Learning objects in medical education

JORGE G. RUIZ2, MICHAEL J. MINTZER1,2 & S. BARRY ISSENBERG1
1University of Miami Miller School of Medicine, USA; 2VA GRECC, Miami, USA

ABSTRACT  A learning object (LO) is a grouping of instructional materials structured to meet a specified educational objective. Digital LOs, which can be stored electronically, allow a new approach to instructional activity, making medical education more efficient, and potentially more cost-effective. They are reusable and can incorporate text, graphics, animations, audio, and video to support and enhance learning. A learning object can stand alone or be aggregated with additional objects to create larger forms of educational content meeting multiple educational objectives. Digital learning objects located in online repositories can be accessed by many computers and are easily handled by an array of learning management systems for delivery to learners at any time. Integrating digital learning objects with traditional educational methods in a blended learning approach assists medical educators in meeting the challenges of competing priorities. Multimedia LOs enable learners to tailor their experience to their preferred learning style. Through the use of learning objects, learners’ reactions, their acquisition of knowledge, skills and attitudes, and their behavioral changes become readily measurable. Learning objects provide multiple research opportunities, such as their use in adaptive learning, their added value in preclinical versus clinical education, and their impact as part of a blended learning strategy.

Introduction

International trends in medical education focus on accountability, outcomes, and competency-based learning (World Health Organization & Educational Commission for Foreign Medical Graduates, 1995; ACGME, 2004; AAMC, 2005). Competency- and outcomes-based medical education requires a disciplined effort to produce curricula based on established educational principles, in which the learning objectives, the assessment tools and the instructional design of the learning materials are clearly aligned (Leung, 2002). Over the past several years, medical educators have faced increasing challenges associated with changes in healthcare delivery, and advances in medical science and technology. For example, education has shifted from hospital acute care settings towards community-based and long-term care settings (Nair & Finucane, 2003). These changes have increased the clinical demands on medical educators, resulting in less time available for teaching (Ozuah, 2002). New developments in genomics, end-of-life care, geriatrics, complementary medicine and information technology compete for time in the already crowded medical school curriculum (Ozuah, 2002). With the shift from traditional instructor-centered education toward learner-centered education where learners are the builders of knowledge (Bannan-Ritland et al., 2002), there has been an effort to complement this change with competency-based curricula that emphasize the product of education (Leung, 2002). Advances in technology and a growing understanding of the optimal approach to learning have facilitated integration of these trends.

Medical educators are increasingly using e-learning and information technologies to support their curriculum design, delivery and evaluation (Ward et al., 2001; Whitcomb, 2002; Lau & Bates, 2004; Barzansky & Etzel, 2005). Early e-learning efforts were fraught with deficiencies in the design and evaluation of materials (Chumley-Jones et al., 2002). Training systems were typically sequential, rigid and monolithic training modules designed for one specific purpose or audience and delivered only via a specified e-learning platform.

To make e-learning more efficient, instructional resources must be adaptable to varying contexts, learners and educators. To achieve this, instructional designers are focusing their efforts on using learning objects as practical tools in a rapidly changing educational environment. This article defines learning objects, describes their benefits to medical educators and discusses methods for their use in medical education. It also outlines important pedagogical and technical implications and provides relevant examples. In addition, it addresses resources for locating learning objects and methods of evaluating their impact. Finally, the article discusses the future role of learning objects in medical education and proposes a research agenda to advance this new approach to learning.

Practice points

- A learning object is a grouping of instructional materials structured to meet a specified educational objective.
- Learning objects are interactive, interoperable, multimedia and easily accessible in online repositories.
- Learning objects can stand alone or can be aggregated to create larger forms of educational content to meet multiple educational objectives.
- Learning objects allow a blended learning approach to instructional activity, making medical education more efficient and potentially more cost-effective.
- Learning objects create new teaching efficiencies for educators and create new learning opportunities.
What are learning objects?

