An Agile Learning Design Method for Open Educational Resources

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***Abstract*—Open Educational Resources (OERs) have provided new perspectives for the construction, access and sharing of knowledge. While OERs can bring benefits to, and impact on education, there are still challenges to their widespread production and use. One of the challenges faced by developers (including educators and practitioners) of OERs has been how to produce quality and relevant learning materials, capable of being reused and adapted in different learning situations. In our work we propose and define an agile learning design method to support the design and creation of OERs. It is based on agile practices from software engineering and on practices of learning design from the OULDI project at the UK Open University. We illustrate our ideas with an experiment that validates the proposed method through its application in the design and creation of an OER in the software testing domain. The results obtained so far have shown that the method is feasible and effective for the design and creation of OERs.**

Keywords—open educational resources; learning design; agile practices

I. INTRODUCTION

Open Educational Resources (OERs) have provided effective mechanisms for open and flexible education, expanding access to knowledge with reduced costs and enhancing cooperation and collaboration. They promote and support innovative practices in teaching and learning. OERs can be characterized as teaching, learning and research materials in the public domain or released under an intellectual property license allowing their free use or re-purposing by others[1]. They include full courses, course materials, lecture notes, modules, textbooks, streaming videos, images, software and any other tools, materials or techniques used to support the construction and access to knowledge.

Although the creation and adoption of OERs have been gaining support and incentives from institutions and researchers across the globe, the full potential of OERs has not yet been reached [14]. One of the difficulties faced by educators and practitioners is to understand the implicit design behind OERs to know how to reuse them in their own teaching contexts [17]. Making the design more explicit helps to capture its key aspects, as well as the learning objectives, the activities and outcomes associated with the learning materials, supporting both teachers and learners [20].

Instructional Design (ID) is an approach for designing learning instructions [13]. Molenda [21] defines ID as a systematic application of scientific principles about "how people learn" to develop instruction. The term "instructional" means anything that is done purposely to help and facilitate learning [22].

With the advent of Web 2.0, new approaches for designing learning materials have been proposed. Learning Design (LD) has emerged within this context, bringing a broader perspective to teaching and learning and helping with the definition, creation, and sharing of effective pedagogical designs of learning materials [12,17]. LD consists of a set of activities supporting the understanding, description and sharing of pedagogical design practices. Research on LD has increased in the last few years primarily due to a gap between the potential and actual use of technology to support teaching and learning [12]. However, initiatives to foster the design and creation of quality OERs with reduced time and costs are still incipient.

The need for systematic and flexible approaches to the design and creation of OERs is highlighted by several authors [2,24,25]. This paper offers a contribution to address this need, by proposing a method for the development of OERs that learns from practices in other disciplines, namely the practice of agile methods in software development.

Agile methods gained prominence in software development, to address problems of long delivery times, and of software that has not fulfilled its promises or solved what was required. They promote simplicity and flexibility to deliver products and services that are relevant and add value to the market in due time. One of the characteristics of agile methods is that they are "people-centered", encouraging and prioritizing effective collaboration and involvement of users in the development to deliver software more quickly and efficiently [4].

The concerns and characteristics of agile methods resonate with the needs identified in the development of OERs, as previously mentioned. The collaboration and involvement of users (educators, learners) is also appealing in the context of the development of OERs [8,10].

[1] hewlett.org [last accessed on 03-2015]

In our work we propose and define an agile LD method to support the design and creation of OERs based on agile practices from software engineering [1,7,26] and on practices of LD that originate in the Open University Learning Design Initiative (OULDI) project proposed by the UK Open University [12]. The OULDI was funded by JISC, a public body that supports and champions the use of digital technologies in education and research across the UK. Our proposal builds on a preliminary version firstly introduced by Arimoto and Barbosa [3]. We validate our method with an experiment involving the design and creation of OERs to teach software testing, a topic within software engineering education.

This paper is organized as follows. In section II we discuss related work; in section III we describe the main characteristics of the agile LD method for OERs; section IV reports on an experiment to validate the method by designing and creating an OER within a software testing domain; concluding remarks and further work are presented in section V.

II. Related Work

Instructional Design (ID) has a long trajectory as an approach for designing learning instructions in a systematic way [13]. "It is the process of deciding what methods of instruction are best for bringing about desired changes in student knowledge and skills for a specific course content and specific student population" [23]. Learning Design (LD) has emerged more recently over the last decade, primarily in Europe and Australia [18]. "It has developed as a means of helping teachers make informed choices in terms of creating pedagogically effective learning interventions that make effective use of technologies" [12].

LD and ID are closely aligned but have distinct focuses. As argued by Conole [13], ID focuses on designing the instructions to meet learning needs for a specific audience and setting, while LD takes a much broader perspective and regards design as a dynamic process, which is ongoing and inclusive, considering all stakeholders involved in the teaching and learning.

