WEB EDEN AND MOODLE: AN EMPIRICAL MODELLING APPROACH TO WEB-BASED EDUCATION

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ABSTRACT
The paper introduces a web-based interactive environment for creating and exploring software artefacts. The authors describe a case study where the environment has been combined with Moodle and used for the implementation of an online introductory database course currently being taught as part of computer science degree programme. The aim is to show how the environment can offer web-based education that goes beyond providing digital learning materials, by supporting the learner at different kinds of learning activity, from guiding along a well-defined path, to exploring particular paths of interest, and eventually, to creating a new path for themselves.

KEY WORDS
Web-based education, innovative learning environments, virtual universities

1. Introduction

Despite the popularity of web-based education, many applications have failed to deliver the expected results. Online courses often suffer from high drop-out rates (e.g. less than 20% of the students for the online Virtual Studies in Computer Science (ViSCoS) programme graduated during the period 2000-2005). Research by Sutinen and Suhonen, based on findings from the ViSCoS, concluded: "Digital learning materials are not in themselves either adequate or sufficient for addressing the whole range of student needs and problems" [1].

While the reasons behind problems of online retention are likely to be complex, and course designers, content creators, tutors and students may all bear some responsibility, certain scholars have highlighted obvious limitations of web-based education. As Salomon discusses in relation to university level education [2], there are certain functions that 'electronically mediated learning' can accomplish quite well, but 'there are other functions that are quite alien to electronically mediated learning' such as 'the cultivation of skills, the construction of meaningful knowledge and of meta-knowledge'. Web-based education only goes so far and web-based educators should understand what educationalists have been saying for years: 'learning is not a simple matter of absorbing, internalizing, or acquiring bodies of ready-made knowledge; learning requires *face to face mediation* between the material and the learner' [2].

So, one problem with web-based education, as succinctly described by Moallem in reference to Salomon, is that '[in the brief history of WBE,] the overriding educational principle has been access to information, and not the knowledge that guides it and results from it' [3]. The reasons for this might be that web technologies have until recently made two way propagation of state change problematic – it has been technically moderately difficult to set up web applications that update at the learner interface except when an update is solicited by the learner, and this does not stimulate the learner to take an active role. One solution to the problem of passivity, as suggested by Jonassen [4], is to inject more construction or model-building into technology-enhanced learning. The model-building tools described in this paper exploit the active two-way nature of the communication in the new generation of rich internet applications. Therefore, they encourage an approach to technology-enhanced learning that focuses more on the experience of the learner – experience that precedes the development of meaningful knowledge.

The contribution of this paper is to demonstrate how Empirical Modelling [5], as an approach to learning, can be applied in web-based education. This is achieved by taking a recently developed web-based Empirical Modelling tool, called 'Web Eden', and integrating it with the Moodle virtual learning environment [6,7]. The first deployment of this approach is an online degree-level introductory database course for the ViSCoS programme [1]. The aim of this paper is to introduce the approach, the implemented technology and a short case study in how the approach and the technology can be used in an online course.

2. Previous work

Empirical Modelling (EM) is an area of computer science research that has been developed by Beynon & Russ at

the University of Warwick [5]. The principles and tools for EM enable the construction and manipulation of software artefacts with a unique emphasis on the role of experience. Artefact construction is seen as intimately connected with sense-making, and models have a high degree of openness encouraging exploration and embellishment.

While the wider benefits of EM as an approach to computing have been discussed by members of the EM group (see [5]), research by Beynon [8], Roe [9] & Harfield [10] has particularly focussed on EM's contribution to educational technology.

2.1 Basic features of Empirical Modelling

There are a number of key features of EM that make it highly suited for application to educational technology, and which clearly distinguish it from other approaches to software development and use. Firstly, in an EM environment, the artefact or model being viewed, explored or created is 'alive' (live in terms of being running) and all parts of the artefact are constantly open to observation and change. Secondly, the artefact or model is composed of a set of definitions which express dependency (a definition specifies an object, value or thing as deriving from the properties/values of other objects, values or things). These two features taken together form the underlying concepts of a spreadsheet environment [10]: a spreadsheet is always 'live', open to observation and modification (there is no concept of 'compiling and running'), and it is composed of values and definitions (in cells) that rely upon dependencies (between cells). In this respect, a spreadsheet is very unlike a program because it is not constrained to one use and it does not have to be completely written before it can be run. The merits of spreadsheets as educational artefacts are widely accepted [11].

