System for creation, support and tracking of interactive learning activities

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Abstract. The paper presents a study in the field of m-learning with interactive learning content. The approach used is to integrate a system (plug-in), which converts learning activities into EPUB learning content, suitable for usage and tracking on any mobile device, with an existing e-learning environment, full with learning courses. Therefore, a plug-in for exporting learning content from the Learning Management System Moodle into an EPUB interactive book is developed. The plug-in can export the following Moodle resources and activities: labels, files, folders, URLs, pages, books, lessons and tests. The data about students’ learning activities is collected through xAPI statements, stored in a Learning Record Store. On the basis of the stored data, various types of reports are generated, which help teachers track students’ progress. The software is tested with real users and short statistics are derived from their opinions in six areas (practical applicability; design; accessibility; interactivity, support and feedback; communication and collaboration; understanding).

1. Introduction

Without any doubt students prefer using mobile devices. But most of the learning resources at universities are developed and placed mainly in e-learning environments. The Learning Management Systems (LMS) are complex, offer many functionalities and need permanent internet connection. On the other hand, e-books in EPUB format are suitable for all mobile devices and can also be used in offline mode.

One of the main challenges in education is to track the students’ learning progress and all of their performed actions, in order to analyze them later and take proper actions to correct learning gaps or failures, especially in performance-centered learning \cite{1}. Since the creation of e-learning standards, this effort has been carried out by several implementations, focused on structuring the learning content and providing mechanisms to track interactions in web-based learning environments \cite{2,3}.

This paper aims to present the results of a study, conducted at the University of Plovdiv “Paisii Hilendarski”, in the field of tracking interactive learning activities on mobile devices. Section 2 points some related works that influenced ours – on EPUB standard for e-books and xAPI specification for tracking learning experiences. The methodology of our study is given in Section 3. Section 4 presents an approach how to offer students easier and more comfortable way of learning, using their favorite mobile devices, on the basis of existing e-courses in the university’s e-learning environment. Section 5 briefly shows the impact of the developed software to the students’ learning process, explained with
results from the conducted survey with real students. The conclusion focuses on the obtained results and future objectives.

2. State of the art
E-books in EPUB format are easily usable on all mobile devices like smartphones, tablets and e-book readers, and that is why the standard continues to spread widely.

2.1. EPUB standard
The EPUB standard [4] is an open XML-based format for e-books, which allows copying the static content of printed books into digital ones. The latest version of the standard – EPUB3 introduces mechanisms for interactivity and multimedia integration through JavaScript and HTML5. All these new features of the standard can provide learners’ tracking (one of the main objectives in the improvement of learning technologies), like in web e-learning environments.

Some authors identify the main advantages of EPUB as:
- Content is easily shared and reused [5];
- Integration of multimedia and interactive components based on web technologies [5];
- No special metadata related to education [5];
- Mechanism for automatic adjustment and content reformat for devices with small screen sizes [5];
- Simplicity of downloading the learning content [6];
- Access to the educational course content without the necessity of permanent Internet access [5, 7];
- Openness of EPUB [8].

2.2. xAPI standard
The Experience API (xAPI) [9] is a specification for standardizing and collecting formal and informal educational data in the form of statements. XAPI is often described as the next generation of the well-known standard SCORM. The main difference between xAPI and SCORM is the type of learning that they can track. SCORM can store information only for online learning, while xAPI can track wider range of learner activities, both online and offline. Therefore, xAPI gives a more detailed information about the learner’s progress in any learning environment. For example, xAPI can track the following learning activities: starting/ reading/ completing a learning resource (webpage), starting/ answering/ completing a test, completing a test question, and etc.

The xAPI collects data about learning experiences, a student has done online or offline, in statements in the form of “Noun, verb, object” (e.g. “I did this”). User actions are saved as statements in a Learning Record Store (LRS) [10] – a repository for storing learning records. The LRS can exist on its own server or inside a Learning Management System, and it can share these statements with other LRSs. Every time the learning content is opened, it goes to the last done activity from the previous session (e. g. last read page) and student can continue from the point where he/she had left the course. This is not device dependent and the student can change devices during the studying without losing the progress made – switching from reading the same course in an e-book on a smartphone to reading it in the e-learning environment on a PC and then again on the e-book, it will always let the student continue from the point, left in the previously used device.

