calculating the average scores for each IDS item for six domains given by all the reviewers. This would be considered as horizontal calculation of scores. In this way, we had one average score for each IDS item. Hence, we had a total of 50 item scores for each module evaluated.

2) Calculating the average scores for each domain of instructional design for each module. This step would be considered as vertical calculation of scores that used two stages: (a) the calculation of average scores for each instructional design domain and (b) the calculation of one single average score (average of scores for 50 items) for each module. For example, content design had nine items. The average of nine item scores provided us with the evaluation score of content design domain. Similarly, the feedback domain had seven items; thus, the average of scores came from these seven items (e.g., an evaluation score for feedback domain). Finally, all the averages coming from 50 items were combined to produce the overall scores of an evaluation of a single learning module.

In addition, to determine the passing score for each module, we calculated the sum scores for each module for every reviewer across six instructional design domains among 50 items. The score for each module was rescaled to 0–100 by the multiplication of 2 (50 × 2 = 100). Then, the averaged sum score across all reviewers was further calculated among six raters.

### Analysis of element 4

We applied the descriptive statistics (percentages) to see the consensus regarding the levels of interactivity for all modules.

## Results

As the starting point of analysis regarding the 18 PNS online modules, each module revealed the following segments with a consistent structure:

- Pretest assessing baseline knowledge;
- Chapter-based recorded presentations;
- Clinical case scenarios which include knowledge application, skill assessment, matching activities, pop-ups, and quizzes as practice exercises with immediate feedback on performance and as a means of mastery of knowledge and skills;
- Post test to assess knowledge retention;
- Supplementary materials, including case discussion and applied learning activities.

In addition, we compared the length of modules from the structural and consistency perspectives. The results showed that Module 10 (TPN and Enteral Feeds for Children) was the longest with 80 pages showing on the progress bar, whereas Module 3 (Fluid and Dietary Management of Acute Diarrhea and Dehydration) was the shortest with 36 pages showing on the progress bar. The median length of the modules was 54 pages. All modules included the same navigational features such as the "menu," "back," "next," and "exit" buttons, including the page information and completion % bar to show the learner's progress in completing the modules.

The following are the evaluation results of the modules from the four-pronged approach:

#### *1. Level of cognition related to module objectives*

A total of 66 learning objectives were analyzed in 18 modules. The number of learning objectives varied between three and four in each module. The action verbs used in the learning objectives corresponded with Bloom's taxonomy delineated by Clemson University and Fresno State, except for the fourth objective in Module 11. This objective used "utilize" as an action verb, which does not appear in either list, so we replaced this action verb with the terms "apply" and "use." Three objectives started with "understand" as an action verb, but this is not a measurable verb, so those objectives were labeled as "not defined." The action verb "describe" created a variance since it is one of the most frequently used action verbs in the learning objectives, and it is listed under three cognitive levels: knowledge, comprehension, and evaluation (Group A). The majority of

the objectives were grouped under the knowledge and comprehension levels, and the evaluation level was also loaded because of the cross-loaded action verb "describe." Cognitive loading was not much different from what the cross-loaded goals provided (cross-loaded objectives address more than one cognitive level). Fifty of the 66 objectives focused on the knowledge and evaluation levels, but there were fewer devoted to the comprehension level. When the cross-loaded items were reduced to the lowest cognitive levels (Group C), 54 of the learning objectives focused on the knowledge level, and the remaining nine were distributed across higher cognitive levels from comprehension to evaluation.

### *2. Pedagogical strategies (types of instructional approaches used in the interactive modules)*

The close examination of the 18 modules showed that all modules integrated multichannel learning elements such as audio, videos, visuals, pictures, text, interactive tasks (drag and drop, interactive visual diagrams, matching activity, clicking to see the dynamic content, and quick check to check knowledge), and audio narration to guide the learners through the module. Except for the narration, which was specific to each module, all the PNS presenters' segmented video and audio clips were embedded throughout the modules. In Module 9, we counted a total of 64 integrated video and audio clips (17 videos and 47 audio clips), the highest of any module. The number of integrated video and audio clips for the rest of the modules ranged from 25 to 54 clips.

Based on the framework described in the methods section, the following six pedagogical strategies were used most commonly in the PNS interactive modules (Table 2).

The qualitative analysis results showed that these six pedagogical strategies applied to all modules as follows:

#### Problem-based learning (PBL)

This learner-centered instructional approach embedded in the majority of the learning tasks and activities that required learners to take active roles in solving a problem as part of the learning experience. Through case-based scenarios or role assignment (role play), PBL anchored most learning

**Table 2.** Frequently used pedagogical strategies.

| Category of pedagogical strategies | Most to least used pedagogical strategies | Frequency & percentage (%) |
|---|---|---|
| Problem-Based Learning (PBL) | • Modules 4, 10, and 16 used the most PBL approaches compared to the other modules.<br>• Module 3 utilized the least PBL-anchored activities. | 75 (8) |
| Discovery Learning with Gaming or Video(s) | • Each module had an average of four or five discovery learning activities built within the module.<br>• Modules 8, 10, 13, 16, and 18 combined discovery learning with games<br>• Detective games were used heavily in Module 13 (three games).<br>• Another model of game mode was used in decision-making type of case study activities in Module 18. | 218 (22) |
| Segmented (Hyperlinked Content with Graphics | • Modules 2 and 13 used the highest number of segmented approaches compared to the other modules. | 45 (5) |
| Teaching with Testing | • This was the most dominant pedagogy utilized for all 18 modules.<br>• The number of questions of each type varied from module to module, but Module 9 had the highest number of true/false questions (15).<br>• Module 2 had the least number of true/false questions (two).<br>• Module 15 heavily used a case-based counseling model and posed 12 questions for teaching.<br>• The rest of the modules included six to eight questions in the multiple formats, but the visual slider scale was used in only a few modules (Modules 6, 13, and 18). | 516 (53) |
| Progressive Disclosure | • Modules 9 and 10 used the greatest amount of this "progressive disclosure" type of content, whereas Module 14 had only two examples of this pedagogy.<br>• The rest of the modules used an average of four to five progressive discourse strategies in presenting the content. | 95 (10) |
| Questions and Answers Session | • The greatest number of questions (four) was posed in Modules 9, 13, and 16.<br>• Most of the modules used three segmented question and answer sections (12 modules), but Modules 4 and 18 had only two questions.<br>• Module 17 had only one question posed to the speaker. | 18 (2) |

content that required critical thinking skills and decision-making to develop a viable solution to a defined problem.