Figure 1. An example of an EM artefact for learning Thai language

EM shares the qualities of a spreadsheet environment, but it generalises the basic principles so that a model-builder (or a learner in the case of educational technology) can go beyond the limitations of a grid of cells. EM has been developed as a complete approach to developing software artefacts (the word 'artefact' or 'model' is used rather than 'program' to distinguish EM from traditional software development and use). Previous research has demonstrated how a learner might interact with an EM artefact as a support for learning Thai language for example [10]. In the study, the author shows how an EM artefact (shown in Figure 1) could be used to reinforce basic vocabulary and grammar for buying items at a market (exercising an artefact), to explore the possibility of connecting a clock artefact for transferring a knowledge of Thai numbers to telling the time (exploring an artefact), and to create an extension to the artefact to take account of new vocabulary (building an artefact). These activities (observing, exploring and building) go beyond what can be achieved from exercising many existing educational applications, which rarely encourage active engagement on the part of the learner (an exception might be an environment such as Kahn's Toontalk [12]).

An artefact, such as the Thai language learning model in Figure 1, can involve words, pictures, user interface elements, animation, 3D graphics, sound and even, as has been demonstrated recently [13], external robotics. However, previous EM research has mainly involved a tool called 'Eden' which is a desktop program that runs on Windows, Mac OS, and Linux (available online [5]). This has meant that using Eden has mostly been feasible only in a local (seminar or classroom) setting.

3. Design and implementation

When using the existing EM tools as desktop programs, the learning artefacts (in the form of scripts) also need to be downloaded (e.g. from the EM project archive [5]) and loaded inside the tool. This presents a barrier for many learners even before they access the authentic learning activity.