The New Media Consortium, as part of its Learning Object Initiative, defines a learning object as any grouping of materials that is structured in a meaningful way and is tied to an educational objective (Smith, 2004). For the purpose of this paper, learning objects are considered to be digital elements. They consist of discrete digital pieces of content—such as text, audio, video, graphics and animations—called learning assets. Digital learning assets are the key elements in creating larger instructional e-learning materials. A digital learning object is usually more complex and is constructed using multiple learning assets. Learning objects are often compared to Lego® blocks, in that small pieces can be used and reused to build many different structures. Examples include tutorials, case-based learning, simulations and game-based learning modules. Content creators use both instructional design and pedagogical principles to produce learning objects and assemble them into instructional materials.

Learning objects remove contextual references. This allows them to be used for a variety of learners, making them cost effective and customizable (Bannan-Ritland et al., 2002). As technology advances, learning objects are well suited to become the basic unit of e-learning. Because they may be delivered across computer networks, including the Internet, they extend the boundaries of the classroom so that an unlimited number of learners in different locations can access them on demand (Wiley, 2002b).

Although learning objects, according to the above definition, have only recently been introduced into medical education, their use is supported by research in cognitive theory showing that human beings learn more effectively when content is presented to them in small chunks. This process of ‘chunking’ improves learners’ comprehension and retention. Learning objects represent small chunks of content, packaged and presented in a fashion consistent with established theories of information processing (Gagne & Medsker, 1996; Clark & Mayer, 2002).

The structure of learning objects

Learning objects consist of content, an interface and the package (Smith, 2004). Content is digital media (as described above) produced using instructional design strategies. Each multimedia element—whether a graphic, a video clip or an animation—is a learning asset. The content is assembled using text and learning assets to construct the learning object, as the example in Figure 1 illustrates (Medical Teacher website—http://www.medicalteacher.org).

The interface includes all the onscreen elements that allow the learner to interact with the learning object. This may include such simple navigational elements as ‘Next Screen’ or ‘Play Video’ buttons; but with the increasing use of the Internet, many learners are familiar with more sophisticated navigation and interactivity features such as search boxes, link bars and toolbars, among others.

In order to be able to upload or download the learning object, a digital package is necessary. This requires defined technical standards and specifications that facilitate finding, sharing and reusing the learning objects. Although the technical specifications are beyond the scope of this article, it is important to emphasize two aspects of the package: metadata and the runtime environment. Metadata include the information necessary for cataloging the learning object, such as the title, author, content, target audience and technical specifications. Such labeling makes it possible to rapidly search, organize and update the learning objects (Barratt & Alderman, 2004; Wiley, 2002a). Metadata are, in short, the ‘card catalog’ of the digital age. Based on Dublin Core, MedBiquitous, an e-learning organization, has developed a metadata standard called Medical Learning Object Metadata (Medical LOM), which provides a consistent way of describing learning objects containing medical content (MedBiquitous, 2005).

The run-time environment is software that tracks the interaction between the learner and the learning object. It allows learning objects to function on a variety of e-learning platforms (e.g. Blackboard®) and enables instructors to monitor the performance of learners (Fallon & Brown, 2003).

Table 1 specifies the criteria a learning object should meet in order to be used in instructional activities: stand alone, reusability, interactivity, aggregation, interoperability and accessibility (Carnegie Mellon Learning Systems Architecture Lab, 2003; Duncan, 2003; Fallon & Brown, 2003; Littlejohn, 2003). Table 2 shows some of the main advantages and disadvantages for educators and learners of using learning objects.