**Discovery learning with gaming or video(s)**

This learner-centered method used inquiry-based learning approaches that were mostly applied in unguided problem-solving situations. The learner was expected to explore information and concepts to construct new ideas, identify new relationships, and create new models of thinking and behavior. Learners were asked to answer questions before they had not yet been fully exposed to the module content. Furthermore, gaming and videos as multimedia learning were integrated into the discovery learning method in the learning activities to make them more interesting and engaging. Some of the game-based activities had a tally counter that showed the number of the learners' attempts to complete the exercise (number of tries).

**Segmented (hyperlinked content with graphics)**

This visually inspired graphic organizer method and presented concepts that organized large amounts of content segmented into digestible "knowledge chunks". Graphics were utilized to enhance comprehension and lead to more information as the learner chooses to explore. A majority of the segmented content/knowledge chunks in the modules were used in a table format. Some of the modules (6, 9, and 10) used the anatomic components of digestion and the human body for segmented learning approaches, including hyperlink with a graphic interface (knowledge was provided when the link was clicked).

**Teaching with testing**

This was an integrated method of linking testing with instruction. Rather than traditional testing (feedback limited to "correct" or "incorrect"), learners were provided with multiple forms of feedback, such as audio or video recorded expert opinion, hints, guidance, and additional levels of knowledge, which were provided when the learner selected an incorrect answer. When the correct answer was selected, the presenter provided additional knowledge and remediation of critical concepts. The testing concepts were integrated into the whole module in two main categories:

- Quizzes/Examination Jam/Quick Check: The type of questions for this category included true/false, drag and drop, and multiple-choice questions. The use of multiple-choice questions for each module varied between three and five questions.
- Test Integrated Content Teaching: This second category of question type consisted mostly of case-based scenarios, email exercises, "you do the research," multiple-choice questions (one or multiple answers options), matching or drag and drop, and visual slider scale.

**Progressive disclosure**

Multiple large portions of content within the PNS modules were presented in digestible chunks, one at a time using a tables and graphics format (e.g., clicks on the tables or graphics were required to populate the full content). This method was to reveal additional details on an on-demand basis so that the learners receive answers for the questions they pursue. Large amounts of content (i.e., tables) are presented one-at-a-time (digestible chunks). For example, learners click on each item in the first column (level of dehydration) and then the adjacent column (symptoms) is populated with relevant knowledge.

**Question and answer session**

This is a method that organizes information via questions with linked answers instead of straight presentation of concepts. For example, a video includes segmented questions and answers. Learners can select from individual questions that have been segmented and categorized for easy access. Once a learner selects a relevant question, the video of the presenter appears providing the correct answer. Finally, all 18 modules provided a "Questions from Your Peers" session at th end of the modules.

***3. Instructional design properties of the modules***

The results showed that the six domains of instructional design evaluation scores of the PNS modules ranged from 1.78 to 2.00 for content design, 1.80 to 2.00 for assessment, 1.69 to 2.00 for feedback, 1.64 to 2.00 for media design, 1.81 to 1.99 for visual design, and 1.64 to 2.00 for navigation domains (Table 3).

Table 4 displays the average minimum and maximum scores for all 18 modules across six instructional design domains. Average evaluation scores ranged between 1.75 and 1.94 for the overall scale.

The overall results suggested that all modules were considered to be between "very good" with a score of 1.5 and "excellent" with a score of 2.

**Table 3.** Six domains of instructional design scores (50 items).

| Modules | Content design | Assessment items | Feedback mechanism | Media design | Visual design | Navigation | Overall score | Converted to 100 |
|---|---|---|---|---|---|---|---|---|
| M1 | 1.94 | 1.91 | 1.95 | 2.00 | 1.98 | 1.89 | 1.94 | 97.0 |
| M2 | 1.86 | 1.97 | 1.93 | 1.75 | 1.97 | 1.86 | 1.90 | 95.0 |
| M3 | 1.89 | 1.97 | 1.89 | 1.89 | 1.86 | 1.86 | 1.90 | 95.0 |
| M4 | 1.97 | 1.94 | 1.75 | 1.71 | 1.81 | 1.64 | 1.81 | 90.5 |
| M5 | 1.89 | 2.00 | 1.86 | 1.79 | 1.94 | 1.89 | 1.90 | 95.0 |
| M6 | 1.89 | 2.00 | 1.82 | 1.86 | 1.97 | 1.92 | 1.92 | 96.0 |
| M7 | 1.92 | 2.00 | 1.86 | 1.86 | 1.86 | 1.92 | 1.91 | 95.5 |
| M8 | 1.86 | 2.00 | 1.86 | 1.86 | 1.86 | 2.00 | 1.91 | 95.5 |
| M9 | 1.94 | 2.00 | 1.75 | 1.79 | 1.92 | 1.86 | 1.89 | 94.5 |
| M10 | 1.78 | 1.80 | 1.79 | 1.64 | 1.83 | 1.65 | 1.75 | 87.5 |
| M11 | 1.82 | 1.81 | 1.77 | 1.64 | 1.81 | 1.72 | 1.77 | 88.5 |
| M12 | 1.90 | 1.97 | 1.91 | 1.68 | 1.86 | 1.79 | 1.86 | 93.0 |
| M13 | 1.97 | 2.00 | 1.80 | 1.75 | 1.94 | 1.82 | 1.89 | 94.5 |
| M14 | 1.93 | 1.94 | 1.69 | 1.71 | 1.96 | 1.87 | 1.86 | 93.0 |
| M15 | 1.93 | 1.99 | 1.84 | 1.86 | 1.99 | 1.93 | 1.93 | 96.5 |
| M16 | 1.85 | 1.96 | 1.79 | 1.88 | 1.97 | 1.92 | 1.90 | 95.0 |
| M17 | 1.96 | 1.98 | 1.83 | 1.67 | 1.89 | 1.76 | 1.86 | 93.0 |
| M18 | 2.00 | 1.98 | 1.79 | 1.76 | 1.94 | 1.85 | 1.90 | 95.0 |
| AVG | 1.91 | 1.96 | 1.83 | 1.78 | 1.91 | 1.84 | 1.88 | 94.0 |

**Table 4.** Minimum and maximum instructional design evaluation scores.

| | Content design | Assessment | Feedback | Media design | Visual design | Navigation | Overall scale |
|---|---|---|---|---|---|---|---|
| # items | 9 | 9 | 7 | 7 | 9 | 9 | 50 |
| Min | 1.78 | 1.80 | 1.69 | 1.64 | 1.81 | 1.64 | 1.75 |
| Max | 2.00 | 2.00 | 2.00 | 2.00 | 1.99 | 2.00 | 1.94 |

