Using Quality Criteria for Assessing and Comparing Open Courseware

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Abstract. Despite the momentum of the open courseware movement around the world, no quality criteria and metrics for evaluation of open courseware or open educational resources' repositories are available yet. Therefore, learners and instructors have no support and guidance in their quest for locating the most suitable learning resource that fulfills their educational aims. The same is true for developers, who have no guidelines for designing and building such educational resources. We present here an evaluation and comparison between two open courseware on data structures and algorithms, which are available from two important open courseware providers and that comply with different open courseware paradigms. Both evaluation and comparison rely on our socio-constructivist quality model, which consists of a set of quality criteria that serve as general guidelines for development, use, modification, evaluation, and comparison of open educational resources and open courseware.

Keywords. open courseware, open educational resources, quality assessment, quality criteria, open courseware on data structures and algorithms

1 Introduction

Nowadays learning is more and more a continuous lifelong and life-wide process that is no longer limited to dedicated spaces, times or modalities, in which learners themselves are both consumers and providers of knowledge that evolves towards a public good that can be accessed, shared, used and reused, adapted etc. Thus, users and communities contribute to social construction of knowledge, based on today's ubiquitous technologies. They provide further for open educational paradigms that are expected to provide for fulfillment of both needs and challenges of the 21st Century's knowledge economy and learning society. The growing number of open courseware and open educational resources projects worldwide has a key contribution to these emerging open educational models.

Such initiatives have evolved either as a unique university project or as a repository or consortium that cumulates educational resources from various sources. The most well-known it is, of course, the MIT OCW program – now having more than 2100 courses online, with which has started the OpenCourseWare (OCW) movement more than a decade ago. Since then, more and more universities have been

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offering open access to a growing number of their courses: Stanford, Carnegie Mellon, Harvard, Yale, Berkeley, Rice, Open University, Michigan, Carlos III and Politécnica of Madrid, and so on. In addition to these open courseware programs that are hosted by top universities, wide-ranging open courseware repositories are available, the most prominent being OpenCourseWare Consortium, Open Education Resources (OER) Commons, and The Saylor Foundation's Free Education Initiative [1, 2].

In spite of the scale, pervasiveness, and impact on users worldwide, the open courseware movement lacks a quality assessment framework on which users, being them learners, teachers, faculty, or developers, to rely on when they evaluate, choose, compare, design, or develop open courseware and open educational resources. Thus, learners need support when choosing the most suitable instructional resources that match their educational needs. Instructors are interested in locating those instructional resources that support meaningful instructional activities, which provide for reaching the expected learning goals, objectives, and outcomes, and for achieving reflective learning. Faculty who are or want to become involved with open courseware may be interested in how challenging and rewarding this participation can be [3]. Finally, developers need guidance when approaching the construction of such resources.

Related work is extremely thin with just a few works approaching the general subject of quality assurance for OCW and OERs in the context of assessing the impact of these paradigms in education nowadays. All these works emphasize on the importance of quality of OCW/OER resources, and on the need for continuous quality evaluation and assurance [4-11]. However, despite of their concern, none of these works has attempted to elaborate some criteria to be used for quality evaluation and assurance. In one of our previous works, we introduced a set of such criteria *that serve as general guidelines for development, use, modification, evaluation, and comparison of OERs and open courseware, from a social and constructivist perspective* [12].

In this paper we evaluate and compare two open courseware on data structures and algorithms, which are available at two providers that comply with two different open courseware paradigms. The evaluation and comparison are performed against our proposed set of quality criteria. Moreover, this work attempts to work those quality criteria on the chosen open courseware, and to learn from this experience how to develop further the initial set of quality criteria towards a quality assessment framework.

The structure of the paper is as follows: the second section presents briefly our set of quality criteria, the third one presents the evaluation of the two open courseware versus the quality criteria, followed by their comparison, while the last one includes the conclusions and some future work ideas.