Over the last year, a new EM tool has been developed by Myers [14]. The tool, called Web Eden, is an online version of the Eden desktop tool and runs inside a web browser. It's only requirements are a web browser and Adobe Flash Player. Not only does this make EM more accessible, but it makes integration with other materials possible – for example, links from web pages to specific EM artefacts and activities. The first use of Web Eden in a learning context was for an online course for talented and gifted youth in July 2008. This made use of Web Eden through web links that loaded a sudoku model in a particular state for further exploration.
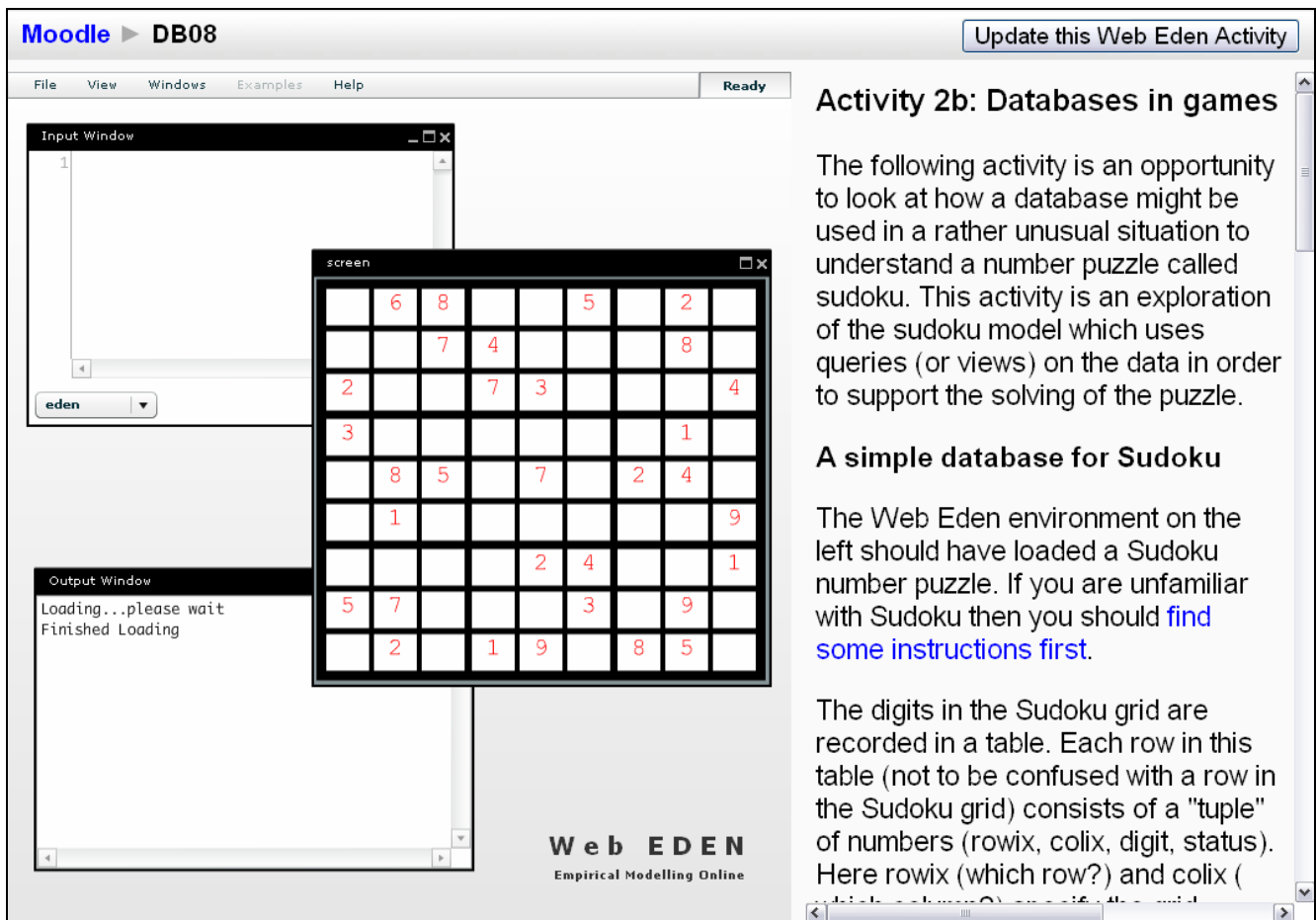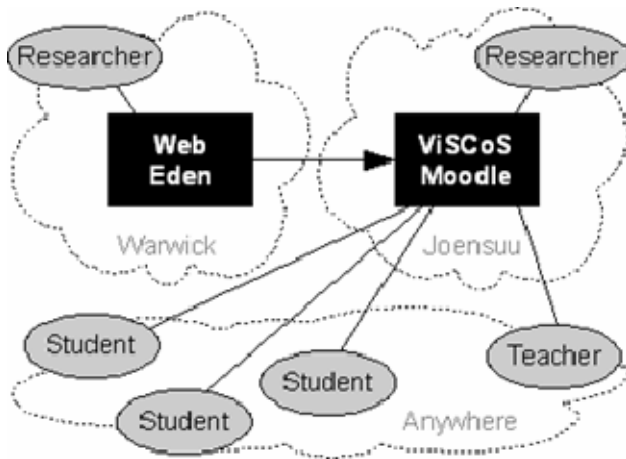
Figure 2. Web Eden embedded in Moodle