Intraclass correlations (ICCs) were examined for the inter-rater reliability. ICCs were not calculated for some modules due to low variability, and some were marked as "1" if the scores provided by each evaluator were identical (Table 5). Thus, raters' agreement on overall scale was interpreted instead of each specific assessment domain. ICC coefficients ranged from 0.21 to 0.83, indicating that the raters had considerably low agreement over certain PNS modules such as Modules 5 and 7. On the other hand, the raters had moderate and/or high agreement on some modules such as Modules 3, 11, 14, and 15. ICCs indicated that six raters' agreement ranged from 0.00 to 1.00 for content design and assessment, 0.00 to 0.89 for feedback, 0.00 to 0.94 for media design, 0.00 to 0.68 for visual design, and 0.00 to 0.50 for navigation domains. In addition, the analysis of raters' agreement using ICCs showed that their agreement on overall scoring of each module ranged between 0.21 (Module 7) and 0.83 (Module 14). Most of the modules showed a moderate agreement among six raters.

Finally, the final evaluation scores for 18 modules and 50 items ranged from 87.4 (Module 10) to 97.0 (Module 1). The results showed that all modules passed the minimum score of 80 for the 50-item IDS, which was the goal that we initially set for each module.

### *4. Level of interactivity*

The results showed that interactivity scores ranged between 2.50 and 3.50. The majority of raters reviewed nine of all 18 modules. Table 6 indicates that the six raters' scores for the level of interactivity regarding the module design varied, but most of the scores fell into the Level 3 category; all raters agreed that these modules were definitely not at Level 1.

**Table 5.** IDS intra-class correlations (50 items).

| Modules | Content design | Assessment | Feedback | Media design | Visual design | Navigation | Overall scale |
|---|---|---|---|---|---|---|---|
| M1 | 0.57 | 0.47 | 0.00 | 0.00 | 0.00 | 0.46 | 0.45 |
| M2 | NA | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.42 |
| M3 | 0.00 | 0.00 | 0.89 | 0.80 | 0.68 | 0.40 | 0.65 |
| M4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.54 | 0.40 | 0.46 |
| M5 | 0.18 | 1.00 | 0.00 | 0.42 | 0.00 | 0.33 | 0.34 |
| M6 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 |
| M7 | 0.00 | 1.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.21 |
| M8 | 0.13 | 1.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.41 |
| M9 | 0.00 | 1.00 | 0.71 | 0.42 | 0.50 | 0.00 | 0.53 |
| M10 | 0.03 | NA | NA | 0.44 | 0.19 | 0.14 | 0.50 |
| M11 | 0.28 | 0.37 | 0.39 | 0.94 | 0.06 | 0.26 | 0.62 |
| M12 | 0.04 | 0.20 | 0.66 | 0.71 | 0.22 | 0.18 | 0.47 |
| M13 | 0.20 | 1.00 | 0.15 | 0.82 | 0.00 | 0.04 | 0.61 |
| M14 | 0.39 | 0.00 | 0.50 | 0.93 | 0.00 | 0.23 | 0.83 |
| M15 | 0.40 | 0.00 | 0.78 | 0.74 | 0.00 | 0.14 | 0.68 |
| M16 | 0.17 | 0.30 | 0.19 | 0.76 | 0.00 | 0.38 | 0.52 |
| M17 | 0.00 | 0.00 | 0.33 | 0.92 | 0.00 | 0.49 | 0.75 |
| M18 | 1.00 | 0.00 | 0.10 | 0.80 | 0.33 | 0.36 | 0.63 |

**Table 6.** Levels of interactivity.

| Raters | #Modules reviewed | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|
| A | 6 | NA | NA | 100% | NA |
| B | 9 | NA | 56% | 44% | NA |
| C | 9 | NA | NA | 33% | 67% |
| D | 9 | NA | NA | 22% | 78% |
| E | 9 | NA | 100% | NA | NA |
| F | 9 | NA | NA | 100% | NA |

NA. Not Applicable.

In Table 6, "NA" means that no raters rated/assigned a score to the module that they reviewed, while the percentage indicates the levels of interactivity of the rater assigned to modules they reviewed. For example, rater A assigned all six modules "Level 3" for the levels of interactivity, whereas rater B assigned 56% of modules "Level 2" and 44% of modules "Level 3" among the nine modules reviewed.

## Discussion

The main purpose of this study was to introduce a novel four-pronged approach for evaluating e-learning module designs. This conceptual framework was combined to assess the learning objectives, pedagogical strategies, instructional design attributes, and interactivity levels of the modules under this study. We also provided detailed information about how to employ each step in the evaluation process. We strongly believe that examining instructional design properties of any e-learning application is necessary to gain a deeper understanding of best design principles and key tenets of learning theories behind the learning activities as well as to detect possible imbalances among modules. The proposed model in this study provides a valuable method to guide future design and development and, especially, to remind educators not to overlook or miss some of the important elements in an effective instructional design process using the IDS. Furthermore, the IDS can provide a replicable model for a consistent value-driven process for evaluating any e-learning-based modules or

projects. The following are further reflections on this study.

### *Learning objectives*

As mentioned above, the results showed that the learning objectives of the PNS modules heavily addressed the low-cognitive levels in reference to Bloom's taxonomy. While objectives in the group of low-order skills (knowledge, comprehension, and application) provide an important base for learning, they cannot produce deeper cognitive processing that is necessary to improve critical thinking and evaluate judgments for decision-making [34]. At the same time, lower-order skills require less cognitive processing and represent the lowest level of learning outcomes in the cognitive domain. Literature has also shown similar shortcomings regarding higher learning levels in many training programs. For example, one study conducted by Le´gare´ et al. [35] evaluated that the objectives of 110 accredited continuing professional development activities offered to healthcare professionals found that half of the learning objectives concentrated on the lower levels in the cognitive domain based on Bloom's taxonomy.

We also have concerns regarding the distribution of the learning objectives over different cognitive domains for each module, as a more balanced distribution of learning objectives across cognitive domains is desirable. The pedagogical and cognitive perspectives of the PNS learning modules might be improved by modifying the learning objectives to equally and substantially address all cognitive domains and by aligning them with the pedagogical approaches and assessment practices. On the other hand, the number of objectives per module seems reasonable at three to four. There are no globally accepted standards regarding the number of learning objectives for an e-learning module. According to Brookhart and Nitko [36], it is assumed that each instructional unit should have two to four specific learning objectives or outcomes, which might be considered in alignment with the adequate number of goals of an e-learning application.