The OULDI was initiated in 2007 to derive a more "practice-focused approach for LD" [11]. It defined a method, tools and a notation to represent LD including: (1) different types of design representations to help guide design decision-making process; (2) digital tools to help visualize and represent designs; and (3) mechanisms to encourage the sharing and discussion of learning teaching ideas, including face-to-face events [12].

Design representations in the OULDI include [11]:

1. *Macro-level* (the course map view): an overview of main components of the course to enable educators and practitioners to think about the design of a course using 4 dimensions: content and experience, guide and support, communication and collaboration, and reflection and demonstration.
2. *Meso-level* (the learning outcomes view): a notational vision showing how learning activities and assessment tasks are linked with learning outcomes of the course.
3. *Micro-level* (the task swimlane view): a map of tasks that the learners undertake to the learning materials and tools they use during the activities in the course.
4. *Pedagogy Profile*: types of activities in which learners participate during the course or sequence of learning events. These are categorized as assimilative, information handling, communication, productive, experimental, adaptive and evaluation.
5. *Course Dimensions:* details on the nature of the course, a refinement of the course map view.

As highlighted by Avraamidou and Economou [5], levels 1 up to 5 of the OULDI cannot be seen as separate parts. LD often requires refinement and improvement. This implies that the design process should allow moving back and forwards through the levels according to the needs. Although the OULDI approach intends to make the design more explicit, it does not specify the steps and guidelines for a LD process.

There are other initiatives using LD. Learning Activities Management Systems (LAMS) [15] is a platform that offers automated support for LD. This platform is used to design learning activity sequences, describing the whole teaching process including learning contents, learning activities, and assessment. The Learning Design Support Environment (LDSE) [19] is another initiative in this direction. Both LAMS and LDSE have in common more self-contained and complex environments than the OULDI, which difficult their use. The demand for the creation of learning materials as OERs within the expected cost and schedule, together with the lack of time [27] to produce these materials, also highlight the need for more agility in the LD process.

In the context of LD, there is a lack of initiatives that explore the use of agile methods; this is not the case with ID. Bahl [6] proposed an approach for ID based on ADDIE [28], and Scrum [26]. ADDIE is a generic model for ID used for the development of instructional materials and training; whilst Scrum is a well-known agile method used for the management and planning of software (and non-software) projects. The approach proposed by Bahl defines a linear and iterative cycle:

1. *Initiation and planning* of the overall project, including project definition, pedagogical needs, objectives, stakeholder's identification and high level budget and timelines.
2. *High level analysis* of functionalities needs to prepare a high level project plan.
3. *Iterative design & development* of functionalities reviewed by experts at the end of each iteration.
4. *Feature integration* of functionalities implemented throughout the cycles.
5. *Solution roll out* culminating with the closure of the project.

Willeke [29] discusses the use of Scrum in ID in an online educational course at Ohio Christian University with the following quantitative improvements:

- *Satisfaction:* positive feedback on the Scrum process, contributing to a better quality course.
- *Time saving*: the time invested reduced over 30%, and the time for total development dropped 40%.
- *Internal communication:* the interaction and communication within the team involved in the process increased, allowing problems to be solved quicker.

Despite this success, Willeke [29] mentions the need of a cultural change for the adoption of an agile approach in the educational environment. These initiatives also fall short of the application of some agile practices such as the active participation of users (e.g., potential learners), throughout the development. Our proposed method combines a wider range of agile practices with LD; in particular, it gives emphasis to the collaboration and active participation of users to ensure the quality and relevance of the produced learning material.

III. An Agile Learning Design Method for Open Educational Resources

We propose an agile LD method for OERs based on a combination of agile software design practices and OULDI practices. This method allows designs to be modified, repurposed and evolved according to the needs of users emerging during development. Pedagogical design practices are embedded in the development of OERs improving quality and facilitating reuse and adaptation. It also accommodates change and improvement, minimizing cost and impact.

The agile practices, in Table I, are combined with LD, assisting and guiding the design and creation of OERs:

