# Applying an instructional design method to serious games - experiences and lessons learned

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Tjitske Faber, MD
Institute for Medical Education Research Rotterdam
Erasmus University Medical Center
Rotterdam, the Netherlands
t.faber@erasmusmc.nl

Mary Dankbaar, PhD
Institute for Medical Education Research Rotterdam
Erasmus University Medical Center
Rotterdam, the Netherlands

Jeroen van Merriënboer, PhD
School of Health Professions Education
Maastricht University
Maastricht, the Netherlands

*Abstract*— **The ABCDE method, used internationally to treat seriously ill patients, is a complex skill that is commonly trained in face-to-face-courses. In the abcdeSIM game, used as a preparation for these courses, players treat patients in a virtual emergency department. We applied the Four Component Instructional Design theory to redesign the existing game. In this article, we describe how the components of this instructional design theory can be applied to a serious game for medical education.**

***Keywords—serious game, instructional design, education, emergency medicine***

## I. Introduction

Caring for acutely ill patients is a demanding task in which doctors have to combine medical knowledge with procedural, problem solving and communication skills. Proficiency in these skills is often directly related to patient safety. For the young doctor or medical student, the endeavor can be daunting when not sufficiently trained. However, this type of skills training is expensive, as it usually is done in small groups [1]. Games can be used in combination with face-to-face training and have the potential to teach complex cognitive skills in an engaging, flexible and patient-safe way [2].

The ABCDE method is used internationally to assess and treat acutely ill patients. By applying the principles of 'treat first what kills first' the health practitioner can structure the approach to the acutely or seriously ill patient using a simple mnemonic: Airway, Breathing, Circulation, Disability, Exposure. The ABCDE method is taught to medical students, physicians, and nurses in various face-to-face courses. Although such courses are generally effective, costs are high [1].

By offering part of the training in a serious game, the results of training for residents preparing for a rotation on the emergency department were improved [3]. However, medical students, playing the game did not perform better than students who studied the same (low fidelity) text-based cases without game elements. The game group showed higher motivation and higher cognitive load, but did not perform better on assessment of their ABCDE skills [4]. A possible explanation for this observation may be that students experience too little support and guidance in the game, not knowing where to start improving their skills. An alternative explanation is that students believe there is no additional learning to be gained by completing the same case more than once.

Instructional design theories help to develop effective instruction. The Four Component Instructional Design approach [5] (4C/ID) provides a framework for developing instructional material for complex tasks, such as applying the ABCDE method. 4C/ID has been used in designing games for learning in several fields, including marketing and communication [6], mechatronics [7], and research methods and statistics [8]. For medical education, the 4C/ID model is suggested to design evidence based medicine training programs in classrooms and clinical settings [9]. To our knowledge, no serious games for medical education have been designed according to 4C/ID. Thus, we seek to answer the following research question:

> How can the Four Component Instructional Design theory be applied to redesign an existing serious game for training complex skills in emergency care?

We hypothesize that to apply the 4C/ID model to an existing game while preserving the game experience, we will require input from various perspectives including game designers. Not all elements may be as easily translated to the game context.

## II. Materials

### A. Four-component instructional design

The four components of instructional design as described by van Merrienboer et al. [5] consist of learning tasks, supportive information, procedural information and part-task practice (Fig. 1). *Learning tasks* engage the learner in activities that require them to work with the skills that make up the complex skill. The learning tasks stimulate learners to construct cognitive schemata, specifically mental models that allow for reasoning within the domain, and cognitive strategies that guide problem solving in the domain. However, if a task presented at the start of training is too

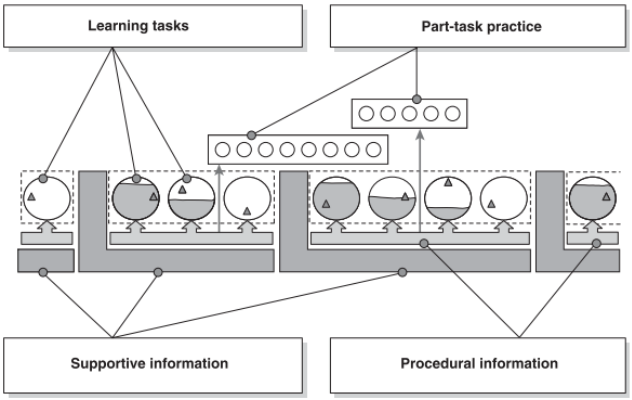


Fig. 1. A schematic blueprint of the Four Component Instructional Design. Adapted from [5] with permission.