### *Pedagogical approaches*

All modules used a variety of tasks and activities. We believe that just as different foods contribute to good nutrition, different learning activities contribute to more memorable and effective learning. The six pedagogical approaches used in the modules were also appropriate for the targeted level of instruction, but their use across 18 modules did not give us consistent results for each module. This inconsistency may be partially related to the nature of the content that may have required different pedagogical design approaches. Besides, the different content authors/presenters involved in this project had no orientation or guidance for the instructional design components. We noticed another important point about the pedagogical approaches in this study: the three methods of learning (problem-based learning, discovery learning with gaming, and teaching with testing) were well-aligned with the higher-order thinking skills according to Bloom's taxonomy (analysis, synthesis, and evaluation) [17]. However, the majority of the learning objectives of modules were not compatible with higher-order thinking skills, especially, when cross-loaded items (objectives) were reduced to the lowest cognitive levels. We think that this deficiency stems from the collaboration process. The design team was not able to directly communicate with the content authors/presenters regarding writing the objectives because of the size of the project, involving three different parties (i.e., the PNS working group/faculty, the content authors/presenters, and the technology provider).

Another noticeable result was that the use of "teaching with testing" method was the highest (54%) among the other most frequently used pedagogical approaches. Various testing formats were embedded as a formative assessment to promote learning. Learning and assessment are clearly connected and inter-related to construct new knowledge or skills; especially, the prompt feedback would tell learners how they should learn as well as what they should learn to improve the learning. From the e-learning design perspectives, this type of design in modules would benefit learners as a positive learning outcome, specifically reinforcing knowledge development and better content acquisition with various testing formats that are designed to improve critical thinking and decision-making and/or problem-solving skills. Literature also shows that the benefits of test-enhanced learning can directly affect learning by promoting better retention of information and enrich learning in a variety of different contexts [37–39]. Larsen's study also emphasized the importance of alignment between the form of testing and educational objectives. At this point, in the design of teaching with testing formats, it is crucial to use Bloom's taxonomy as a valuable guide to examine the targeted educational outcomes with associated cognitive levels for better alignment.

In addition, the results showed that discovery learning was the second most frequently used pedagogical approach. In fact, discovery learning [31] is viewed as problem-based learning [29,40,41] since the concepts are closely tied to each other, and the characteristics of both instructional approaches have the same pedagogical aims in three areas: 1) promoting deeper learning, 2) promoting metacognitive skills, and 3) promoting learner engagement. However, we separated them because the problem-based learning activities were presented in a more guided format within scenarios targeting a viable solution to a defined problem. On the other hand, the discovery learning used a variety of instructional techniques such as searching for relevant information, exploring or manipulating objects, timed tasks for exploration, inquiry-based games, decision-making tasks, and logic required tasks for comparative analysis.

### *The IDS framework*

As we stated earlier, we were unable to locate in literature any studies that provided validated comprehensive instructional design tools or a checklist for interactive instructional design modules. The lack of an existing tool or checklist encouraged us to develop the IDS, which is novel and distinguishes six key domains of an ideal instructional design. However, the reliability and validity of this tool may need further investigation. From a general perspective, some validity evidence such as face validity and content validity were collected, but further psychometric analysis would make the IDS tool even better. We believe that the IDS has the potential to ensure the consistency of the common elements of each instructional design domain across any e-learning module design. We obtained relatively different results for inter-rater reliability for some modules (5 and 7) compared to most of the other modules. This inconsistency may be due to the raters' varying backgrounds as well as the raters' knowledge of the content in the modules. Future work may need to recruit more raters and address how rater training with the IDS can provide even better consistency. Further analysis of Modules 5 and 7 compared to other modules may be informative regarding the types of dynamics and elements embedded in those modules that may have affected inter-rater reliability.

### *Interactivity determination*

The results showed that most of the scores for the interactivity level fell in the range of Level 3 (moderate interaction). However, two of the raters (C and D) scored the interactivity level of the nine modules as Level 4, "high-level interaction" (67% and 78%). One reason for their high scores may be related to the games that were integrated into some of the modules. Level 4 is described as the simulation and game-based learning level, where the learner is an active participant in the process of the learning experience. Unfortunately, there are no reliable guidelines or validated tools to measure the actual interactivity for modules designed for self-paced e-learning. During the search, we encountered one rubric-based tool developed by Yamamoto [42], which measures the interactivity of e-learning from both the learners' and the instructor's perspective. When we talk about interactivity in an online environment, many people usually think of the three types of interaction: 1) learner-content, 2) learner-teacher, and 3) learner-learner interaction [43]. In fact, in the self-paced e-learning concept, interactivity is a measure of learner involvement during an instructional activity. This involvement is usually related to the learner-content and the learner-machine (computer). Understanding how users and technology communicate with each other is fundamental to the design of e-learning modules. The key to e-learning modules lies in how to achieve the right balance in effective instructional design elements so that they are truly interactive and engaging for learners.

This study prompted us to question how much interactivity is ideal for a state-of-the-art online module. The "more is better" cliche might not always be appropriate in e-learning design. In our opinion, good instructional design and interactivity must have a clear purpose. Interactivity strategies should be selected based on the nature of the content, learning goals, learner characteristics and needs, cognitive loads, assessment, and evaluation strategies to deliver better achievement in learning. At this point, it is difficult to ascertain how much interactivity is ideal for an e-learning module. However, recent neuroscience of learning research has produced profound insights into the ways that learning occurs [44–46]. These insights highlight the importance of intentional design in learning and indicate the need for interactive, engaging brain-based instructional design practices [47,48]. These principles help us to understand learning designs that go far beyond the transmission of information to achieve behavioral change and targeted performance levels. The PNS modules integrated self-paced navigation throughout all of the modules. In

this way, the learners cannot move forward unless they actively participate in the module as a learning dialogue.