- Users (educators[2] and potential learners) actively participate throughout the development, either in person or via collaborative technologies (wikis, microblogging, social networking and messaging systems). They assist in the identification and establishment of learning objectives, activities and pathways, content and assessment.
- Collaborative development is promoted by the constant interaction and communication amongst all involved. Several activities are carried out in group brainstorming and workshop sessions, either face-to-face or by synchronous communications tools (text mode or videoconference). This helps to reduce time and effort and enables effective design of OERs.
- Architecture/Design envisioning is used early in LD activities to sketch a design (initial architecture and resources) to obtain an overview of the OER, and help educators and potential learners to think about the key elements.
- Iterative modelling/design produces sketches of OER's modules that are revised in each iteration; they represent the learning activities, and connections to learning outcomes, content, the tools and assessment.
- Design storming is used for the flow of activities and the strategies for the development of the OER. It triggers refining and decomposition of activities into individual activities and tasks, helping educators and potential learners to reflect upon an aspect of design.
- Refactoring improves the learning structure and content without changing the learning outcomes. It is performed whenever an opportunity for change and/or improvement is identified.
- Evaluation is carried out early and continuously throughout the development, especially at the end of each iteration. With the design of small modules of the OER, educators have the opportunity to check whether the modules designed are in agreement with those planned. It is possible to identify new designs, modifications or inclusion of new activities and content, and improvements in relatively short periods of time, minimizing the cost of change.

TABLE I. AGILE DESIGN PRACTICES

Practices	Description
Active users participation	Users are involved in the development process, helping to identify and solve problems and mistakes and providing rapid feedback to the team
Collaborative development	All team members constantly interact and communicate throughout the development process, promoting a collaborative and productive environment
Architecture/ Design envisioning	Initial software architecture and requirements are designed at the beginning of a project to identify and think through critical issues
Iterative modeling/ design	Software functionalities are designed at the beginning of an iteration to identify team's strategy for that iteration
Model/ Design storming	Software functionalities are designed on a just-in-time (JIT) basis to reflect on specific aspects of team's solution
Refactoring	Small changes are performed to improve part of a solution without changing its semantic meaning
Early and continuous Evaluation	Testing and validation activities are conducted at the beginning of the project and extend throughout the development process

Our agile LD method is structured in four steps or macro-activities (Establish the initial architecture, Plan and create the structure, Refine the structure/create the content and Evaluate), as shown in Fig. 1.

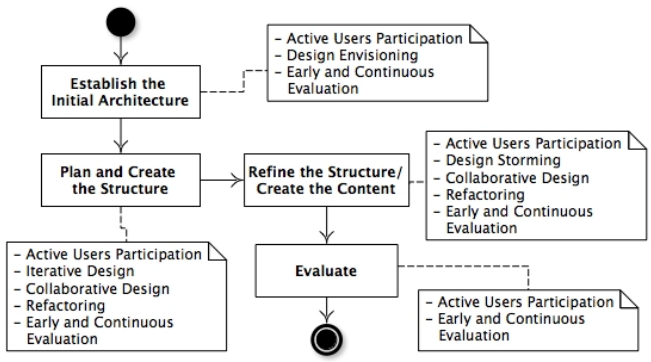

Fig. 1. Agile LD method for OERs: an overview

[2] By using the term "educators" we also include practitioners, teachers, lectures and tutors.

A. Establish the initial architecture

This step defines an initial architecture for the OER (Design envisioning) based on the Course Map View from OULDI. At the beginning of development, all users including educators and potential learners come together by a brainstorming session (face-to-face or by synchronous communications tools – videoconference) to identify and think about critical issues and the main elements of the intended learning. The initial architecture of the OER is sketched without too much detail ("just barely good enough"), as the design should be constantly evolving throughout the iterations.

Educators start by drafting the learning objectives and the context or domain of the OER. Irwin DeVries [16] highlights that many OERs do not have basic elements of LD such as learning objectives. This makes it hard to assess the OER in terms of its overall purpose, and the pedagogical alignment of learning materials, activities and assessment. He also argues that learning objectives are essential elements for reuse; they help identify if an OER has the level of coverage and depth appropriate to be used in a different context.

Educators specify the context or domain in which the OER will be applied. For instance, whether the OER will be a key part of a course in the curriculum, a complementary part of a course, or a short specialization course. They also need to include cultural and languages issues in the OER's context.

Pre-requirements and specific knowledge needed to use the OER are defined. The estimated time (duration) for the application/use of OER in a particular course or training is also specified. For instance, a short course or class may require only a few hours while a full course (such as a complete software engineering course) may require weeks or months.

Educators identify the primary content of the OER. There is no need to identify all content a priori; further content can be added or changed throughout development. In order to identify content, the following issues should considered:

- the way in which the OER will be delivered to learners, i.e., face-to-face, online or both;
- the way in which learners will be supported, i.e., face-to-face, online or both; and,
- the kind of activities learners will need to perform.

Typical examples of content include: lessons, lab activities, study guides, examples, readings, support materials, case studies, pilot projects, surveys, systematic reviews, and experiments/controlled experiments.

Educators need also to define learning assessment activities to help teachers gather evidence from learners to adjust and improve their teaching strategies. In the same way, learners can improve their learning strategies according to these activities. Learning assessment activities are defined considering:

- whether the assessment activities will be online, paper based or both; and,
- whether the assessment strategies will be diagnostic, formative, summative or all of them.