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complex, it results in cognitive overload for the learner, which impairs learning and performance. By grouping learning tasks into task class levels, the learner starts with less complex tasks and progresses toward more complex tasks. Within a task class, support and guidance is offered at a high level initially, and decreased in subsequent tasks. After mastering one task class, the learner moves to the next task class, again starting with a high level of support and guidance. *Procedural information* is information that supports the learner in performing recurrent aspects of a skill, that is, aspects that are always performed in the same way and that can become routines. This information, intended to support automation, should be presented in a just-in-time (JIT) manner. *Supportive information* is domain-general information and is not task-specific, but task-class specific. It supports the learner in developing general schemas and problem-solving approaches. Finally, *part-task practice* can be necessary for recurrent aspects of a task where a high level of automaticity is required. These four components are the building blocks for training programs designed according to the 4C/ID model.

### B. *The abcdeSIM game*

The abcdeSIM game (Erasmus University Medical Center/VirtualMedSchool, 2012; more detailed description at http://virtualmedschool.com/abcdesim) was developed in a close collaboration between medical practitioners, game designers and educationalists. In the game, the player is presented with an acutely ill patient in a virtual emergency department. The virtual nurse provides brief information on the patients' condition. All the tools and information available in a real-life emergency department are available to the player. The player can perform a physical examination, start treatments (e.g. insert an IV cannula, start high flow oxygen), administer medication and order additional diagnostic tests (e.g. laboratory testing or a chest X-ray). In fifteen minutes, the player must complete a full ABCDE assessment of the patient and start the necessary treatments. Several patient cases are available with different medical conditions and levels of sickness. Vital parameters and the condition of the patient are generated by a complex physiological model that is influenced by the players' actions. This results in a realistic feel of the scenario. After completing the assessment and starting treatment, the player can decide to move on to 'secondary survey'. They are then provided with feedback on their actions and a game score, as well as a narrative on how the patient fared after their care. The game score depends on the number of acceptable decisions made according to the ABCDE approach. Completing a case faster than 15 minutes rewards additional points. For more details on the original game design, please refer to [3].

## III. Intervention

To improve the instructional value in abcdeSIM using the 4C/ID model, we investigated and redesigned the game, looking closely at each component in turn. To improve the *learning tasks*, a content expert classified the available patient cases into three complexity levels based on the level of physiological disturbance and the number of interventions required to successfully complete the case. Three additional cases were added to ensure adequate distribution of cases across complexity levels.

While solving unfamiliar problems, experts use Systematic Approaches to Problem Solving (SAPs), that is, a general prescriptive plan that specifies the goals and subgoals that must be reached when solving problems in a particular domain. The ABCDE approach is an example of a SAP used to solve the problem of assessing and stabilizing a critically ill patient. We created time-based reminders on essential case-specific interventions to help the player stay on track and follow the ABCDE approach.

*Supportive information* is offered in two ways. An e-module explaining detailed information on the ABCDE method was already provided alongside the game tutorial and could be accessed in between cases. To provide the opportunity to use the supportive information available in the e-module during play, we created a pause button, in order to prevent the patient from deteriorating (as would normally happen in the absence of game interventions). This button may also serve as a way for the player to deal with cognitive overload, or use other types of help, such as peer or faculty support, depending on the setting in which the game is embedded in the curriculum. As additional support for schema construction, we added a transfer form to the cases, prompting the player to describe the patients' condition according to the ABCDE structure (fig. 2).

Some *procedural information* was already embedded in the game; for example, the virtual nurse would provide corrective feedback if the player supplied to little oxygen for the chosen oxygenation device, or when they would select inappropriate invasive treatments such as a chest tube or neck brace. We designed three additional procedural supports. First, when selecting a tool, just-in-time information about using the tool appears, to enable automation of routine aspects of the task. Second, to facilitate tool use, we enabled hit areas to be shown when selecting an instrument. Finally, on-demand feedback during the case from a virtual supervisor enables the player to see where they can improve their performance.

We did not identify opportunities for *part-task practice* within the game. However, the ABCDE approach as a whole contains several skills that would benefit from part-task practice, such as placing an IV cannula or intraosseous needle. This practice could be implemented as addition to the game, in a blended (online and offline) design curriculum.

All support options were designed in a collaborative effort between game developers, content experts, and educationalists. We implemented all support to allow any combination of support options at a time. This way, the support a player receives can decrease in the course of his or

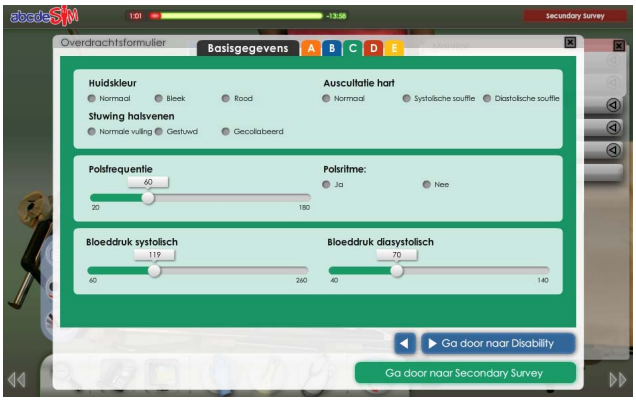


Fig. 2. Supportive information in abcdeSIM: a transfer form prompts the player to describe the patients' condition according to the ABCDE structure.

her gameplay. We designed a standard game flow according to 4C/ID principles, where players start with the low complexity tasks and high levels of support, working towards low complexity without support, then continuing with moderate complexity levels and high support, et cetera.

