Developing effective environmental exposure education for clinicians

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Abstract

The Division of Toxicology and Environmental Medicine (DTEM) of the Agency for Toxic Substances and Disease Registry (ATSDR) is developing several products to increase the primary care provider's knowledge of hazardous substances in the environment and to aid in the evaluation of potentially exposed patients. Little evidence exists on how to best design and deliver medical education materials for effective environmental health educational interventions. Much evidence, however, supports best practices of designing and developing instructional materials for other educational interventions. DTEM is applying instructional design, formative evaluation, and information mapping in the development of instructional materials in three formats for the primary care provider: print-based self study, online self study and instructor-led presentation (live and taped). We are revising these three interventions with a formative evaluation process that relies on target audience (primary clinicians) input. In this paper, we explore a comparison of research findings on best practice in instructional materials development with the primary care provider’s feedback on DTEM’s materials. Suggested guidelines and lessons learned from DTEM’s materials development and the formative evaluation are discussed, and recommendations for future research in this area are presented for discussion.

Keywords: Environmental Health, Education, formative evaluation, instructional design, medical education.

1 Introduction

The Division of Toxicology and Environmental Medicine (DTEM) of the Agency for Toxic Substances and Disease Registry (ATSDR) is developing
several products to increase the primary care provider's knowledge of hazardous substances in the environment and to aid in the evaluation of potentially exposed patients. Little evidence exists on how to best design and deliver medical education materials for effective environmental health educational interventions. There is, however, much evidence of best practice in the design and development of instructional materials dealing with other educational interventions.

We will discuss in this paper:

- The importance of applying learning theory to environmental health educational materials developed for the primary care physician
- Recommended processes used to develop effective environmental health educational materials for primary health care providers
- A process to formatively evaluate educational material
- Existing research concerning clinicians’ preferences regarding continuing education material
- How the DTEM division of ATSDR is applying educational research and best practice in the development of its educational materials for the public health professional

2 The importance of applying learning theory to environmental health educational materials

Our target population needs lean and efficient materials because of their demanding schedules. They also need materials that are current, easily updated, and help them efficiently absorb content.

What does it take to maximize the effectiveness of learning materials for primary care physicians? Two equally critical components are accurate, appropriate content and a sound instructional methodology. Much care is currently taken to ensure content validity, including peer review and source checking; but often, little is done to ensure that these materials effectively transmit skills and knowledge. These materials are rarely developed using the science of learning theory nor are they regularly adjusted based on systematically gathered feedback from the target population. Therefore, an important part of the process to meet learning needs is often missing.

Much of the current material in professional education for public health professionals is basically a specialist or content expert’s sharing of what he or she knows about a certain topic. Very rarely are these presentations or papers structured based on learning theory. Extraneous information is often evident, as is redundancy, missing important prerequisite information, or organisation of content that does not build skills and knowledge in a logical sequence. This is where application of learning theory can improve the value of materials. While lecture is sometimes recommended, it is overused and sometimes poorly done. Professional organisations such as the Association of American Medical Colleges and the Accreditation Council for Continuing Medical Education have suggested changes to the traditional passive lecture that is most typically used for the continuing education of clinicians [1].
3 Recommended processes to develop effective environmental health educational materials for health care providers

Instructional design is the learning-theory–based science of creating and using detailed specifications for the analysis, development, implementation, evaluation, and maintenance of interventions that facilitate the learning of both large and small units of subject matter at all levels of complexity.

Why use instructional design in the development of environmental health education materials for primary care physicians? Instructional design gives the tools to take accurate content and to develop educational materials that are effectively and efficiently mastered by learners [2, 3].

- Content and any related assessment is directly related to identified skill or knowledge gaps.
- Content, media, and methods are selected based on a thorough analysis of the situation and learners. The media and method chosen fit both the content and needs of the target populations.
- The “need to know” is clearly presented and the “nice to know” is kept to a minimum. Subject matter experts (SMEs) need a systematic method to keep content focused on what the learners need to know at the end of a learning experience.
- Materials are formatively evaluated by using them with the target population and then revising them based on subjective feedback, post-test results, and expert observation of the process.

The following is an overview of the instructional design process, often called the “ADDIE” (Analysis, Design, Development, Implementation, Evaluation) model [2, 3].

Analysis. Identify the performance gaps and their probable causes.
- Determine root causes of performance gaps and skill/knowledge deficiencies.
- Analyze learners: What works best with the target population?
- Determine best types of intervention based on content, resources, and target population characteristics.

Design. Verify the desired performances; develop learning and testing strategies based on gaps identified in the analysis phase.
- Identify instructional goal(s)—what learners should be able to do after the intervention.
- Analyze the goal(s) to determine enabling objectives. Objectives should state what the learners will be able to do after the instruction.
- Determine activities to support objectives.
- Determine which media and methods best support mastery of the objectives.
- Determine learner assessment strategies.
Development. *Generate and validate the training materials.*
- Production-produce according to best practice for the media selected.
- Formative evaluation (structured trial with target population)
- Revision based on SME, instructional designer, and learner input

Implementation. *Prepare the training environment and conduct the training.*

Summative Evaluation. *Assess the quality of the instructional products and processes both before and after implementation.*
- Participation: How many and who were trained?
- Participant reactions: Did they like it?
- Learning outcomes: Did they learn it?
- Transfer of learning to the job: Do they use it on the job?
- Results: How does it benefit the organisation or public health?
- Return on investment (ROI): What are the monetary benefits to the organisation or public health [4]?