### Implications, Limitations, and Future Directions

We applied the four-pronged approach for the first time to the PNS modules. We believe that this model of assessment has a potential to guide future design and development and, especially, to remind educators not to overlook or miss some of the important elements in an effective instructional design process. The most important implication of this study is that the interactivity, the instructional design properties, and diversity of pedagogical strategies used in e-learning design can be evaluated and quantified, to allow comparison of different learning modules or to compare module design against a desired standard. However, we would like to note some of the limitations of the present study that should be addressed in future work:

- While our novel four-pronged approach has served the study purposes well, this model can be improved by further identifying strengths and weaknesses or potential flaws during the development of various e-learning applications.
- This study was descriptive in nature and limited to the 18 PNS modules.
- We assumed that the module reviewers had basic knowledge about instructional design and responded truthfully to the IDS items, including their experience, perceptions, and beliefs during the review of the PNS modules.
- Validity was limited by the small number of reviewers who voluntarily completed the reviews.
- The IDS was applied only to the PNS interactive modules; we do not know how it would work with other e-learning modules. This systematic process should be applied to other online curricula to assess the value of this framework.
- Psychometric analyses of the IDS were beyond the scope of this study. Although ICCs indicated moderate- to high-level inter-rater reliability and showed the structure validity evidence for the IDS for most of the modules, further investigation is suggested to determine if these are all necessary items in the assessment of value.
- The feasibly of the IDS instrument should be tested how it would work as a checklist format during the development of e-learning solutions.

In summary, the analysis of the instructional design framework of the PNS modules provides essential insights regarding the science of instruction, showing that different instructional concepts require the selection of different instructional pedagogies. We strongly believe that consistency in instructional design practices is critical for developing high-quality instructional e-learning modules. Proactively planning instruction using the proposed model with an instrument like IDS at the onset of developing any instructional online module may produce innovative pedagogies that allow the learner to engage in self-directed and independent learning. Furthermore, the four-pronged approach can provide a valuable road map to determine a standardized approach or instructional alignment to assure instructional design quality for the development of educational modules while it has the potential to be an evaluation model for other e-learning applications in any field of the study.

## Conflicts of interest

The authors have no conflicts of interest to declare.

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## Appendix 1

### INSTRUCTIONAL DESIGN SCALE

This tool is developed to evaluate the instructional design properties of interactive e-learning modules. The tool is divided into six domains, consisting of 50 items and one additional item for evaluating the level of interactivity for each module.

Now check the box below to access the list of evaluation forms for each PNS module. If you have any questions about this review, please contact Kadriye O. Lewis, Ed.D at kolewis@cmh.edu.

**Note:** Module access information was sent to you earlier.

**Evaluator's Name:**

**Please select the module you are evaluating from the pull-down menu:**

Module 1: 10 Things You Must Know About Nutrition
Module 2: Be Knowledgeable About Breastfeeding
Module 3: Fluid and Dietary Management of Acute Diarrhea and Dehydration
Module 4: Fluids, Glucose, Calcium, and Parenteral Nutrition for the Neonate
Module 5: Enteral Nutrition for Premature Infants
Module 6: Over-Nutrition in Teens: Obesity and the Metabolic Syndrome
Module 7: Toddler Feeding: Navigating the Transition
Module 8: Sports and Nutrition
Module 9: Eating Disorders in Teens
Module 10: TPN and Enteral Feeds for Children
Module 11: Sports Nutrition for the Teen Athlete
Module 12: Management of Adolescent Eating Disorders in the Medical Setting
Module 13: Impact of Maternal Nutrition on Children's Health
Module 14: The Challenge of Complementary Foods for Babies
Module 15: Nutrition in Adolescents: Promoting Optimal Health
Module 16: Counseling Mothers and Families about Breastfeeding and Breastfeeding Concerns
Module 17: Basic Newborn Nutritional Needs
Module 18: Basic Newborn Nutritional Formulas

## Part I: Instructional Design Properties

**Please score each item on a 0–2 scale, with 0 = poor and 2 = excellent.**

| Criteria | Scoring | | | | |
|---|---|---|---|---|---|
| **Content Design** | **Poor (0)** | **Fair (0.50)** | **Good (1)** | **Very Good (1.50)** | **Excellent (2)** |
| 1. The level of the content presented is appropriate and relevant to the target audience (e.g., medical or other healthcare professionals). | | | | | |
| 2. The information is "scaffolded" well to guide learners to complete the sections within the module. | | | | | |
| 3. The content is stimulating, engaging, motivating, and relevant to the targeted learners. | | | | | |
| 4. The content is informative and promotes deeper learning. | | | | | |
| 5. The module uses multiple interactive teaching strategies such as cases, videos, problem-based learning, discovery, and testing with teaching. | | | | | |
| 6. The vocabulary and terminology used in the module are clear and supported by references or glossaries. | | | | | |
| 7. The content presented in the module uses visuals such as graphs, pictures, and illustrations. | | | | | |
| 8. The module summarizes the information to be presented at the beginning of the module. | | | | | |
| 9. The module summarizes the information at the end of the module. | | | | | |
| **Assessment Items** | **Poor (0)** | **Fair (0.50)** | **Good (1)** | **Very Good (1.50)** | **Excellent (2)** |
| 1. The module includes a pre- and posttest. | | | | | |
| 2. The pre-/posttest and other assessment questions within the module are aligned to the module content and objectives. | | | | | |

*(Continued)*

| | | | | | |
|---|---|---|---|---|---|
| 3. Assessment items allow repeated or multiple attempts when appropriate. | | | | | |
| 4. Knowledge assessment questions incorporate interactive graphics, images, or videos related to the core concept of the module. | | | | | |
| 5. The module uses multiple types of questions such as true-false, multiple-choice, multiple answers, fill-in the blanks, matching, interactive graphs or drag/drop items, and quick check questions. | | | | | |
| 6. Assessment items have an appropriate level of rigor and/or demonstrate a progression of cognitive complexity to measure for a range of learners' thinking and understanding. | | | | | |
| 7. Assessment items intend to measure critical content elements embedded in the module. | | | | | |
| 8. The number of questions is well-distributed within the module (not only at the end). | | | | | |
| 9. The format of the assessment matches the nature of interactive modules with measurable progress. | | | | | |
| **Feedback Mechanism** | **Poor (0)** | **Fair (0.50)** | **Good (1)** | **Very Good (1.50)** | **Excellent (2)** |
| 1. The module provides immediate feedback after the completion of the pretest, including correct and incorrect responses. | | | | | |
| 2. Assessment questions provide immediate explanatory feedback as to why the selected answer is true or false. | | | | | |
| 3. The module forces learners to find the right answer by giving guided feedback. | | | | | |
| 4. The module visually highlights/indicates the learner's correct or incorrect responses to the assessment items. | | | | | |
| 5. The module provides unique explanations for each wrong answer as feedback. | | | | | |
| 6. Learning modules guide learners to external resources as feedback to enhance learners' understanding. | | | | | |
| 7. Overall, the feedback mechanism is interactive and efficient and guides learners toward understanding the content knowledge through questions. | | | | | |
| **Media Design** | **Poor (0)** | **Fair (0.50)** | **Good (1)** | **Very Good (1.50)** | **Excellent (2)** |
| 1. The module includes clearly narrated presentations during the delivery of the content (if applicable). | | | | | |
| 2. The narrator introduces the speaker and provides an explanation of the module with a brief introduction, including the subsections. | | | | | |
| 3. The instructions or directions given by the narrator are clear and simple. | | | | | |
| 4. The images, text, and audio are well-synchronized (sound and written text/video properly overlap) in the module. | | | | | |
| 5. The learner has the full control of narrators' audio and/or the videos (e.g., stop and start, rewind to a specific segment, or pause on a specific frame). | | | | | |
| 6. The audiovisual materials/videos work properly on different web browsers. | | | | | |
| 7. Overall media design elements are integrated into multimodal presentation that explains the core concepts of the module effectively. | | | | | |
| **Visual Design** | **Poor (0)** | **Fair (0.50)** | **Good (1)** | **Very Good (1.50)** | **Excellent (2)** |
| 1. Each page within the module has consistent color coding regarding the title, body of the text, and assessment activities. | | | | | |
| 2. The module has a consistent font size, color, and text format which is easy to read. | | | | | |
| 3. The module uses captioning and/or bold, italic, and underscored text to highlight organization or important information. | | | | | |