Typical examples of learning assessment activities include: in-text questions, self-assessment questions, brief in-class assessments, oral presentations, team projects, papers, essays, and exams (written or oral).

Educators also need to think about the way in which learners will interact and collaborate with educators and colleagues when using the OER within a course, and consider:

- whether learners will communicate and collaborate with their colleagues online, face-to-face or both;
- whether learners will communicate and collaborate with educators online, face-to-face or both; and,
- whether learners will perform their activities individually, peer-work or work in a group.

Typical examples of means of communication and collaboration include: synchronous and asynchronous tools (such as instant messaging system, forum and email), and face-to-face tools (such as workshops, brainstorming sessions, work in groups, peer-to peer works and seminar).

At the end of this step, all those involved in the design and creation of the OER (including educators, designers, media creators[3] and potential learners) need to agree on the initial architecture of OER and approve it.

B. Plan and create the structure

This step plans and creates a learning structure for the OER in the current iteration, representing the connections between the main elements for learning to achieve an effective learning pathway. The design is created "just enough for now, since we can always come back later" (Iterative Design)[1]. It prioritizes the most relevant aspects to be addressed by the OER. Other aspects considered less important are discussed later.

Initially, educators together with the designers, media creators and potential learners plan and agree the releases to be delivered in a short period of time, usually ranging from a week to month (depending on the complexity and size of OERs). In terms of OERs, a release corresponds to modules or small sets of modules (or components, topics) considered "ready" to be used by potential learners. A release is composed by learning activities, contents, assessments, roles and tools needed to meet the learning objectives of the OER.

The modules of the OER are designed in a few short iterations, each lasting hours, days or a few weeks. Short iterations promote visibility for the OER; an opportunity for users to perceive how the design and creation of the OER is progressing during the development.

Educators prioritize small modules or parts of the OER to be designed and created in the current iteration based on the initial architecture of the OER established in step A. They introduce these modules to designers and media creators, indicating what should be done with each one.

Educators along with designers and media creators come together in a brainstorming session to discuss the design of the OER to obtain a structured process for the learning. Based on the initial architecture of the OER, they establish the activities that learners will perform (learning activities) to achieve the

[3] We refer to media creators the responsible for editing and updating all contents and media associated to the OER.

desired learning results. This helps them reflect on the flow of the activities of the OER and the strategies for its development.

The learning activities are linked with the intended learning outcomes, content, tools and assessment activities. A sketch of this mapping is created based on the meso-level (learning outcomes view) from OULDI. The structure of the OER is reviewed and approved by educators and potential learners, serving as input for the next step.

C. Refine the structure /create the content

In this step the learning structure of the OER is refined and related content is created. Designers and media creators come together to discuss how to design effective learning materials with embedded pedagogical design practices. The active participation of all users (mainly the educators and potential learners) is essential.

Designers together with educators refine and decompose the OER activities in simpler activities and atomic tasks, helping them to reflect upon one aspect of the design solution and how they can transform it for a more effective OER. This refinement is based on the micro-level (task swimlane view) from OULDI.

Learning content and the required media are developed: text documents, html pages, wikis, multimedia files (such as podcast, streaming videos and animations), images, open textbooks, and lecture notes. These materials can be developed from "scratch" or reusing third-part material. Educators and media creators should search for suitable materials that could be reused and adapted to meet the learning objectives.

When third-part material is used to compose a new OER there is a need to check and assess whether: (1) the file format is modifiable and suitable to the desired needs, (2) the licensing policies are explicitly defined, allowing reuse and modification, (3) the contents are from reliable sources (institutions engaged with education, renowned authors, etc.), (4) the content fit the didactic and pedagogical objectives, among others.

Licensing policies to share the OER must be established. An OER must be shared through an open license with little or no restriction on its (re)use and adaptation. The licensing policies for an OER need to consider: (1) the authorship and intellectual property rights of third-part materials (when used), (2) how the OER will be available (non-commercial allowed or not), and (3) the appropriate license according to items 1 and 2.

Primary metadata for the OER are identified and gathered. Metadata describe relevant characteristics of the OER, facilitating its reuse and recovery by search engines. When an OER has integrated metadata, any user can easily find it.

Media creators and users (educators and potential learners) work in constant collaboration. New solutions and improvements could be highlighted through feedback provided by interactions and cooperation with users. Media creators constantly refactor their solution aiming to simplify and enhance it.

The structure of the OER, activities and content are regularly reviewed throughout the development to detect mistakes and other problems which may affect the quality of OER. Media creators must update the work to reflect the necessary corrections and changes.