Figure 3. Organisation of the ViSCoS database course

Figure 4. Basic queries in a relational language

The topic of this paper is how the Web Eden environment has been combined with Moodle [7]. As Web Eden is a Flash application, it can easily be placed inside other web pages. This led to the idea that it could be placed inside a Moodle page. This has the advantage that you can use Web Eden in any Moodle course, thus benefiting from the learning style of Web Eden, and the course organisation and communication features of Moodle.
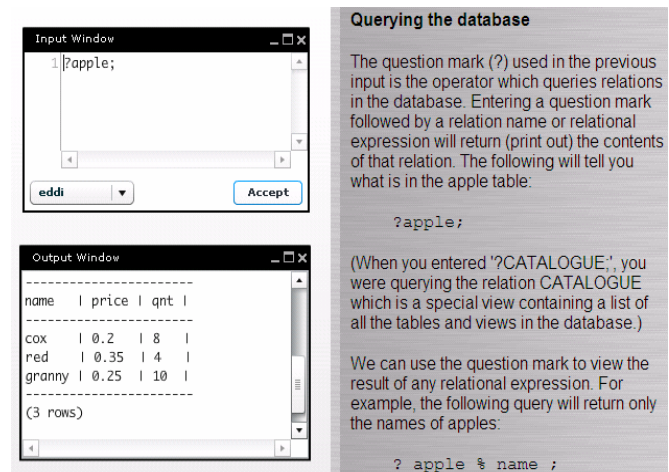
A plug-in module was developed for Moodle that adds a new type of activity, called a 'Web Eden Activity' (see Figure 2 as an example). For this activity, the learner will be shown the Web Eden environment (on the left hand side of the screen) and some accompanying tasks/guidance/notes (on the right). See the screenshot in Figure 2, where the student is first guided through some basic interactions with the model, and then given some tasks or challenges to complete.

4. Case study

The motivation for combining Web Eden and Moodle originally came from the principal author's desire to research new teaching methods for a course prepared for the Virtual Studies in Computer Science (ViSCoS) programme at the University of Joensuu. ViSCoS started as a one-year online computer science course for Finnish students who could study from anywhere in Finland [1]. It has developed into an international course, taught in English, with many students participating from parts of Africa and other countries worldwide. As of September 2008, ViSCoS became a full degree level course – hence the need to develop new second and third year courses. The introductory database course (called 'Introduction to Databases') examined in this case study is one of the second year courses being given in the first semester of the current academic year.

The ViSCoS programme adopts the FOrmative DEvelopment Method (FODEM) introduced by Suhonen [15] to develop virtual learning environments suitable for sparse learning communities. The community for 'Introduction to Databases' consists of the course participants, potentially taking part from anywhere in the world, and the course tutor, currently residing in the UK. The course Moodle is managed by researchers and support staff at the University of Joensuu in Finland. The Web Eden environment is managed and developed by researchers based at University of Warwick in the UK. Figure 3 demonstrates the sparse nature of the community involved with the course.

The database course developed contains a few standard Moodle activities (e.g. an assignment on entity-relationship modelling which required the students to submit a file containing their work), but we shall not be concerned with these in this paper. Instead, we will examine the Web Eden activities that might offer new forms of interaction. In particular, the case study explores three types of *learning* activity (to be discussed in the following sections) that demonstrate Web Eden's capability for providing a diverse learning environment that complements Moodle's course management tools.

To clarify the three types of learning activity, they can be compared to possible stages in learning about a play. In the first instance, a student might be engaged in reading a play or watching it on stage – an activity that involves *following a well-defined path* through a topic or artefact (in this case a play). The second stage might be the student attempting to understand the state of mind of a particular character in the play – an activity that would involve the learner *experimenting with possible interpretations* (which are perhaps less obvious to someone who is only watching the play). In a third stage, the student could undertake to write and perform a short play – an activity that engages the student in *creating or building a path* through a topic or artefact. In the following sections, these three activities are demonstrated through the use of Web Eden in the database course.

4.1 Exercising an artefact

The first type of activity to be examined, and one that is likely to come early in a course, is the introduction of a topic by *following a well-defined path*.

A traditional database course might introduce SQL by explaining its syntax and giving the student some examples of how to use it. In lecture notes and books, this is often achieved by showing snippets from SQL manuals, or example SQL queries with corresponding output. In a demonstration environment, the teacher might show how queries can be performed on a live database. In an online course, the teacher can offer text/graphics/videos to introduce the student to a topic, but it would usually be up to the student to find a suitable environment in which to guide themselves through (e.g.) trying out SQL statements.