Each statement [11] describes a learning activity, the relevant user action, performed with it, and all of the interconnected objects in the given context. XAPI uses natural language to describe the statements, readable by both humans and machines. They are presented in JavaScript Object Notation JSON as hierarchically structured elements.

For improving the statements, [12] recommends five additional data elements to be incorporated in them: the achievement types, the duration of the learning experience, experience source information, domain learning and forgetting and assessment scores. All of these statements and their corresponding verbs, extensions and contexts are documented into an xAPI profile [13]. The profiles guarantee a
semantically interoperable development and successful storage of data, that can be used multiple times for different use cases.

The statements, logged in an LRS, can be previewed and analyzed later. That way students can be monitored, no matter the learning environment or the device they are using – a traditional e-learning system on PC or an e-book on any mobile device.

3. Approach for creating an EPUB e-book

The main goal of our research is the creation of interactive and traceable EPUB content from standard Moodle e-courses. The used approach is to develop a software plug-in, which will be integrated with Moodle, and will automatically export (Fig. 1) all learning resources and activities in EPUB format – in an e-book.

Students can download the e-book and use it online or offline. During the learning process they have to read the learning content and interact with the e-book (e.g. answer to some questions). All student’s actions are saved through xAPI statements [14] to an LRS (it does not matter where they occurred – in the LMS or in the e-book), using the same xAPI profile statement templates. This ensures equal tracking of the learner’s progress and interactions in both learning places.

Figure 1. The process of exporting courses to e-books and sending and gathering xAPI statements for reporting.

The data (xAPI statements) in the LRS can be retrieved at any time and processed for different purposes. With it several types of reports can be generated (available in the Moodle reports page) for the teachers to analyze students’ behavior and progress.

3.1. A plug-in for creating interactive e-books

The existing adds-in for e-learning platforms, which realize some conversion from/to EPUB format (Lucimoo, custom plugins for Moodle and SHeilds) are presented in [14].

We propose the following functionality in our plug-in: Export, Tracking Learning, Data Collection, Reports and Settings.

**Export.** An e-book for learning is created through the automated conversion of an e-course from the e-learning environment Moodle. The following Moodle elements can be exported: labels, files, folders, URLs, pages, books, lessons and quizzes. While most of them are static resources and do not require any other specific user action, besides reading them, the last two elements in the list demand students to perform a certain action (like answering a question).
**Tracking Learning.** Students’ actions in the e-book are tracked – completing a test, answering a question, starting to read the book, etc. The xAPI profile used in the e-book contains all learning elements, that are integrated in the e-book, as well as the activities that will be tracked and some additional information (like duration of the activity). The information about all trackable student’s activities is passed on by xAPI statements.

**Data Collection.** Standardized data (from xAPI statements) for student’s actions, taken from the e-books, is collected in the LRS.

**Reports.** Graphical presentations of the collected data from the LRS are prepared for a better analysis of the student’s learning progress and behavior by teachers. The system can automatically generate the following reports, divided in categories:

- course reports – show the ratio between the number of people who have started, completed and left a course unfinished or the users’ average time spent on a course;
- quiz reports – reports for every question of the quiz, displaying how many users have answered the same, the average time spent on a question and user groups, based on their quiz score;
- assessment reports – show crucial points in the assessment of the students like questions, that got the most wrong answers, or questions, that took the most time to be answered;
- leaderboard reports – give an overall look of users, who performed the best on tests (achieved top scores on a quiz), who have submitted an assessment in record time or who had the most logins or time, spent on a course section;
- learner’s path reports – display all of the trackable actions and their sequence for a specific user;
- engagement reports – combine stat measurements like course views, quiz submits and time spent on modules to present how much the users were involved in the learning activities;
- effectiveness reports – compare the results of two user evaluations – one, that’s done before the user takes the course and one afterwards, in order to show whether the course was indeed effective;
- time period reports – usually a time period gets selected (month, week, etc.) and a specific metric is evaluated (time spent on a course, users who finished a quiz, the number of activities, performed by the student, grouped by dates, etc.).