D. Evaluate

This step evaluates and approves the work and artifacts delivered in each iteration which compose a release. Educators and potential learners are involved in verifying whether the learning pathways associated with the content contribute to the learning. They also analyze whether the type of content and activities, learning assessment, and tools are appropriate to the purpose of the OER, e.g., aligned with the learning outcomes.

Peer review should evaluate the design quality, and academic staff and domain experts should also evaluate it.

Also, designers and media creators need to think about the strategy adopted during iteration, focusing on how they can improve their work. They should identify "what worked well" and "what did not work well" during the iteration. They also discuss "what needs to change and improve" in the next iteration. Lessons learned and feedback from the evaluation are gathered and will be used for improving the following iterations, contributing to the continuous improvement process.

Early and continuous evaluation of the design process helps clarify the problems and solutions and identify the needs for corrections and improvements. The OER modules, or part of them, can be reviewed by educators and potential learners throughout the process, and any change can be made at any stage of the development. This is one way to ensure the design quality and therefore the OER as a whole.

Once the OER module (release) has been approved by the educators, it can be used in a teaching environment. Its use by a group of learners is critical to identify weaknesses and propose improvements. Educators should provide the support needed by learners in their activities and monitor their progress. Data about the learners experience should also be collected and analyzed to improve the quality of the OER.

Effective access to the OER release should be through platforms or repositories and institutional or stand-alone websites. Media creators need to check whether the OER is made available together with associated metadata, according to packaging standards, and appropriate license.

IV. APPYING THE AGILE LEARNING DESIGN METHOD

An experiment was conducted within the software testing domain in order to evaluate the applicability and effectiveness of the Agile LD method by comparing it with an AD-HOC approach. With an AD-HOC approach the development is informal with no defined process to guide the development.

We chose to perform an experiment to allow a more rigid control on the environment, and a more rigorous manipulation of the phenomenon we study. An experiment can generate more concise results based on quantitative analysis, providing evidence of the validity of our proposal to create OERs. It can also allow the generalization of the results within a population, and the replication of the experiment.

In the experiment we refer to our proposal as AM-OER (**A**gile **M**ethod for the Development of **O**pen **E**ducational **R**esources). The research questions for the experiment were:

- How effective is the AM-OER in the creation of OERs compared to AD-HOC approach?
- How efficient is the AM-OER in the creation of OERs compared to AD-HOC approach?
- How much better are the results obtained by AM-OER compared to AD-HOC approach?

The subjects of the experiment were 8 participants including graduate students (MSc and PhD), educators and researchers in Computer Science from the Institute of Mathematics and Computer Sciences (ICMC) at University of São Paulo (USP).

The participants were divided into two balanced groups with the same number of participants. We also tried to create homogeneous groups according to the level of knowledge of each participant, especially in relation to the development of learning materials and software testing.

Both groups created the same module of an OER, representing a full class (3 hours of duration) within the software testing domain, focusing on Functional (Black-box) Testing and its criteria, including Equivalence Partitioning Testing and Boundary Values Analysis. Each group had 4 hours and 30 minutes to finish the work.

Before the developmental activities of the experiment, the participants took part in a training, lasting 2 hours and 30 minutes. The training covered topics related to OERs and software testing, especially regarding to the specification of the OER module to be created within this domain. Furthermore, the group of participants that used the AM-OER method was also trained into the main aspects of the method. The materials used in the training were also made available to the participants. During the experiment, the groups could not communicate each other.

We consider some factors that may affect and impact the analysis and interpretation of the results from the experiment. The main threats to validity of the experiment:

- *Internal validity*: the AM-OER method cannot provide well-defined steps to guide the development of OERs, requiring appropriate training.
- *Extern validity*: the number of subjects is relatively small and may not adequately reveal the applicability and effectiveness of the AM-OER in the development of OERs. The level of experience of subjects can also influence in the validation. Furthermore, the experiment must be performed in laboratories adequately furnished with computer and internet access.
- *Construct validity*: the responsible for the experiment must be careful with the treatment of variables in order to meet the objectives predefined.

A. General Overview of the OER Module

The group using the AM-OER created the module following the agile design practices for OERs discussed in Section III.

The learning objectives established for the module were:

- Students will summarize the fundamentals of Functional Testing.
- Students will argue and defend the two major Functional Testing Criteria: Partitioning Functional Testing and Boundary Values Analysis.
- Students will be able to apply the Partitioning Functional Testing and Boundary Values Analysis.

The module is in the context of a software testing course. The target audience includes undergraduate students in Computer Science and other related areas. It can also include students interested in learning about Functional Testing. As prerequisites and experience, the students must have basic skills on fundamentals of programming and software testing.

The content required for the module include guidelines, lessons, examples, supporting materials and specification and the implementation of a selected program (Calendar program named Cal). Assessment activities include essays, self-assessment questions and reports. The means of communication and collaboration include chat, forum, peer-to peer work and discussion in group.