*(Continued)*

| | | | | | |
|---|---|---|---|---|---|
| 4. The design of each page within the module shows an appealing visual organization (not crowded and text-heavy). | | | | | |
| 5. Text and audiovisual materials are well-balanced with appropriate whitespace (e.g., presented in esthetic ways). | | | | | |
| 6. The positions of audiovisual materials on the screen are easy to follow and appealing to learners. | | | | | |
| 7. The screen titles, symbols, or icons clearly represent the corresponding message. | | | | | |
| 8. The module is free of errors in grammar, capitalization, punctuation, and spelling. | | | | | |
| 9. Consistent language is used throughout the entire module. | | | | | |
| **Navigation** | **Poor (0)** | **Fair (0.50)** | **Good (1)** | **Very Good (1.50)** | **Excellent (2)** |
| 1. The function of the module's navigation control is easily determined at a glance. | | | | | |
| 2. The user interface of the module allows learners to easily identify their learning path. | | | | | |
| 3. The navigation of the module is consistent, logical, and easy for a learner who may have little or no experience with the use of technology/ computers. | | | | | |
| 4. The module provides narrated navigational directions in conjunction with visual indicators (if applicable). | | | | | |
| 5. Learners can control their learning progress by navigating between the subsections using a menu, back, and next buttons and a clearly identifiable "exit" button. | | | | | |
| 6. The module has a progress indicator showing which parts of the learning module have been completed (e.g., page number or progress bar). | | | | | |
| 7. The interface of the module allows users to find information and sections quickly. | | | | | |
| 8. The module has a resume function which will save the learner's progress when they want to leave the module and allow them to continue from the exact place when they return. | | | | | |
| 9. The module is free from broken navigational links and technical glitches. | | | | | |

## Part II: Interactivity Section

**Please evaluate the overall interactivity level of the learning module based on the following criteria:**

LEVEL I (*Passive-no interaction*): The course development is linear and could be considered basic training, in which the learner acts only as an information receiver. The sequence of screens is fixed, and the learner cannot choose the order in which s/he wants to see the content, return to a previous topic, or browse freely. It can be effective for communicating simple concepts and is relatively inexpensive to develop. At this level, the learner does not interact with resources, but s/he just has graphics, images, simple animations, rollovers, and basic quiz questions.

LEVEL 2 (*Limited interaction*): At this level, the learner has more control over their training. S/he has the ability to do more than just watch, read, and navigate. This level is used for non-complex operations and maintenance lessons. At this level, the learner interacts with resources such as clickable animated graphics, navigation expands to menus, glossaries, and links to external resources. This may often include simple exercises (i.e., drag-and-drop, matching, and identification components), audios, and videos.

LEVEL 3 (*Moderate interaction*): At Level 3, there is a high degree of complexity and customization of the course. The learner has more control over his/her training and perceives the course as a participative and dynamic activity and not just a presentation of content. This level optimizes active learning. Some key features include animated videos, customized audio recording, complex simulations where the learners enter data into fields, scenario-based cases, and custom flash animations where the learner has the ability to investigate.

LEVEL 4 (*High-level interaction*): Level 4 training is the simulation and game-based interactive learning, where the learner is an active participant in his/her training experience. This level of interactivity can be used for functions such as enhancing understanding, particularly when the process is complex and multifaceted (e.g., impart knowledge, impart situational understanding, conceptualize training, application of training, reflective practice, and reaction). This level of interactivity provides the opportunity to become immersed in the learning and enables the learner to conceptualize, react, and apply learning to his/her roles, duties, or task.

**Note:** The four levels of interactivity scale is adopted from Virtual College (https://www.virtual-college.co.uk/)

## Appendix 2

### Quality Assurance Rubric and Checklist Examples

| Tool name | Criteria | Reference |
|---|---|---|
| Quality Online Course Initiative (QOCI) | 1. Instructional design (course information and course design)<br>2. ICommunication, interaction, and collaboration<br>3. IStudent evaluation and assessment (feedback and grading)<br>4. IAccreditation compliance | QOCI. Available at: https://icc.edu/faculty-staff/teaching-learning-center/teaching-online-at-icc/qoci-quality-online-course-initiative/ |
| Learning Object Review Instrument | 1. IContent quality<br>2. Learning goal alignment<br>3. Feedback and adaptation<br>4. Motivation<br>5. Presentation design<br>6. Interaction usability<br>7. Accessibility<br>8. Reusability<br>9. Standards compliance | Leacock TL, Nesbit JC. A framework for evaluating the quality of multimedia learning resources. Educational Technology & Society. 2007; 10(2): 44-59. |
| The Quality Matters™ Rubric | 1. Course overview and introduction<br>2. Learning objectives (competencies)<br>3. Assessment and measurement<br>4. Instructional materials<br>5. Learning activities and learner interaction<br>6. Course technology<br>7. Learner support<br>8. Accessibility and usability | Quality Matters™ (2014). "Higher Ed course design rubric". Available at: https://www.qualitymatters.org/qa-resources/rubric-standards/higher-ed-rubric |