Locating learning objects

Learning objects are expressly designed for sharing. Several websites provide the medical educator with access to a variety of learning objects:

- Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE; http://www.ariadne-eu.org/) project, enables better quality learning through the development of learning objects, tools and methodologies, based on a ‘share and reuse’ approach to education and training.
- The AAMC MedEdPortal (http://www.aamc.org/meded/mededportal/) is an online repository for curriculum and assessment materials organized around core competencies in medical education and populated with up-to-date peer-reviewed teaching and assessment materials (Mededportal, 2005).
- The Campus Alberta Repository of Educational Objects (CAREO) (http://www.careo.org) is a project supported by Alberta Learning and the Canadian Network for the Advancement of Research in Industry and Education (CANARIE). Its primary goal is the creation of a searchable, Web-based collection of learning objects for educators.
- The Cooperative Learning Object Exchange (CLOE; http://tlc.waterloo.ca/projects/ccco/cloe_stories.html), founded at the University of Waterloo, Canada, attempts to foster a collaborative model for the development, use and reuse of learning objects. Key to this initiative is the creation of a virtual market economy whereby credits are awarded for those LOs that are used and reused the most.
- The Education Network Australia (EdNA Online) (http://www.edna.edu.au) is a not-for-profit organization supported by the Australian government. It provides access to a database of learning objects useful for teaching and
Table 1. Minimum criteria for learning objects.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
<th>Example</th>
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<tbody>
<tr>
<td>Stand alone</td>
<td>Learners can use a single learning object to achieve a specified learning outcome.</td>
<td>The learning outcome states that the learner will be able to perform a standardized depression screening in primary care. This outcome can be accomplished with an online video tutorial demonstrating proper use of a standardized screening instrument.</td>
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<tr>
<td>Reusability</td>
<td>Learning objects can be used by diverse groups of learners in a variety of educational situations.</td>
<td>The same online tutorial can be used effectively by medical students, hospice nurses or clinical pharmacist trainees to learn a standardized method for assessing pain.</td>
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<tr>
<td>Interactivity</td>
<td>Each learning object requires an interactive response from the learner.</td>
<td>A multimedia learning object describing the neurological exam requires the learner to select the answer by clicking a box from a menu of options. Once “clicked,” the learner receives additional content or feedback needed to continue the practice exercise.</td>
</tr>
<tr>
<td>Aggregation</td>
<td>Learning objects can be linked into larger collections to form lessons, modules, or courses.</td>
<td>Three learning objects—one covering the New York Heart Association classification of heart failure, the second explaining the pharmacology of diuretics, and the third describing the use of echocardiography to assess cardiac function—can all be incorporated into a larger module on heart failure</td>
</tr>
<tr>
<td>Interoperability</td>
<td>A learning object can be used with appropriate “plug-ins” by multiple software applications and on a variety of computers and e-learning platforms.</td>
<td>A learning object created with an authoring program (e.g., Authorware®) can run on any personal computer and can be delivered over the Internet by any web browser (Explorer, Netscape, Firefox, Safari) for use by any learning management system (WebCT, Angel, Blackboard, etc.).</td>
</tr>
<tr>
<td>Accessibility</td>
<td>A learning object must be tagged with standardized indexing information (metadata) that allows it to be easily found by course designers, educators, learners, and evaluators.</td>
<td>An educator responsible for teaching internal medicine residents about the pharmacological treatment of osteoporosis can search for learning objects online by using standard MESH terms such as osteoporosis, fracture, vitamin D, alendronate, post-menopausal, etc.</td>
</tr>
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Table 2. Advantages and disadvantages of learning objects (LOs).

Advantages for Educators:
- Avoids the need to recreate existing resources
- Consistent design and development process
- Facilitates searching for existing content
- Reusable in diverse educational contexts and for different trainees
- Able to monitor learners’ use of materials
- Affordable in the medium and long term
- Standardizes content for widespread use

Disadvantages for Educators:
- Lack of experience with e-learning production
- Resource requirements
- Requires considerable technology support
- Lack of expertise in using LOs in the instructional process
- Lack of expertise in evaluating LOs
- Information technology requirements, including broadband Internet access and learning management system

Advantages for Learners:
- Consistent look and feel of instructional resources promotes comfort
- “Just-in-time” availability
- Can individualize education
- Serves a variety of individual learning styles

Disadvantages for Learners:
- Lack of familiarity with the instructional process
- Limited availability
- Requires the learner to develop a level of comfort with the computer as an instructional tool

Adapted from (Barritt & Alderman, 2004)
learning that cover a wide range of subjects, including healthcare.