Regardless of the type of media used, certain strategies should be included to make any educational event effective. One excellent guideline to help ensure instructional quality is Gagne’s nine events of instruction [3]. These events are applicable for any medium or method. Ensuring that these nine events are applied for each objective will help ensure learner mastery of the material.

1. Gain attention.
2. Inform learner of objective.
3. Stimulate recall of prior knowledge.
4. Present the material.
5. Provide guidance for learning.
7. Provide feedback.
9. Enhance retention and transfer.

Gagne, Dick, and Thiagarajan are excellent resources on the instructional design process [2, 3, 5].

Another process that can be helpful for both web- and print-based instruction is the information mapping process developed by Robert Horne [6]. This process can help with the instructional design process and also gives a clear process for making the layout of Web pages and printed text more effective for learning.

4 A process to formatively evaluate educational material

All the phases in the ADDIE model on instructional design are important; however, this paper highlights one part of the model—formative evaluation—because it is often ignored or poorly completed. Formative evaluation is described by Dick et al. [2] as a three-step process in which progressively more polished versions of the instruction are “tried out” with members of the target population.
4.1 One-to-one formative evaluation or a walk through

A one-to-one evaluation is when the instructional designer works with individual learners from the target population to obtain data to revise educational materials. A one-to-one should be done at an “early draft” stage early in the development process to identify errors before major production has begun. During one-to-one evaluation, one learner at a time reviews the instruction with an evaluator and gives comments upon it. The designer regularly asks the learners what they think of a particular section or activity. The purpose is to identify major problems in the instruction, such as missing content, ambiguity, and poor or missing directions.

4.2 Small group evaluation/ tutorial and small-group tryouts

Small group evaluation occurs when a group of 8–20 learners, representative of the target population, complete the instructional materials independently and are tested to collect the required evaluation data. Materials are more complete than during the one-to-one formative evaluation but minimal work is invested in the implementation infrastructure. The purpose of small group evaluation is to check the efficacy of the one-to-one revisions and to ascertain how well the instruction works with more varied learners. Pre-test and post-test data should be analyzed during small group formative evaluation. At times a designer will gather the small group together to discuss feedback or interview learners individually to explore problem areas in the instruction.

4.3 Field test or pilot test

Field tests are similar to beta tests in that instruction at this phase of evaluation is in its most complete state, yet is still open to revisions. A field test can be used to create final suggestions for revision, to ensure revisions made during previous phases of formative evaluation are effective and to observe the effectiveness of the instruction. The designer should collect information about performance, time, and attitude as well as information from the instructors/trainers regarding the administration of the instruction, also known as process evaluation. According to Dick and Carey, “The goal of the field trial is effective instruction that yields desired levels of learner achievement and attitudes and that functions as intended in the learning setting”) [2].

5 Existing research concerning our clinicians’ preferences regarding continuing education material

What do primary care physicians say about their preferences for continuing education? The preferences often vary based on gender, age, and region of the learner [7]. Older primary care physicians tend to favor traditional face-to-face, conference-type continuing medical education (CME) experiences. Younger physicians tend to favor distance learning media. More isolated learners tend to be more favorable to distance learning options. A preference for increasing the number of options available to learners is a common finding [7, 8].
A study in New Zealand examined the preferences of general practitioners for CME. The general practitioners interviewed had a preference for CME activities that involved personal interaction, but clinicians also wanted the choice of distance learning. This study also stressed the need for succinct, evidence-based, general practitioners-focused content [9].

The South Central Public Health Training Centre, in coordination with the Tulane Centre for Applied Environmental Public Health (CAEPH), asked clinicians, “What learning formats or tools are most useful to you for CME?” The results are typical of many studies examining clinicians’ preferences. The top answers from physicians (in order, starting with the most) were books, handbooks/workbooks, reference manuals/materials, and in-person lectures and short courses. When nurses and physicians were considered as a group, the top answers (in order) were case-based exercises/case studies, handbooks, workbooks, in-person lectures and short courses, and interactive Web-based learning modules. The learning tools that ranked low with both groups were discussion boards, reference files with environmental information, self-assessment exercises, and technical support given by phone and e-mail. This study indicates that many clinicians prefer traditional methods such as journals and traditional lectures, but little evidence supports that these methods are effective at behavior change [10].

5.1 When examining CME presented in the traditional lecture format, studies show [8, 9, 11, 12]

- Higher satisfaction for interactive lectures than for straight lecture with no discussion.
- Adding case studies and a question-and-answer session to a traditional lecture are techniques suggested by participants to increase satisfaction with continuing education events.
- Adding “hands-on” activities such as role play works well only when these activities are directly related to content.
- Despite the wisdom that much learning takes place in informal discussions, clinicians indicate a preference that their information come from the expert lecturer during a question-and-answer session rather than during a peer discussion following an activity.
- Very few clinicians indicate that they want a traditional grand rounds that lasts more than 60 minutes.