A sketch of the learning structure of the module is shown in Fig. 2. According to the figure, a student enrolled in a software testing course can take as *activity Design and execute test cases using Functional Testing Criteria.* A learning outcome could be that the learner has acquired practical knowledge on the subject (*Demonstrate ability to apply Functional Testing Criteria*) according to evaluations conducted throughout the course (*Report on Design and Execution of Test Cases*).

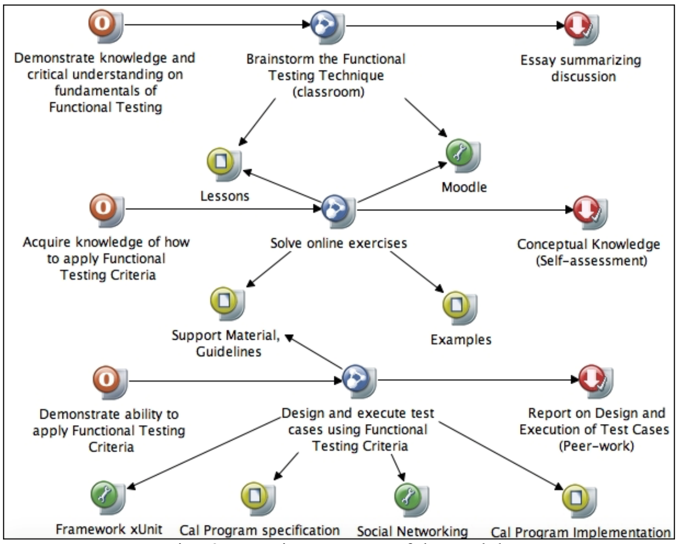

Fig. 2. Learning structure of the module

Figure 3 shows a sketch of a refinement of the structure of the module above for the activity *Design and execute test cases using Functional Testing Criteria*. It contains atomic tasks associated with their content and respective assessment activity.

The Functional Testing module is composed by html pages, text documents, lecture notes, images and video. Fig. 4 shows one of the proposed activities to assess students.

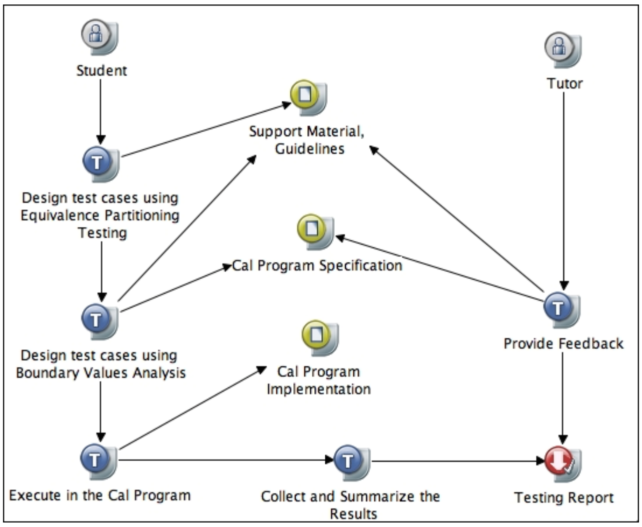

Fig. 3. Refinement of the learning structure

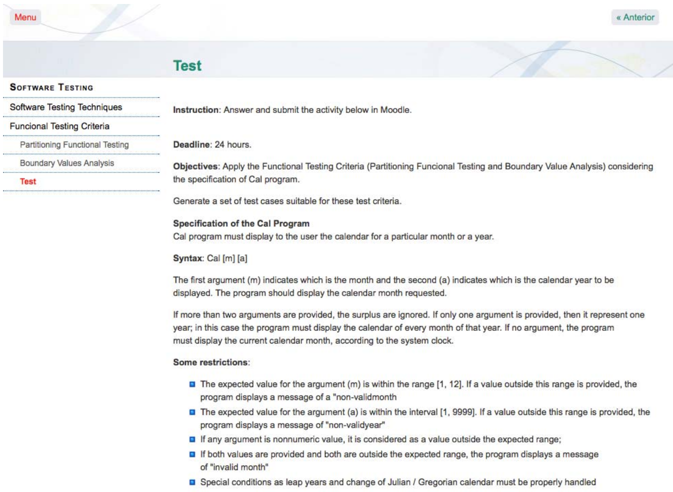

Fig. 4. OER on software testing

B. Comparing Effectiveness

Effectiveness measures the capacity of each approach in the development of the planned OER. It is related to the OER module "planned" to be developed and to the OER module "developed".