- The Harvey Project (http://www.opencourse.org/Collaboratories/harveyproject) is an international collaboration of educators, researchers, physicians, students, programmers, instructional designers and graphic artists working together to build freely available interactive learning objects for human physiology education.

- The Multimedia Educational Resource for Learning and Online Teaching (MERLOT, http://www.merlot.org) is a not-for-profit organization that fosters the sharing of educational resources through a library of links to digital resources, including learning objects (Malloy & Hanley, 2001). MERLOT’s health science section contains over 300 resources from several academic institutions.

- The Health Education Assets Library (HEAL, http://www.healcentral.org) is a repository for multimedia learning assets such as images, videos and animations used to create learning objects (Candler et al., 2003). HEAL also contains a variety of learning objects that are used by medical educators.

- MedBiquitous (http://www.medbiq.org), a consortium of medical societies, pharmaceutical companies, medical schools and government entities working to develop standardized pedagogical and technical specifications for e-learning materials, including learning objects (Medbiqitous, 2005).

- The International Virtual Medical School (IVIMEDS, http://www.ivimeds.org) is an international organization whose mission is to set new standards in medical education through a partnership of medical schools and institutions, using a blended learning approach. IVIMEDS hosts a repository for use by its member medical schools (Harden & Hart, 2002).

These organizations are providing the infrastructure to promote widely available digital resources. Most of the materials in these repositories are free to use. Some materials have clearly defined conditions for use. In the future, these and other repositories may require a membership or other fees in order to cover the ongoing expenses and maintenance of the website.

Creating learning objects

In terms of instructional design and pedagogical principles, creating e-learning materials is no different from creating other curriculum products. Curriculum development involves the search for evidence-based content, guided by specified learning outcomes. Next comes the design and development of the instructional activity, its implementation with targeted learners and the ongoing evaluation (Kern et al., 1998). As the example in Figure 2 illustrates (Medical Teacher website—http://www.medicalteacher.org), the process should include attention to clearly defined instructional design processes and should follow pedagogical guidelines such as focused educational objectives; meaningful content that directly supports the educational goal; presentation of content in appropriate ways; appropriate activity structures; choice of paths through the LO; a range of activities that address different learning modalities; prompt and constructive feedback; and appropriate assessments. This may require assistance from an educator skilled in the formulation of learning objectives, or the services of an instructional designer.

Although the technical expertise necessary to produce sophisticated learning objects is beyond the capability of most medical educators, new developments in authoring tools and enhancements to existing software will make the task possible for most educators in the next five years. However, creating learning objects still requires the educator to be familiar with the principles of instructional design and educational technology, as well as the rational use of a variety of multimedia elements and the use of computer interfaces and the Internet. The educator must be able to work within an interdisciplinary team of e-learning experts that may include instructional designers, multimedia specialists, programmers, graphic artists, usability experts and educational psychologists.

Using learning objects in medical education

Competency-based education provides opportunities for flexible, individualized learning (Leung, 2002). Learning objects provide this flexibility when they are matched to the competency gaps of the trainees. Effective use of learning objects requires a new way of looking at an instructional method, namely blended learning.