2 Set of Criteria for Quality Assurance of OCW and OER

We summarize here our set of criteria for quality assurance of open educational resources and open courseware, which we have introduced and presented in much more detail in [12]. They are applicable for assessing quality of either small learning units or an entire courseware. These criteria have been grouped in four categories that refer to content, instructional design, technology, and courseware evaluation. In the remaining of this section these quality criteria will be briefly outlined in Table 1. For the time being the evaluation is subjective, being based on more than 20 years of au-

thor's experience in Higher Education, particularly here, in teaching data structures and algorithms.

Table 1. Criteria for Quality Assurance of OCW and OER

Content related	*Criteria that reveal to what degree an educational resource allows learners to have engaging learning experiences that provide for mastery of the content.*
	• readability • uniformity of language, terminology, and notations • availability of the course syllabus • comprehensiveness of the lecture notes • modularity of the course content • possibility to select the most suitable learning unit • opportunity to choose the most appropriate learning path • top-down, bottom-up or combined approach • availability of assignments (with or without solutions) • *resource related*: accuracy, reasonableness, self-containedness, context, relevance, availability of multi-media inserts, and correlation with the entire course
Instructional design	*Criteria that address the instructional design, and other pedagogical aspects of teaching and learning for that resource.*
	• goal and learning objectives • appropriate instructional activities • learning outcomes • availability of the evaluation and auto-evaluation means • learning theory • instructional design model • *reflective learning opportunities* in which the desired outcome of education becomes the construction of coherent functional knowledge structures adaptable to further lifelong learning [13-16]
Technology related	*Both open educational resources and open courseware are expected to benefit fully from ICT technologies, to have user-friendly interfaces, and to comply with various standards.*
	• conformity with standards for interoperability • compliance with standards for accessibility • extensibility (both instructors and learners) • user interface's navigational consistency and easiness, along with its multimedia appearance • supporting technology requirements at user's end • the prerequisite skills to use the supporting technology • multi-platform capability • supporting tools • security of users' confidential information

Courseware evaluation	*Despite of the original claim of just offering high quality educational materials, all major open courseware initiatives have recently become more involved with their learners. Hence, regular assessment of effectiveness of open courseware becomes essential, along with using the results for further improvements.*
	• *courseware overview*: content scope and sequence, intended audience, grade level, periodicity of updating the content, author's credentials, source credibility, multiple-languages, instructor facilitation or semi-automated support, suitableness for self-study and/or classroom-based study and/or peer collaborative study, time requirements, grading policy, instructions on using the courseware • availability of prerequisite knowledge • availability of required competencies • matching the course schedule with learner's own pace • availability of repository or institutional policies • freeness of bias and advertising • providing a formal degree or a certificate of completion • appropriate user interface • suitable design and presentation of educational content • *participatory culture and Web 2.0 facets*: contribution to the content, collection of users' feedback, collaboration with fellows, sharing the development/using experience

3 Evaluation and Comparison of the Two Open Courseware

This section includes the evaluation of the two open courseware on data structures and algorithms that have been announced in the Introduction. They have been assessed using the quality criteria introduced and explained in very much detail in [12], and summarized here in Section 2. The evaluation is followed by a comparison between the two open courseware "candidates", based on the proposed quality criteria.

3.1 University of Washington's Open Courseware on Data Structures and Algorithms against the Quality Criteria

This section includes a short description of the University of Washington's Open Courseware on Data Structures and Algorithms [17], followed by our quality assessment for this courseware, against the proposed set of quality criteria. The evaluation will be performed for each category of quality criteria in turn. The Computer Science and Engineering 373 course entitled *Data Structures and Algorithms* covers the fundamental data structures and algorithms. The available courseware includes the lecture notes, the homework assignments, some solved problems and exams, along with the grading policy for the enrolled students. For the time being, beside its obvious openness, this courseware does not address any other issues related to the open

courseware paradigm. While some of the available information is of interest only for University of Washington's students, most of it is useful for external users as well.