## Appendix 3

### Number of Learning Objectives Under Each Cognitive Level

| Module | Group | Knowledge | | Comprehension | | Application | | Analysis | | Synthesis | | Evaluation | | N/D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | F | C | F | C | F | C | F | C | F | C | F | |
| Module 1 | A* | 3 | 3 | | | | | 1 | | | | | | |
| | B* | 2 | 3 | | | | | 1 | | | | | | |
| | C* | 3 | 3 | | | | | | | | | | | |
| Module 2 | A | | | | | | | | | 1 | 1 | | | 2 |
| | B | | | | | | | | | 1 | 1 | | | 2 |
| | C | | | | | | | | | 1 | 1 | | | 2 |

*(Continued)*

| Module | Group | Knowledge | | Comprehension | | Application | | Analysis | | Synthesis | | Evaluation | | N/D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | F | C | F | C | F | C | F | C | F | C | F | |
| Module 3 | A | 4 | 4 | 2 | 2 | | | | | | | 2 | 2 | |
| | B | 2 | 2 | | | | | | | | | 2 | 2 | |
| | C | 4 | 4 | | | | | | | | | | | |
| Module 4 | A | 1 | 1 | 2 | 2 | | | 1 | | 3 | 3 | 1 | 1 | |
| | B | | | | 1 | | | 1 | | 2 | 2 | 1 | 1 | |
| | C | 1 | 1 | 1 | 1 | | | | | 2 | 2 | | | |
| Module 5 | A | 4 | 4 | 3 | 3 | | | | | | | 3 | 3 | |
| | B | 1 | 1 | | | | | | | | | 3 | 3 | |
| | C | 4 | 4 | | | | | | | | | | | |
| Module 6 | A | 4 | 4 | 2 | 2 | | | | | | | 2 | 2 | |
| | B | 2 | 2 | | | | | | | | | 2 | 2 | |
| | C | 4 | 4 | | | | | | | | | | | |
| Module 7 | A | 3 | 3 | 1 | 1 | | | | | | | 1 | 1 | |
| | B | 2 | 2 | | | | | | | | | 1 | 1 | |
| | C | 3 | 3 | | | | | | | | | | | |
| Module 8 | A | 3 | 3 | 1 | 1 | | | | | | | 1 | 1 | |
| | B | 2 | 2 | | | | | | | | | 1 | 1 | |
| | C | 3 | 3 | | | | | | | | | | | |
| Module 9 | A | 4 | 4 | 1 | 1 | | | | | | | 1 | 1 | |
| | B | 3 | 3 | | | | | | | | | 1 | 1 | |
| | C | 4 | 4 | | | | | | | | | | | |
| Module 10 | A | 5 | 5 | 2 | 2 | | | | | | | 2 | 2 | |
| | B | 3 | 3 | | | | | | | | | 2 | 2 | |
| | C | 5 | 5 | | | | | | | | | | | |
| Module 11 | A | 2 | 2 | 3 | 3 | | 1 | 2 | 1 | | | | | 1** |
| | B | 1 | 1 | 2 | 3 | | | 2 | 1 | | | | | 1** |
| | C | 2 | 2 | 2 | 2 | | 1 | 1 | | | | | | 1** |
| Module 12 | A | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | B | 1 | 1 | 1 | 2 | | | 1 | | 1 | 1 | 1 | 1 | |
| | C | 3 | 3 | 1 | 1 | 1 | 1 | | | | | | | |
| Module 13 | A | 3 | 3 | 1 | 1 | | | 1 | | | | 1 | 1 | |
| | B | 1 | 2 | | | | | 1 | | | | 1 | 1 | |
| | C | 3 | 3 | | | | | | | | | | | |
| Module 14 | A | 4 | 4 | 3 | 3 | | | | | | | 3 | 3 | |
| | B | 1 | 1 | | | | | | | | | 3 | 3 | |
| | C | 4 | 4 | | | | | | | | | | | |
| Module 15 | A | 4 | 4 | 2 | 2 | | | | | | | 2 | 2 | |
| | B | 2 | 2 | | | | | | | | | 2 | 2 | |
| | C | 4 | 4 | | | | | | | | | | | |
| Module 16 | A | 2 | 2 | 2 | 2 | | | | | | | 2 | 2 | 1 |
| | B | | | | | | | | | | | 2 | 2 | 1 |
| | C | 2 | 2 | | | | | | | | | | | 1 |
| Module 17 | A | 2 | 2 | 1 | 1 | | | | | | | 1 | 1 | |
| | B | 1 | 1 | | | | | | | | | 1 | 1 | |
| | C | 2 | 2 | | | | | | | | | | | |

*(Continued)*

| Module | Group | Knowledge | | Comprehension | | Application | | Analysis | | Synthesis | | Evaluation | | N/D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | F | C | F | C | F | C | F | C | F | C | F | |
| Module 18 | A | 3 | 3 | 2 | 2 | | | | | | | 2 | 2 | |
| | B | 1 | 1 | | | | | | | | | 2 | 2 | |
| | C | 3 | 3 | | | | | | | | | | | |
| TOTAL 66 | **A** | **54** | **54** | **31** | **31** | **1** | **2** | **6** | **2** | **5** | **5** | **25** | **25** | **3** |
| | **B** | **25** | **27** | **3** | **6** | **0** | **0** | **6** | **1** | **4** | **4** | **25** | **25** | **3** |
| | **C** | **54** | **54** | **4** | **4** | **1** | **2** | **1** | **0** | **3** | **3** | **0** | **0** | **3** |

***Group A:** distribution of cross-loaded objectives which address more than one cognitive level; **Group B:** cross-loaded items are upgraded to the highest cognitive level addressed by the learning objective; and **Group C:** cross-loaded items are reduced to the lowest cognitive level addressed by the learning objective. **C:** Clemson University **F:** Fresno State University.