**Settings.** The LRS connection can be set up or changed to correspond to the desired LRS, that’s going to be used.

The plug-in is created as a Moodle block. This block can be added on every Moodle page. It shows all courses available for exporting and contains links to download them in EPUB format.

### 3.2. Exporting Moodle e-learning content

Our plug-in succeeds in the export of the following Moodle elements [14] into EPUB format: file (different formats), folder (with possibility for containing sub-folders), URL (any URL address with learning resources), label (a few words or an image), page (a single, scrollable screen that a teacher creates with the robust HTML editor), book (a multi-page resource with a book-like format), lesson (combination of HTML learning content pages and question pages with adaptive and dynamic navigation) and quiz (a test with different types of questions). The conversion of file, folder, URL, page, label and book builds the static part of the EPUB course.

The Moodle’s activities lesson and quiz include interactive parts with questions. Six types of questions are created in the lesson element [15]: Multichoice (or Multiple answers), Essay, Matching, Numerical, Short answer (incl. fill in the blank) and True/false. As for the quiz element, five question types are created. They include the same ones as in the lesson element (excluding the question type Essay), however they are handled differently.

The lesson is probably the most interesting Moodle activity, because it offers the most dynamic content paths (through navigation buttons with predefined activities in the lesson page). The lesson
also gives the opportunity for navigating students into different paths (adaptation), according to the correctness of their answers to the questions.

The process of question answering and navigation in the resource is realized with the use of JavaScript. The correct answers are hidden into the e-book files. Student’s answers are assessed (by comparison with the correct answers) and sent through respective xAPI statements.

Some of the lesson parts are shown conditionally. The locked parts being open only if a certain prerequisite is met (e.g. answering right to a question bring you to one page, while answering wrong would bring you to another one).

The student’s progress is also stored through xAPI – using the endpoint of the State API, available in the same LRS. A statement gets sent every time the student progresses forward in the e-book and it becomes available for retrieval. This ensures that the next time when the student opens the e-book and a connection to the State API is made, the book will open on the last place where the user has left, not from the start (even if the e-book is opened from a different device).

4. Experiment
The developed plugin „EPUB+XAPI export“ was tested by 42 full-time students at the University of Plovdiv “Paisii Hilendarski” during the “Object-oriented design and programming (C++)” course. Students used the plugin to export the learning materials included in the topic "Inheritance" in an interactive file in EPUB format. After testing the plugin, students had the opportunity to evaluate the developed plugin and its applicability in formal training by taking part in a survey. The questionnaire was prepared in such a way, that without being time-consuming to complete, to give a clear picture of students' attitude towards the use of EPUB books in education. It contains 19 questions divided into six sections (see Table 1):

- **Section I.** Practical applicability (I.1-I.4) – assessing the applicability of EPUB interactive materials in formal training;
- **Section II.** Design (II.1-II.3) – assessing if the learning material in the EPUB files is intuitive and easy to use;
- **Section III.** Accessibility (III.1-III.4) – assessing the ability to access and use materials in EPUB format on various mobile devices;

![Figure 2. A preview of a test question in the e-book.](image-url)
**Section IV.** Interactivity, support and feedback (IV.1-IV.3) – assessing how the interactivity in the EPUB file compares to that in an LMS and how fast is the feedback from the interactive actions;