To assess the effect of the various support options and the viability of the chosen game flow, medical students will be invited to test the redesigned game in a mixed-method study. We will combine cued retrospective interviewing with observational data and cognitive load measurements. Findings will be consolidated into points for further improvement. This will be the first assessment phase in a process of iterative improvements.

## IV. Conclusion

The Four Component Instructional Design model provides a structured approach for design choices in a serious game. Working in an existing game, we encountered some challenges, such as scarce available visual space to display the reminders and tool information Still, by following the 4C/ID principles and closely collaborating in a team of educationalists, content experts and game designers, we were able to create several theoretically sound support options.

## V. Discussion and lessons learned

In this project, we developed several support options for a serious game for emergency care skills in harmony with the 4C/ID model. Potential issues remain regarding the impact of these changes on the learning and especially the gaming experience. First, lowering complexity for the initial levels may result in decreasing challenge. Motivation for playing often arises from experiencing a state of flow, when an optimal balance exists between challenge and required skill [10]. For optimal gameplay, a delicate balance must be sought between challenge and support.

A second concern is the added cognitive load resulting from the support mechanisms themselves. The increased load may be considered germane to the learning task, but if the support does not match the players' needs it may instead increase extraneous load, that is, load caused by processes that do not contribute to learning but instead burden available working memory.

Finally, the need for support can be different for each player. Very specific supports, such as the time- and interventions-based reminders, may not align with the players' needs. They may arrive too soon or too late, causing cognitive overload or frustration. By adapting the support to the actions and achievements in previous cases, it may be possible to tailor the support to the level of the player. This adaptivity could further increase effective learning in the game context.

In summary, this study demonstrates applying the Four Component Instructional Design Model to a serious game for emergency care. Input from various perspectives, including educationalists, game designers and content experts was essential in implementing additional support and improving the learning tasks. The Four Component Instructional Design model provided a structured approach for improving the instructional design of a serious game for emergency care medicine.

## Acknowledgment

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## References

[1] G. D. Perkins, "Improving the Efficiency of Advanced Life Support Training," *Ann. Intern. Med.*, vol. 157, no. 1, p. 19, Jul. 2012.

[2] C. J. Kalkman, "Serious play in the virtual world: can we use games to train young doctors?," *J. Grad. Med. Educ.*, vol. 4, no. 1, pp. 11–3, Mar. 2012.

[3] M. E. W. Dankbaar *et al.*, "Preparing Residents Effectively in Emergency Skills Training With a Serious Game," *Simul. Healthc. J. Soc. Simul. Healthc.*, vol. 12, no. 1, p. 1, Feb. 2016.

[4] M. E. W. Dankbaar, J. Alsma, E. E. H. Jansen, J. J. G. van Merrienboer, J. L. C. M. van Saase, and S. C. E. Schuit, "An experimental study on the effects of a simulation game on students' clinical cognitive skills and motivation.," *Adv. Health Sci. Educ. Theory Pract.*, vol. 21, no. 3, pp. 505–21, Aug. 2016.

[5] J. J. G. van Merriënboer and P. A. Kirschner, *Ten steps to complex learning : a systematic approach to four-component instructional design*. Routledge.

[6] J. Enfield and Indiana University, *Designing an educational game with ten steps to complex learning*. ProQuest LLC. 789 East Eisenhower Parkway, P.O. Box 1346, Ann Arbor, MI 48106. Tel: 800-521-0600; Web site: http://www.proquest.com/en-US/products/dissertations/individuals.shtml, 2012.

[7] H. Lukosch, R. Van Bussel, and S. Meijer, "A Game Design Framework for Vocational Education," *Int. J. Soc. Behav. Educ. Econ. Bus. Ind. Eng.*, vol. 6, no. 5, pp. 770–774, 2012.

[8] P. Van Rosmalen, E. A. Boyle, J. Van der Baaren, A. I. Kärki, and Á. del Blanco Aguado, "A case study on the design and development of minigames for research methods and statistics," *EAI Endorsed Trans. Game-Based Learn.*, vol. 1, no. 3, p. e5, Aug. 2014.

[9] L. A. Maggio, O. ten Cate, D. M. Irby, and B. C. O'Brien, "Designing evidence-based medicine training to optimize the transfer of skills from the classroom to clinical practice: Applying the four component instructional design model," *Academic Medicine*, vol. 90, no. 11. pp. 1457–1461, Nov-2015.

[10] M. Cziksentmihalyi, *Flow : the psychology of optimal experience*. HarperPerennial, 1991.