Content-related. The lectures that are available in two formats, namely .pdf and .ppt, are easy *readable* and very *uniform* in terms of language, terminology and notations, as they have a unique author. In addition to the lectures, learners have access to java programs and animation in Javascript that are useful when learning about data structures and algorithms. The offered materials are characterized by uniformity, except for the animations, which come from various online sources. The *course syllabus* for the course taught in Spring 2012 is available. The courseware is *modular* and quite *comprehensive*, covering all the necessary topics related to the subject. As the courseware main target is the enrolled students, the *assigned homework* is available without solutions, some of them being accompanied though by some support links or files. However, the homework specification includes more detailed *how to* instructions, along with style guidelines and grading information. The selection of the *most suitable learning unit and learning path* can be done simply provided that the learner has some previous knowledge of the subject. The courseware may be approached *top-down, bottom up or combined*. Each available instructional resource is *accurate, reasonable, self-contained*, and *relevant in the context* of learning about data structures and algorithms, being *correlated* with the entire course as well. Some very nice *multimedia inserts* are available. They illustrate by folk dancing some well-known sorting algorithms. Further podcasting is expected as well. The courseware comes with various *links* to several resources: the textbook, which is available to buy, rent or loan – for regular students only, supporting development environment's manual and tutorial, materials on Java programming and data structures and algorithms, along with links to other external resources such as Wikipedia or Wikihow entries.

Instructional design related. The general *instructional goal* is presented both in the course description and in the *course syllabus*, which presents also the *learning objectives* of the entire course, while for the learning units no *learning objectives or learning outcomes* are available. Most of the available instructional materials provide only for *basic instructional activities*. For *auto-evaluation* or *evaluation*, learners may use practice problems and exams – with solutions - both for midterm and final exams. The actual midterm and exam of Spring 2012 are available with solutions as well. *Reflective learning* has not been yet taken into account for this courseware. No aspects related to the *learning theory* or to the *instructional design* are available.

Technology related. The courseware complies with *interoperability* standards. However, no *web accessibility* issues are considered yet. Only the instructors may *extend the instructional resources*. The user interface is basic. The course syllabus presents briefly the *technical requirements*, while the *prerequisite skills* of using the supporting technology are left out, being probably considered basic. The courseware is *multi-platform*, and the *supporting tools* are described in the Links page. No interaction of external users with the courseware is allowed, and therefore no approaching of issues regarding *privacy and security of confidential information* is necessary.

Courseware evaluation. The *content scope and sequence* may be deduced from the Lectures' page. The intended *audience* or *grade level* is not explicitly affirmed in the course web site. No information about periodicity of updating is available. *Authors' credentials* and *source credibility* are very good. No availability in *multiple languages* or *support for learners* have been provided. The courseware may be used for *self-study* or *classroom based study*. *Time requirements* to cover the course materials are not available. *Grading policy* is presented, but it refers only to University of Washington's students. No *instructions on "how to"* use the courseware and its components are available. The *prerequisite knowledge* and *required competencies* are stated both in the Syllabus and in the course home page. The *learning pace* is independent by the *course schedule*. No *repository policies* are presented. The courseware is *free of bias and advertising*. No *degree or certificate of completion* is envisaged for now. Learners may not *contribute* to the resources. Very thin *collaboration* with fellow learners is allowed for enrolled students only. The discussion forum is also closed to external learners. Anonymous *feedback* from users may be given only via the form available via the home page. No inside information about the *development journey* or about the *experience* of using this open courseware, since beside its openness as such, no other issues related to open courseware are taken into account. The *user interface, design and presentation of the instructional content* are basic.

3.2 The Saylor Foundation's Open Courseware on Elementary Data Structures against the Quality Criteria

Saylor.org has been launched by The Saylor Foundation as a free online university and it is *seen as a zero-cost alternative to those who lack the resources to attend traditional brick-and-mortar institutions, and as a complement to mainstream education providers that will both motivate people ..., and lead to institutional change amongst education providers* [18]. The Foundation's goal is to offer to learners the chance to overcome the barriers of pursuing mainstream college education: fixed class schedule, physical distance to a campus, rising costs of tuition, fees, and textbooks etc. Currently, saylor.org provides the appropriate content that is necessary to earn the equivalent of a degree in any of the top majors in the USA. The course CS 201 - *Elementary Data Structures* is one of the 200 courses freely available at The Saylor Foundation site, which is mandatory for the Computer Science program [19]. This course provides students with an introduction to elementary data structures and algorithms. The courseware overview includes the learning outcomes, the course requirements, and the learning units. Syllabus, readings, web media lectures, automated assessments, and the final exam are also available from the course home page. In addition to these components, the course homepage offers also the course's description in a nutshell, as the *course information*, which includes general information about the course designer, the primary resources, the necessary requirements for completion, the needed time commitment, along with tips and suggestions on how to navigate through the course materials, on how to proceed when a learner struggles with a concept, and on the usefulness of taking notes while covering the available instructional resources. Further on, we detail our quality assessment for this courseware based on the quality criteria.