## Appendix 4

### CRITICAL FEATURES OF LEARNING THEORIES FROM THE PROSPECT OF LEARNING DESIGN

| Learning theories | Representations of the learning process | Relevant learning activity |
|---|---|---|
| Behaviorism | • Pre-/postassessment of learners to determine their knowledge level<br>• Use of reinforcement to impact learning performance (informative feedback)<br>• Use of cues or prompts to ensure a strong stimulus-response association<br>• Sequenced knowledge and skills presented in logical steps | • Case-based Test<br>• Matching<br>• Multiple choice<br>• Close-ended questions<br>• Direct question<br>• Compare answers<br>• Quick check<br>• Slider<br>• True/False |
| Cognitivism | • Active involvement of the learner in the learning process through self-paced learning activities with corrective feedback<br>• Use of cognitive task analysis procedures in the learning activities (hierarchical analyses to identify prerequisite relationships)<br>• Explaining complex form of learning such as inductive and deductive reasoning, critical thinking, problem solving, information processing, and concept formation<br>• Use of knowledge analysis tasks to simplify information into basic building blocks<br>• Linking concept with real-world examples<br>• Classifying or chunking information<br>• Presenting large amounts of content information with digestible "bite-sized/small-chunked" format that will help learners assimilate and/or accommodate the new information as quickly and as easily as possible<br>• Use of pictures, mental models, and illustrative examples to ease knowledge acquisition<br>• Providing advance organizers, analogies, mnemonics, concept mapping, hierarchical relationships, and matrices to help learners relate new information to prior knowledge | • Scaffolding exercises<br>• Examination Jam/Quiz<br>• Detective game<br>• Did you know?<br>• Scenarios<br>• Role plays<br>• Animations<br>• Email exercises<br>• WH questions<br>• Problem-based learning<br>• Discovery learning<br>• Segmented content with graphics<br>• Progressive disclosure/ sequencing information<br>• Teaching with testing<br>• Categorization segmentation of questions and answers |
| Constructivism | • Presenting content with anchoring information in meaningful contexts<br>• Self-paced content with the capability of the learner to manipulate information<br>• Connecting new knowledge to the learner's existing knowledge<br>• Presenting information in a variety of different ways<br>• Supporting the use of inquiry-based, problem solving skills that allow learners to develop pattern recognition skills and presenting alternative ways of representing problems.<br>• Dividing up knowledge domains according to a hierarchical analysis of relationships | • Inquiry-based learning<br>• Discovery learning<br>• Case-based learning<br>• Brainstorming<br>• Simulations |

*(Continued)*

| Learning theories | Representations of the learning process | Relevant learning activity |
|---|---|---|
| | • Structuring learning around big ideas and the "why" of learning<br>• Assessment focused on the transfer of knowledge and skills<br>• Mental representations for creating meaning from learning experience<br>• Revisiting content at any time for different purposes and from different conceptual perspectives | |
| Cognitive Theory of Multimedia Learning | • Integrating videos into the instructional objects<br>• Presenting information via auditory narration or on-screen text<br>• Presenting information both visually and verbally<br>• Presenting information using both auditory (narration) and visual (text) displays (dual channels)<br>• Presenting the content with relevant visual or animated images and graphics<br>• Making representations of sounds and images<br>• Using human voice for spoken words<br>• Utilizing the visual processing channel for meaningful learning to occur<br>• Providing hints and feedback via audio or video as learner solves the problems | • Scenarios<br>• Role plays<br>• Animations<br>• Email exercises<br>• Questions and answers<br>• Problem-based learning<br>• Discovery learning<br>• Segmented content with graphics<br>• Progressive disclosure/ sequencing information<br>• Teaching with testing<br>• Categorization segmentation of questions and answers |

## Appendix 5

### SAMPLE TEMPLATE FOR ANALYZING THE TYPES AND STRUCTURE OF THE LEARNING ACTIVITIES

Please critically review each learning activity by examining all segments to determine the purpose, types, and structure of the activity, pedagogical properties, and any connection with the learning theories.

| Activity name | Types and structure of learning activity | Purpose | Pedagogical properties | Related learning theories |
|---|---|---|---|---|
| Matching Activity (Risk Factors of Obesity) | • Matching with the correct factor<br>• Identifying the relationship between two entities (similarities and differences)<br>• Drag and drop | • Development of critical thinking and decision-making skills<br>• Cognitive task analysis<br>• Testing knowledge | • Interaction with the text-based and visual content<br>• Teaching with testing | • Cognitivism |
| Detective Game (Malnutrition and Later Heart Disease) | • Presenting a problem<br>• Interaction with the content and computer system<br>• Gathering clues<br>• Knowledge analysis<br>• Cognitive task analysis by critiquing the problem based on a provided set of criteria<br>• Classifying and chunking information | • Development of critical thinking<br>• Identifying critical key points | • Discovery learning<br>• Exploring information<br>• Problem solving | • Cognitivism<br>• Constructivism |

## Appendix 6

### SAMPLE TEMPLATE FOR TALLYING THE TYPES OF PEDAGOGICAL STRATEGIES

Please review each module for the types of pedagogical strategies that are used to structure the learning activity and then tally them to calculate the frequency of the types of pedagogical strategies used in each module

**Module 1: 10 Things You Must Know About Nutrition**

| Types of pedagogical strategy | Classification and structure of the learning activities | Count (frequency of use) |
|---|---|---|
| Problem-Based Learning | • Presenting a problem, scenario, case, or challenge | |
| Discovery Learning with Gaming or Video(s) | • Inquiry-based experiential learning with games<br>• Timed tasks that count the number of attempts to explore game-based scenarios<br>• Exploring information/concepts to construct new ideas based on previous knowledge<br>• Identifying new relationships and creating new models of thinking and behavior<br>• Asking questions about the content that have not yet been fully exposed or establishing evidence that deeper learning is required<br>• Using decision-making or logic required tasks for comparative analysis | |
| Segmented (Hyperlinked Content with Graphics | • Segmenting large amounts of content into digestible "knowledge chunks" using visually inspired graphic organizer<br>• Graphic-based learning activities that are segmented for learners' exploration<br>• Segmented and hyperlinked knowledge exploration provided when the link is clicked with a graphic interface | |
| Teaching with Testing | • Examination Jam/Quiz<br>• Detective game<br>• Did you know?<br>• WH questions<br>• Case-based test<br>• Matching<br>• Multiple choice<br>• Close-ended questions<br>• Direct question<br>• Compare answers<br>• Quick check<br>• Slider<br>• True/False<br>• Email exercise<br>• Scenarios/role play<br>• Animation | |
| Progressive Disclosure | • Sequencing information across several screens so as not to overwhelm or confuse learners with a large amount of content<br>• Revealing additional detailed information as the learner clicks on a table or a graphic to get answers for his/her inquires<br>• Large amounts of content such as in a table are presented one-at-a-time to make it digestible chunks or clicking on each item in the first column and then the adjacent column populates with relevant knowledge | |
| Questions and Answers Session | • Organizing information via questions with linked answers instead of a straight presentation of concepts<br>• Videos that include segmented questions and answers<br>• Individual questions that have been segmented and categorized for easy access after selecting a relevant question, the video of the presenter appears providing the correct answer | |