Through the use of a Web Eden Activity, the tutor or course designer can offer students the live environment in which demonstrations can be performed, together with support material including walk-through guides and reference manuals. An activity is shown in Figure 4 where a student is presented with information on basic relational queries (in a language called EDDI [16] closely based on relational algebra [17]) and example queries can be executed on the prepared learning artefact inside Web Eden. In this type of activity, the student is likely to be undertaking what might be regarded as simple repetitive tasks. That is not to suggest that learning is always of this type, but it is right to assume that observing, following and repeating has an important role in many learning situations. It has already been pointed out that educational technology is particularly suited to the transfer, communication and repetition of information for learning purposes. Web Eden offers little extra in this area (and may not have the visual appeal of educational artefacts in some of today's online courses), but its strength is in its capability to enable the learner to move from a repetitive 'surface-level' learning to more engaging activities.

To appreciate this, it is helpful to consider the merits of writing a special purpose Moodle plug-in for a particular topic in a course, instead of using Web Eden. The course designer could develop a SQL plug-in to allow students to execute SQL statements against an example database, for instance. However, creating a new Moodle plug-in for every course or topic would be time consuming, and, as we shall discuss in the next section, Web Eden offers a lot more flexibility in terms of reusing artefacts for different purposes, as well as potential for the student to extend an artefact themselves.

4.2 Exploring an artefact

To understand what type of activity might enable a student to go beyond an understanding obtained from observing or exercising an artefact, let us consider using Web Eden to modify, and to experiment with, an existing artefact.

In this second type of activity, the student is not led specifically through a topic, but begins to explore a topic for themselves. For example, in the database course, once students were familiar with some basic queries, they were given activities that required experimentation to find out how they could combine relational operations in order to return a particular result. This early exploration (still within the bounds of the topic/artefact) involved the student interpreting the results they got for queries entered, and hence developing an understanding of the meaning of a particular query.

For example, in the 'SQL Basics' activity, the students were given queries for selecting particular rows from a table of news articles (using the relational restriction operator) and for joining an author table to the news articles table (using the relational join operator). The students were able to execute these queries and observe the results. In the following activity, the same artefact was utilised (including the same 'article' and 'author' tables) with an additional table called 'rating' containing article ratings given by users of a hypothetical news website. One of the tasks given to the students was to "write a query that lists the titles of all articles with a rating of 5". One possible answer is to join the 'article' and 'rating' table and select the rows where the rating is equal to five. This was not necessarily meant as a test to determine if the student could remember how to use the join operator or the restriction operator, but instead as a challenge to the student to work out how to use the two operators together, and therefore explore topics on the boundary of their understanding. The example here is a particularly simple one, but the principle is the same in other activities where the tasks required a much deeper level of understanding.

As part of the database course, the students undertook an activity which called into question the conceptual integrity of SQL itself. Figure 5 shows how Web Eden was used in the activity. The first window is used for inputting database commands (in SQL by default) and the second window shows the output when a command is executed (by pressing the 'Accept' button). This part of the artefact is the same for most of the activities in the database course. The third window is an interface enabling the student to change the way the database engine evaluates queries. By letting students change the internal behaviour of the database engine (on-the-fly and seamlessly while executing queries), they were able to explore the shortcomings of SQL in its implementation of the relational model. In Figure 5, the "use natural join" modification is enabled, and therefore, as can be seen from the output window, joining two tables has become syntactically simpler. (Using EM to explore the inconsistencies and shortcomings of SQL is discussed in previous work [17].)

Figure 5. Executing SQL in Web Eden

4.3 Building an artefact

In the third type of activity the exploration idea is taken further to the point where a learner is not only modifying an existing artefact, but is able to build extensions to an artefact or to construct an artefact from scratch. This is probably the level of understanding a learner may aspire to achieve – as Jonassen states, "if we cannot construct a model then we do not understand it" [4]. It also represents the type of activity that Papert advocates, in his account of 'constructionism', as crucial for learning [18].