Content-related. The *readability and uniformity* of the course materials varies as the learning units have several authors. The course content is a mix of HTML readings, web media lectures, and assignments (quizzes), along with the final exam. The instructional materials may come from other educational institutions, collections or repositories, all of them being free, online materials. Saylor.org states that all the materials have been carefully *selected, framed, and/or developed by their professors* so that they will provide for achievement of the announced learning goal. As for any Saylor's course, the detailed *course syllabus* is available from the course home page. The courseware is *modular* and very *comprehensive* as shown above. *Assignments (quizzes with solutions)* are offered. Selection of the *most suitable learning unit and learning path* can be done straightforwardly as the courseware is very intuitively developed. The courseware may be approached *top-down, bottom up or combined*. However, the general recommendation for beginners is to follow through all the materials in the sequence in which they are presented. Each instructional resource is *accurate, reasonable, self-contained, relevant in the context* of learning about elementary data structures and algorithms, and it is properly *correlated* with the entire course. *Multimedia inserts* are available. Only *links* to the course readings are offered.

Instructional design related. Both the *course's syllabus* and the home page state the general *instructional goal* of the courseware. Unlike most of the open courseware, in Saylor's case, the *learning objectives and outcomes* of each course are available at two levels: *course*-wide and *learning unit*-wide. The existing *instructional activities* are very limited in offering meaningful learning experiences, while *reflective learning* is not taken in consideration yet. As for *auto-evaluation or evaluation* means, only *quizzes with solutions* (the assignments) or *without solutions* (the exam) are available for now. Each time the final exam is taken, learners are offered different questions. No information about the *learning theory* or the *instructional design* is presented.

Technology related. The courseware fulfills the basic *interoperability standards*. Accessibility is approached only in its larger sense rather than as *web accessibility*. For the time being, only the instructors may *extend the instructional resources.* The *user interface* is advanced and suitable. The supporting *technical requirements*, the *supporting tools*, and the *prerequisite skills* of using the technology are presented in The Saylor Student Handbook. The courseware is *multi-platform*. Both the Terms of Use page and the Handbook show the saylor.org's policy regarding *privacy and security of confidential information*.

Courseware evaluation has shown the following: the *content scope and sequence* are shown both in the course syllabus and in the course home page. The course's *intended audience* and *grade level* are explicitly addressed only on saylor.org's home page. No information about periodicity of updating is available for now. For some learning units *author's credentials* are obvious, as they are professors at prestigious universities, while for others learners have to rely on *source credibility*, which is substantial in our opinion. The course materials are available only in English. Some *semi-automated* support with respect to the assignments is available. Currently, the courseware may be

used only for *self-study* and *classroom based study*. However, when considering the latest saylor.org's developments (forums, e-portfolios etc.), it seems that *peer collaborative study* is envisioned as well. Both the syllabus and the course information page provide a *time advisory*, which shows the needed time requirements for completion of each learning unit, and of the entire courseware as well. Student handbook details the *grading policy* and *instructions on "how to"* use the courseware and its components (the latter is available also in the course information page). The *prerequisite knowledge* and *required competencies* are presented in the course home page. There is no predefined schedule, so learners may use the courseware at *their own pace*. The Student Handbook includes also the community standards, i. e. the *repository policies*, along with the statement regarding the *freeness of bias* and *advertising*. *A certificate of completion* having a unique identification code is provided to each learner after she has passed the exam with a score of more than 70%. For the moment, learners may not *contribute* directly to the resources or *collaborate* with fellow learners. However, they may submit materials that might get chosen to be published on the saylor.org, and the forums are starting to grow. *Feedback* from users is collected via a user survey. The *development journey* and the *experience* of using saylor.org are presented briefly in the Student Handbook. The *user interface, design* and *presentation of the instructional content* are well elaborated and user-friendly in our opinion.