Figure 5 shows the results obtained by each approach, displayed by box-plots representing the sample data in three quartiles. The first quartile or lower quartile (Q1) corresponds to the value related to a quarter of data. The second quartile (Q2) corresponds to the value representing the median of the sample data, whilst the third quartile or upper quartile (Q3) corresponds to the value representing three quarters of the sample data. The box-plots also show the minimum and maximum values of the sample. As can be observed, the minimum and maximum values of box-plots range from 50 to 100%. In the sample of AM-OER, most of the percentage of results achieved is between 80 and 100%.

The metric to calculate effectiveness was: $\sum(xi / yi) * 100$, $i = 1..n$, where *xi* is the average percentage of requirements fulfilled by each approach whilst *y* is the requirement planned to be fulfilled.

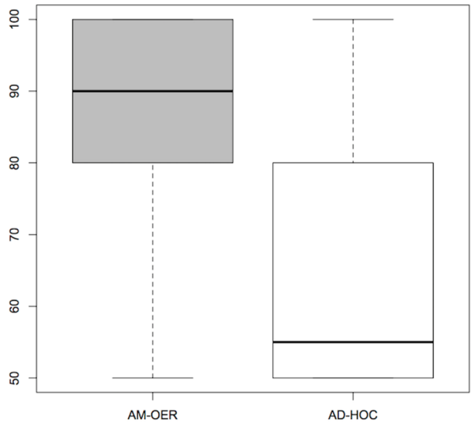

Fig. 5. Results obtained by each approach

According to the results its seems AM-OER presents better level of effectiveness, achieving 86,2% against 65% of AD-HOC approach.

In order to statistically infer that the effectiveness of AM-OER is greater than the effectiveness of AD-HOC approach there is a need to test the hypotheses established for it. Both samples associated to effectiveness are presented as percentage. In this case, test for proportion is indicated.

The hypotheses related to effectiveness are:

- *Null hypothesis* (hypothesis we want to reject): the effectiveness of AM-OER is similar to the effectiveness of AD-HOC approach, `H0: µAM-OER1 = µAD-HOC1.`
- *Alternative hypothesis:* the effectiveness of the AM-OER is higher than the effectiveness of AD-HOC, `H1: µAM-OER1 > µAD-HOC1`.

In the experiment we adopt the usual practice of admitting a low value or level of significance for both errors: $\alpha = 0,5$.

To test both samples for equality proportions we use the function `prop.test()` from R software, a free software environment supporting statistical computing and graphics. The obtained result was `p-value = 0.004`. There is a statistical significance when the p-value is lower than the level of significance used in the experiment. Therefore there is an evidence to reject null hypothesis `H0: µAM-OER1 = µAD-HOC1` and accept the alternative hypothesis `H1: µAM-OER1 > µAD-HOC1`.

C. Comparing Efficiency

Efficiency measures the effort required by each group of participants to develop the planned OER. It is related to the OER module developed by each group of participants and the time (in hours) spent to develop it. The metric to obtain the efficiency was: ∑(xi / yi), i = 1..n, where *xi* is the average percentage of requirements fulfilled by groups on each approach whilst *y* is the time (in hours) spent by them.

Table II shows the results of efficiency obtained for each approach. It is noteworthy that the higher value obtained, the greater the efficiency. It seems that AM-OER presents better level of efficiency, 0.86 against 0.73 of AD-HOC approach.

TABLE II. EFFICIENCY OF EACH APPROACH

Approach	Time (in Hours)	Requirements Fulfilled	Efficiency
AM-OER	4.5 / 4.5 (100%)	86.2%	0.86
AD-HOC	4 / 4.5 (89%)	65%	0.73

In order to statistically infer that the efficiency of AM-OER is greater than the efficiency of AD-HOC there is a need to test the hypotheses established for efficiency:

- *Null hypothesis* (hypothesis we want to reject): the efficiency of AM-OER is similar to the efficiency of AD-HOC approach, `H0: µAM-OER2 = µAD-HOC2`.
- *Alternative hypothesis*: the efficiency of AM-OER is higher than the efficiency of AD-HOC, `H1: µAM-OER2 > µAD-HOC2`.

The result was `p-value = 6.174e-11`. In this case, there is an evidence to reject null hypothesis `H0: µAM-OER2 = µAD-HOC2` and accept the alternative hypothesis `H1: µAM-OER2 > µAD-HOC2`.

D. Comparing Quality Results

The quality of the results is measured by a specialist according to the percentage of compliance to quality attributes / desirable characteristics of an OER derived from the definition and main characteristics of an OER.

In Fig. 6, box-plots were created to show the percentage obtained by each approach regarding the quality of the results. The box-plot of AM-OER shows the results are closer to 80% and 100%, ranging from 50% (minimum value) to 100%. On the other hand, the box-plot of AD-HOC shows a higher variation, ranging from 0% to 100%. Discrepant values within of set of values are considered outliers (0%).