5.2 When examining CME presented in the distance learning formats studies show [8, 9, 11, 12]

- Clinicians like the flexibility of some of the distance-learning formats.
- Some distance-learning interventions (videotape Web casts and broadcasts) had the same deficiencies as the traditional lecture format (lack of interactivity).
Learners also like the ability to view or listen repeatedly to areas that they find most interesting or most difficult. This nonlinear ability of media, such as asynchronous online instruction, computer-based instruction, and DVD, allows the learner to later use an educational event as a reference tool.

5.3 Combination approach

Lane describes a “multimethod package” of interventions in a study designed to “increase primary care physician adherence to national guidelines for breast cancer screening [13]. The package includes formal CME conferences, a physician newsletter, breast examination skills training, a breast cancer CME monograph, a ‘question of the month’ at hospital staff meetings, and primary care office visits.” Physicians in the multimethod intervention group had a much greater increase in compliance with the recommended practices than did physicians in the control group. This multimethod approach is easily applied to topics in environmental health education (e.g., taking an exposure history).

5.4 Other considerations

Equally important to addressing learner preferences is the need to examine objectives and related content to determine best method and media. For example, objectives that involve soft skills such as counseling a patient after a test result would be more effective if the educational event included modeling of technique and then practicing by the learners—traditional lecture without discussion would not be effective. Other topics, such as X-ray interpretation, need clear visuals that clinicians can later access as a reference.

Study is needed of the association between a learner’s satisfaction and an increase in a physician’s knowledge, competence, and performance. Clinicians may not prefer interactive activities such as role playing how best to counsel patients, but such interactions may be the most effective methods for affecting behavior change and transferring the learned behavior to job settings [14].

6 How the DTEM division of ATSDR is applying educational research and best practice in the development of educational materials for the public health professional

DTEM is developing a variety of environmental health education and communication materials for the health professional and for the public. Anticipated DTEM products include:

- 36 case studies: print-based materials with patient-education sheets for clinicians’ use with patients
- 36 case studies: Web-based interactions
- 36 grand rounds: live presentations
- 36 community presentations: live presentations
- 36 grand rounds: video stream on Web
Thus, materials are provided in a variety of formats to address the varying needs of the audience. As each of our existing case studies is updated for content, it is also reformatted with a new template based on instructional design theory. Care is taken to ensure that materials are developed using an instructional design process. Formative evaluation is conducted for each product. Several adjustments were made to our initial case study based on the formative review. For each of the products listed above, standards and procedure guides are being developed by DTEM authors and instructional designers. The following is a one-page overview from a standards guide used in the development of DTEM grand rounds presentations.

### 6.1 Overview page of DTEM guideline for grand rounds presentations:

| Develop materials using the DTEM procedural guide for creating instructional materials | • Group information into small manageable units.  
• Label each unit of information (in left column).  
• Use terminology consistently.  
• Only use graphics that support objectives and label each graphic.  
• Use the block map method to organise content.  
• Create process, procedure, structure, and fact tables as objective dictates. |
| Present objectives | Include behavioural objectives (stating expected skills and knowledge or practice outcomes) that drive the selection of content and strategies. All objectives should explain observable behaviour that the participant will be able to do after the instructional event. Present objectives to participants in the instructional material. |
| Start instruction with overviews | Participants should be given a quick overview at the beginning of the grand rounds and a quick summary at the end of the grand rounds. |
| Participant materials | Participants’ materials include PowerPoint slide reductions and if necessary full pages of content (e.g., a list is illegible in a reduction). |
| Instructor guides | Instructor guides should be thoroughly scripted. All discussion questions, suggested responses, and activities should be explained in detail. |
| Learner assessment | Test items should:  
• match the level of each objective  
• all distracters should be plausible |
| Facilitate learning and recall | Instruction should facilitate learning and recall past learning if appropriate. For example, if mnemonics would help to memorize steps in a procedure, they should be included; if a procedure is similar to a common procedure familiar to physicians, this similarity should be highlighted. |
| Tables and checklists | Checklists and tables should be used when appropriate to help summarize information for the learner. |
| Develop materials using the DTEM procedural guide for creating instructional materials. | • Group information into small manageable units.  
• Label each unit of information (in left column).  
• Use terminology consistently.  
• Only use graphics that support objectives and label each graphic.  
• Use the block map method to organise content. [6]  
• Create process, procedure, structure, and fact tables as objective dictates. |
| Include only content that supports objectives | All content and instruction within the materials should support attainment of the objectives, and all objectives should be supported by strategies that facilitate learning and provide practice and feedback. |
7 Conclusion

In this paper, we have discussed several strategies to help ensure that educational materials developed for clinicians are effective. These strategies can be operationalized in a standards and procedures guide. We suggest that these guides are developed to ensure that:

- content is accurate and timely
- materials are created in a variety of formats for instruction, considering learner preferences
- all materials are formatted using an instructional design process
- all materials are formatively evaluated and adjusted based on an analysis of target population comments

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