**Table 1.** Survey questions with summary of students’ answers.

| Statement                                                                 | 5=SA | 4=A | 3=N | 2=D | 1=SD |
|---------------------------------------------------------------------------|------|-----|-----|-----|------|
| I.1. The use of EPUB learning resources is easier than the use of learning resources in an LMS (e.g. Moodle). | 10   | 12  | 18  | 0   | 2    |
| (23.8%)                                                                   | (28.6%) | (42.8%) | (0%) | (4.8%) |
| I.2. The use of EPUB learning resources is more enjoyable than the use of learning resources in an LMS (e.g. Moodle). | 10   | 14  | 16  | 0   | 2    |
| (23.8%)                                                                   | (33.3%) | (38.1%) | (0%) | (4.8%) |
| I.3. EPUB resources are suitable for higher education training.            | 14   | 22  | 4   | 0   | 2    |
| (33.3%)                                                                   | (52.4%) | (9.5%) | (0%) | (4.8%) |
| I.4. I am inclined to study by using learning resources in EPUB format.    | 12   | 18  | 10  | 2   | 0    |
| (28.6%)                                                                   | (42.8%) | (23.8%) | (4.8%) | (0%) |
| II.1. The design of learning resources in an EPUB book is good.            | 8    | 22  | 8   | 2   | 2    |
| (19.0%)                                                                   | (52.4%) | (19.0%) | (4.8%) | (4.8%) |
| II.2. The design of learning resources in EPUB format is intuitive enough. | 14   | 12  | 12  | 2   | 2    |
| (33.3%)                                                                   | (28.6%) | (28.6%) | (4.8%) | (4.8%) |
| II.3. I have problems navigating between the pages in some EPUB learning resources. | 2    | 6   | 16  | 10  | 8    |
| (4.8%)                                                                   | (14.3%) | (38.1%) | (23.8%) | (19.0%) |
| III.1. Downloading learning resources in EPUB format is easy.              | 16   | 20  | 6   | 0   | 0    |
| (38.1%)                                                                   | (47.6%) | (14.3%) | (0%) | (0%) |
| III.2. The use of EPUB learning resources is more accessible than the use of learning resources in an LMS (e.g. Moodle). | 10   | 10  | 20  | 0   | 2    |
| (23.8%)                                                                   | (23.8%) | (47.6%) | (0%) | (4.8%) |
| III.3. I had trouble opening some EPUB resources.                         | 2    | 2   | 14  | 14  | 10   |
| (4.8%)                                                                   | (4.8%) | (33.3%) | (33.3%) | (23.8%) |
| III.4. I open learning materials in EPUB format faster than it takes me to access the Moodle course. | 6    | 12  | 20  | 0   | 4    |
| (14.3%)                                                                   | (28.6%) | (47.6%) | (0%) | (9.5%) |
| IV.1. EPUB learning resources are as interactive as the learning resources in an e-learning course (e.g. in LMS Moodle). | 16   | 10  | 8   | 4   | 4    |
| (38.1%)                                                                   | (23.8%) | (19.1%) | (9.5%) | (9.5%) |
| IV.2. I receive fast feedback from the learning resources in EPUB format.  | 12   | 16  | 12  | 0   | 2    |
| (28.6%)                                                                   | (38.1%) | (28.6%) | (0%) | (4.8%) |
| IV.3. The teacher provides the necessary support for using learning resources in EPUB format. | 14   | 18  | 10  | 0   | 0    |
| (33.3%)                                                                   | (42.9%) | (23.8%) | (0%) | (0%) |
| V.1. EPUB encourages communication and collaboration with other students.  | 12   | 10  | 18  | 0   | 2    |
| (28.6%)                                                                   | (23.8%) | (42.9%) | (0%) | (4.8%) |
| V.2. I find it easy to provide/share EPUB learning resource to other students. | 10   | 14  | 16  | 0   | 2    |
| (23.8%)                                                                   | (33.3%) | (38.1%) | (0%) | (4.8%) |
| VI.1. EPUB learning materials are presented in an understandable way and I know what is expected of me. | 16   | 12  | 14  | 0   | 0    |
| (38.1%)                                                                   | (28.6%) | (33.3%) | (0%) | (0%) |
| VI.2. Learning with EPUB e-books meets my educational needs.               | 10   | 10  | 20  | 2   | 0    |
| (23.8%)                                                                   | (23.8%) | (47.6%) | (4.8%) | (0%) |
| VI.3. This learning process develops my skills.                           | 14   | 12  | 14  | 2   | 0    |
| (33.3%)                                                                   | (28.6%) | (33.3%) | (4.8%) | (0%) |
Section V. Communication and collaboration (V.1-V.2) – assessing whether students are getting the support they need and if they are willing to help others

Section VI. Understanding (VI.1-VI.5) – assessing how close the training with EPUB files is to the traditional training and whether the tasks in the interactive EPUB files are understandable.