Blended learning combines both traditional methods of instruction (usually face-to-face instructor-led) with diverse e-learning approaches (Masie, 2002). The concept is not novel to medical educators. They already use multiple delivery methods to facilitate learning, such as classroom-based instruction complemented by reading materials, group assignments and small-group discussions. However, these strategies are generally instructor-centered rather than learner-centered (Clark, 2003). Learners also use multiple methods to support formal instruction, including a variety of media from print to electronic, from class notes to the Web (Clark, 2003). Opportunities for blended learning are numerous, as the following examples illustrate:

- A lecture on basic surgical techniques, complemented by a computer-assisted simulation of suturing;
- small-group discussions on environmental issues in the home, aided by an interactive online tutorial on home safety assessments;
- bedside teaching with heart disease patients, preceded by individual study with audio recordings of a variety of cardiac sounds;
- a workshop on communication with patients, assisted by a videotape demonstrating how to deliver bad news;
- a teleconference concerning diabetes mellitus, followed by a small-group discussion on the different treatment options.

After careful assessment of the learner’s needs and the development of a curriculum with clearly stated learning objectives, assessment methods and instructional activity, educators can begin to assess how learning objects can be effectively used as part of a blended learning strategy. Because learning objects are designed to provide chunks of content and because they are linked to learning objectives, they are particularly suited to the blended learning strategy.
The example in Figure 3 illustrates this point (Medical Teacher website—http://www.medicalteacher.org).

Evaluating the impact of learning objects

Learning objects may look attractive to learners but only appropriate evaluation can show how well they work. Donald Kirkpatrick describes four levels for evaluating training programs (Kirkpatrick, 1998). Although originally designed for training settings in varied corporate environments, the concept was later extended to healthcare education (Barr et al., 2000).

Learning objects can be evaluated individually both at the first and second level; at higher levels, they may be evaluated as part of a blended learning strategy.

- **Learners’ participation**: At the first level, the evaluation seeks the learners’ overall impressions of the learning object—it’s organization, presentation, content and usability—as well as aspects of the instructional organization, such as materials and the quality of instruction. The rationale for measuring this level is to ensure that learners are motivated and interested in learning.

- **Modification of attitudes/perceptions**: Outcomes at the second level relate to the changes in the attitudes or perceptions of participant groups that result from using the learning object.

- **Modification of knowledge/skills**: The second level of evaluation also examines how effectively the learner acquires the relevant concepts, procedures and principles (i.e. knowledge) through the use of the learning object. It also looks at the learner’s acquisition of the target skills, such as social, psychomotor or thinking/problem-solving skills.

- **Change in behavior**: The third level evaluation documents the transfer of learning to the workplace (i.e. the learner’s willingness to transfer new knowledge and skills). Educators expect that observable changes in behavior are predictors of a future competent physician. The accessible nature of learning objects may facilitate and, in many cases, reinforce positive behavioral changes.

- **Change in organizational practice**: The fourth level of evaluation considers the wider changes in the organizational delivery of care that are attributable to an educational program.

- **Benefits to patients**: Also at the fourth level, the evaluation documents improvements in the health and well-being of patients resulting from an educational program. The use of learning objects to support learning at the point of care (as, for example, with a recommended list of discharge medications for post MI patients) has tremendous potential for improving patient outcomes.

The future of learning objects

Many issues need to be addressed before learning objects become an established resource for medical educators. Some of these are listed below, along with suggestions for further research.

Adaptive learning uses technology to assess the learner’s knowledge, skills and attitudes in order to deliver the educational material that is most appropriate for the learner (Kreiter et al., 1999) by personalization of the course content, individualized tracking, monitoring, support and assessment (Hodgins, 2000; Martinez, 2002). The learner-centered rather than instructor-centered approach enables the learner to pursue an individualized path through the curriculum. Although the technology to implement adaptive learning has been available for some time, using learning objects to facilitate adaptive learning is a relatively new trend in e-learning (Kreiter et al., 1999). Learning objects may facilitate adaptive learning by offering the chunks of content that the learner needs in order to achieve an accepted level of competence.

The traditional central role of the medical educator has been to dispense information. Learners were treated as passive receivers of this information. The shift in emphasis to a lifelong learning and competency-based education approach has forced a reevaluation of this model. Educators no longer serve simply as distributors of content but become instead facilitators of the students’ learning and assessors of their competence. Learning objects and blended learning offer the opportunity for educators to evolve into this new role, while simultaneously becoming innovators in the learning process.