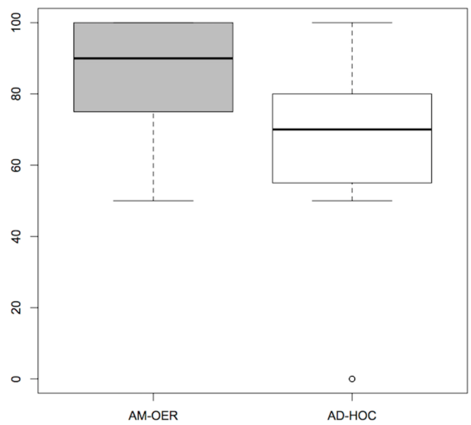

Fig. 6. Quality of the results of each approach

In order to statistically infer that the quality of the results of AM-OER is greater than the quality of the results of AD-HOC there is a need to test the following hypotheses:

- *Null hypothesis* (hypothesis we want to reject): the quality of the results of AM-OER is similar to the quality of the results of AD-HOC approach, `H0: µAM-OER3 = µAD-HOC3`.
- *Alternative hypothesis*: the quality of the results of AM-OER is higher than the quality of the results of AD-HOC approach, `H1: µAM-OER3 > µAD-HOC3`.

The result was `p-value = 3.419e-05`. In this case, there is an evidence to reject the null hypothesis `H0: µAM-OER3 = µAD-HOC3` and accept the alternative hypothesis `H1: µAM-OER3 > µAD-HOC3`.

E. Qualitative Analysis

To explore the applicability of the AM-OER in the development of OERs we also investigate a set of research questions covering three perspectives: appropriateness/ usefulness, ease of use and satisfaction. The answers for the research questions were provided according to the following scale: (a) 1 – Strongly disagree, (b) 2 – Partially disagree, (c) 3 – Indifferent, (d) 4 – Partially agree and (e) 5 – Strongly agree.

Figure 7 summarizes the results of all questions covering appropriateness / usefulness, ease of use and satisfaction by box-plots. According to the results, the majority of answers ranging between “4 - Partially agree” and “5 – Strongly agree”. The results show a tendency of the acceptance of the AM-OER in the development of OERs. However, other assessments must be conducted in order to provide more consistent results.

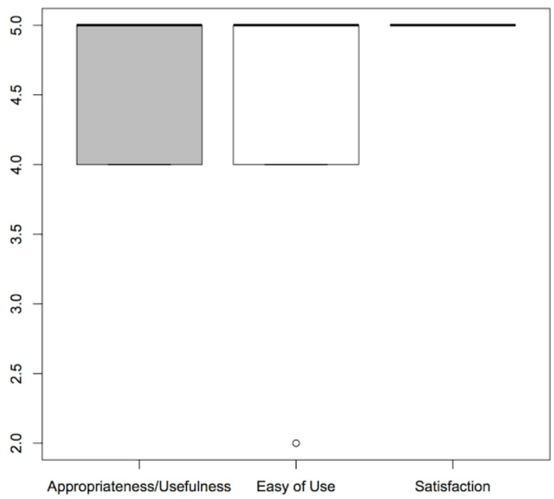

Fig. 7. Qualitative analysis

Participants also provided suggestions for changes and improvements to the AM-OER. The data collected during this analysis will be used later to refine the AM-OER.

This study shows that agile design practices together with LD practices are feasible to design and create OERs.

II. CONCLUSIONS AND FURTHER WORK

In this paper we proposed and applied an agile LD method to support the design and creation of OERs. Our main goal is to provide an explicit and flexible agile LD method that considers not only LD as a dynamic process but also allows for the design to evolve incrementally, and be modified, repurposed and enhanced as needed. We defined the agile LD method to facilitate the reuse and adaptation of OERs and to contribute to their quality by embedding pedagogical design practices. The method provides a more collaborative approach to the development of OERs, prioritizing the participation of users throughout the process to meet their real needs. This can reduce the development time and effort, promoting an effective production process for a sustainable supply of OERs.

The method has been initially evaluated through an experiment. Considering the quantitative analysis, the results obtained so far have shown that the method is effective and efficient to the development of OERs. In terms of its applicability, the preliminary results indicate that the method is useful and easy to use, especially for non-experts in the development of OERs.

Regarding the limitations of the experiment conducted, we highlight: the number of participants was small, what may affect the representativeness of the sample of population, and the time allocated to the experiment was not sufficient, but we were constrained by the unavailability of participants.

We intend to refine and evolve our proposal based on the results of the experiment and on the feedback from participants. For further validation, we plan to replicate the experiment on a larger number of subjects. Also, other experiments will be planned and developed within different knowledge domains. The OERs created by using our proposal should also be evaluated in terms of their effectiveness in student's learning.

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