Most of the questions are multiple choice ones. Students should indicate to what extent they agree with the statements in the 5-point Likert-type scale, where 1 means Strongly Disagree (SD), 2 is Disagree (D), 3 is Neutral (N), 4 is Agree (A) and 5 is Strongly Agree (SA). There are two open-ended questions at the end of the questionnaire which allow students to make recommendations for enhancing and extending the functionalities of the plugin.

Table 1 presents summarized results of the survey. For each statement in the table, the number of responses and their percentage are presented (see Column 2 - Column 6).

The results clearly show that students have positive opinion about the developed plugin. Most students were impressed that using EPUB learning resources is easier and more enjoyable than using LMS resources (only 4.8% of students answered SD to statements I.1 and I.2). According to most students, EPUB learning resources are suitable for higher education (85.7% answered SA or A to statement I.3). They are also inclined to study by using resources in EPUB format (71.5% answered SA or A to statement I.4). Most students think that the design of the EPUB book is good (71.4% answered SA or A to statement II.1). The percentage of students who think that the design is intuitive is also high (61.9% answered SA or A to statement II.2). However, many students stated that they have troubles when navigating and switching between modules in learning resources (52.8% answered SA or A and 38.1% answered N to statement II.3). All students stated that downloading learning resources is easy (0% answered SD or D to statement III.1). A small part of the surveyed students does not agree that the use of EPUB learning resources is more accessible than the use of learning resources in an LMS (only 4.8% answered SD to statement III.2). The percentage of students who stated that the opening of study materials in EPUB format is faster than doing so in an LMS is relatively high (only 9.5 responded to SD in statement III.4), although most students had problems opening some EPUB resources (only 9.6% had opened all resources without problems). Most students shared that learning resources in EPUB format are as interactive as their equivalent in the LMS (61.9% answered A or SA to statement IV.1). Students are satisfied with the speed of the feedback in EPUB learning resources and the teacher’s support (only 4.8% answered SD to statement IV.2). Only 2 students do not think that EPUB encourages communication and collaboration with other students and allows them to share learning resources easily. Most students think that EPUB learning materials are presented in an understandable way and they have a clear idea of what is expected from them (66.7% answered SA or A to statement VI.1). When students are asked to agree that training through EPUB meets their educational needs, almost half of them (47.6%) answered SA or A and N (47.6%). Only 4.8% of students do not agree that the learning process develops their skills and 33.3% of them cannot judge whether this is true (see answers to statement VI.3).

Figure 3 shows the students average score on all sections of the survey. The analysis of the answers and the calculated average score (3.69) shows that students have a positive attitude towards EPUB.
The answers of the open-ended questions indicate that improvements in the learning materials design and navigation are needed. Students also suggest the development of additional functionality, allowing them to write and test programming code.

5. Conclusion
The paper presented a study on the use of interactive e-books in e-learning, where the authors have designed and created a system for creation, support and tracking of interactive learning activities in e-learning. The used approach is to integrate a system (plug-in) in a e-learning environment, that converts learning activities into interactive EPUB learning content, suitable for usage and tracking on any mobile device. By achieving the objective of the study, the following four results were obtained:

- Researched the EPUB learning content opportunities;
- Creation of an approach to develop, support and track interactive learning activities in an independent mobile environment;
- Software realization of a plug-in for converting learning activities from an e-learning environment into a traceable interactive EPUB learning content;
- Conducted experiment – supported and tracked interactive learning activities in an EPUB course with real users.

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