3.3 Comparison of the Two Open Courseware based on the Quality Criteria

We present here a comparison of the two open courseware. To make the comparison easier to follow, two acronyms will be used, namely UW-DSA and SaylorDS.

First, we have to acknowledge that each of the two evaluated open courseware has strong points and weak points, so we cannot state which one is the most beneficial for users, being them learners, teachers or developers. The main merit of UW-DSA is, in our opinion, the broadness of the covered topics, the large range of instructional materials, and the source's credibility. What it misses the most is its engagement with prospective external users, and the participatory culture aspects. SaylorDS has a far better user interface and supporting framework, most probably due to the fact that Saylor.org is aiming at becoming an open online university, where *independent learners are ought to return with pleasure and confidence that the courseware materials are connected to them in a meaningful, unique, transformative way* [18]. It also covers a suitable variety of topics in the field, offering high-quality OERs, many of them coming from top universities and educational organizations worldwide.

Neither of the two open courseware provides for true engaging, reflective learning, but it seems that saylor.org is starting to address this issue, even though for the time being this is true only for some other of their courses, and not for SaylorDS. Moreover, they provide some sort of certificate of completion for each of their courses. Related to that, cheating issues are acknowledged as well. What is also worth mentioning is that both courseware build up on other *open educational resources and open courseware*, which increases the expectations, the benefits, and the confidence of users worldwide with respect to the open courseware movement.

4 Conclusions and Future Work

The OCW initiative has appeared in the larger context of open systems, building up on the reality that opening of the software infrastructure has unleashed the creativity of software developers in unimagined ways, and thinking that something very similar will happen to education, as Charles Vest, the President of MIT, declared when OCW was launched [20]. In our opinion, opening the courseware to people worldwide, and therefore providing for *the dissemination of knowledge for the public good* [21] and for creative collaboration, will create promising opportunities for boosting creativity, because no creative collaboration may appear in absence of knowledge, as creativity may be seen as *the mastery of information and skills in the service of dreams* [22].

This paper's contribution consists in the evaluation and comparison of two open courseware on data structures and algorithms that is performed against our set of quality criteria. Basically, this work has attempted to validate those quality criteria, to put them into practice, and, to learn how to improve them during this process. The choice of the two "candidates" is due to their provenance, i.e. two different open course providers, which comply with two very different open courseware paradigms.

During the evaluation process we have learned that some criteria need to modified or extended, e.g. the security of confidential information is just a component of the terms of use that need to include further aspects such as netiquette, anonymity, various restrictions applicable, copyright and licensing etc. Also, links to other related relevant resources has been added as a criterion. Furthermore, accessibility needs to be seen not only as web accessibility, but in a larger context, as it concerns access of as many people as possible to open education. New quality criteria have proven to be necessary as well, which concern learner's support for other learners, opportunity for peer collaborative learning, and availability of quick guides of relevant software. First future work idea refers to devising a suitable scoring or rubric system that will help elaborate some metrics for open courseware, based on existing quality standards (such as ISO/IEC 25000 SQuaRE standard), educational theories and best practice. This way, users may be provided with a valuable mechanism for choosing the most suitable educational resource and the appropriate learning path to fulfill their educational needs. More, developers may also use that mechanism to tailor their "final products".

Second, the learning theory and the instructional design model are not yet considered by the open courseware designers and, in our view, they could benefit massively by relying on pedagogical theories and valuable practice in this respect. We have to research further how the close the gap between educational specialists and developers, maybe by offering the latter ones some semi-automated frameworks for approaching the pedagogical aspects. Finally, our final conclusion is more of a hope, but at the same time, a belief that having many open courseware and open educational resources available the struggle for quality will be encouraged for users' benefit, being them learners, instructors, faculty, developers, and even educational institutions.

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