New initiatives in traditional medical schools have implemented decentralized models of education, relying less on tertiary medical centers and more on community hospitals, outpatient centers, long-term care institutions and even patients’ homes (Rooks et al., 2001; Carney et al., 2004). Some medical schools have developed educational sites simultaneously in rural and urban locations (Kobernick, 1975). This model of dispersed medical education presents interesting opportunities but also introduces some important challenges for both learners and educators. Large repositories of easily accessible Internet-based learning objects can provide medical educators and learners with a variety of educational materials. Moreover, the proliferation of learning objects may, as Harden proposed, increase access to medical education for underserved urban and rural areas and in countries with few medical and educational resources (Harden & Hart, 2002).

The scarcity of evidence-based literature on the effective use of learning objects in medical education provides numerous opportunities for further research. Existing data on their use in both college education and corporate training can serve as a useful and practical guide for medical education. Research in educational interventions is often difficult and challenging (Wilkes & Bligh, 1999). Research on learning objects, as one of our new educational resources, will demand both careful design and evaluation. The following is a list of areas where research is needed:

- Examining the context for use of learning objects: preclinical versus clinical years, diverse medical specialties and clinical settings;

- determining how to integrate learning objects into a blended learning curriculum;

- evaluating the impact of learning objects on multiple domains: usability, satisfaction, cost-effectiveness, knowledge/skills/attitudes gained, and lifelong learning;

- assessing the validity and reliability of assessment tools used to measure learner outcomes in a blended learning competence-based curriculum;
- developing methods of simplifying the learning object authoring process to gain wider acceptance and use;
- exploring the role of the peer-review process of learning objects in recognizing these materials as evidence of scholarly activity for faculty promotion and recognition.

**Conclusions**

Learning objects offer medical educators an approach to make education more efficient, and potentially more cost-effective. They are reusable electronic text and multimedia resources that both support and enhance learning. Learning objects can stand alone or be aggregated to create larger forms of educational content. They can be accessed by many computers and managed by several learning management systems for delivery to learners at any time. Online repositories now provide access to an array of learning objects from different institutions, 24 hours a day, seven days a week.

A blended learning approach using learning objects in combination with traditional educational methods is a rational strategy for dealing with the competing demands faced by most medical educators. Moreover, the use of learning objects in competence-based education offers learners the ability to tailor their experience to their preferred learning needs. Learning objects also facilitate evaluation of learners’ reactions and their acquisition of knowledge, skills and attitudes.

Research opportunities are numerous. Examples include the use of learning objects in adaptive learning, in preclinical versus clinical education, and as part of a blended learning strategy. The use of learning objects can potentially help faculty implement a new educational paradigm in medical education, one characterized by more personalized, efficient, effective, up-to-date, accessible instruction.

**Notes on contributors**

**JORGE G. RUIZ, MD FACP,** is Assistant Professor of Medicine at the University of Miami Miller School of Medicine, Associate Director for Education and Evaluation at the Miami VA GRECC and Senior Researcher at the Stein Gerontological Institute. He also directs the Online Geriatrics University (http://www.geri.u.org) and serves as e-learning consultant for the Portal of Online Geriatrics Education (http://www.pogoe.org).

**MICHAEL J. MINTZER, MD,** is Professor of Medicine and Director of the Geriatrics Curriculum at the University of Miami Miller School of Medicine. He also directs Community Academic Partnerships at the Miami VA GRECC and clinical education at the Stein Gerontological Institute. Dr. Mintzer teaches nurses, medical students, interns, residents and faculty.

**S. BARRY ISSENBERG, MD FACP,** is Associate Professor of Medicine, Assistant Dean for Research in Medical Education, Director of Educational Research and Technology and Assistant Co-Director at the Center for Research in Medical Education at the University of Miami Miller School of Medicine. His research includes the use of computer-based simulation methods for training and assessment.

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