Construction is often the highlight of classroom activities – whether painting a picture or performing a play. Whereas it is easy to see how course material, assignments and tests can be achieved in a web-based environment, it is much more difficult to imagine what construction activities might be made available to a web-based learner. One example, taken from another ViSCoS course [1], is allowing a group of students to construct their own wiki on a particular topic. While this might be appropriate for a few topics, it is limited in that the artefact (the wiki) is a rather static object when compared to the EM artefacts used in the database course. When you observe a wiki, its state remains constant until someone else comes along to modify it. A database artefact inside Web Eden, in contrast, is a live model that

a learner can interact with in a wide variety of ways that need not be preconceived. This case study has demonstrated a few of these interactions: performing queries, creating tables, and modifying the underlying database engine.

A Web Eden Activity in a Moodle course can begin with an existing artefact in a preconfigured state, or it can start in an empty state (i.e. the artefact contains no definitions). As part of the 'mini project' activity in the database course, Web Eden is loaded in a relatively empty state with just the database engine initialised. From there, the task set for the student is to construct a database that adheres to a set of requirements, to write queries to get particular information from the database, and to test it using sample data. This activity satisfied the needs of an introductory database course, but there is much greater scope for construction activities in Web Eden that explore more advanced topics (e.g. constructing an artefact for understanding a lossless join algorithm from relational theory – as described in previous work [19]).

5. Analysis

While each section of the case study demonstrates a different type of activity that can be provided by Web Eden (when accompanied by Moodle), one of the most compelling reasons for adopting this approach (and technology) is that all of these types of learning activity can occur in a single Web Eden activity. In one session, a student might begin by executing predefined definitions inside an artefact, then start to experiment with the artefact by modifying definitions in ways thought up by themselves, and later might build upon the artefact by adding new definitions.

Web Eden and Moodle have complementary roles in this process. Moodle offers the structure around the activity and the material to support the potentially open-ended learning activity: recognising the need for descriptive and informal communication to explain the character of the interaction required in the exploratory learning activity. Web Eden, through the support for EM, offers support for precise and subtle crafting of state allied to a casual mode of working in which an environment can be incrementally developed by part-time labour (through the creation and modification of definitions) without the same demand for intense concentration on a large comprehension task that conventional software development activity demands.

The case study highlights a number of reasons why using Web Eden and Moodle together in an online course might be appropriate. Firstly, Web Eden enables a course designer to conceive of constructionist activities which allow a student to observe, experiment and build. Such activities are more accessible than before now that Web Eden exists as a web-based EM tool (the previous approach of downloading tools and artefacts was time-consuming and distracting for the learner). Combining Web Eden and Moodle has provided a framework for organising the course, with many communication features built-in (e.g. forums, chat, etc) and Moodle allows learning to be blended with more traditional online activities (e.g. submission-based assignments). There is also potential for Web Eden to be blended as part of a classroom activity, especially given that many schools have access to their own Moodle and would be able to run their own versions of a module.

There are also some reasons why using Web Eden and Moodle might *not* be appropriate. Even with the most thoughtfully designed course, it is still possible for students to get lost and confused when using the tools. In a classroom situation it is easier to see when students are having problems, but in online use of Web Eden without any face-to-face guidance, it is virtually impossible to detect when a student is having a problem. Currently it is not possible to 'watch over' the students to see them making errors and be able to offer them real-time help. Future developments may include closer integration between Web Eden and Moodle so that students can raise issues whilst engaging in the activities. Another limitation is that there is currently no support for collaborative group activities. However, Web Eden does support collaborative model-building, as has been prototyped in the form of a collaborative sudoku game for the talented and gifted youth online course.

6. Conclusion

As discussed in previous work [20], through Empirical Modelling it is possible to realise a truly open-ended constructionist environment. With the development of Web Eden, such an environment is more accessible to learners through the Internet. Furthermore, when used in conjunction with Moodle, Web Eden has all the support tools provided by a virtual learning environment and it can be effectively embedded directly into online courses.

There still remain, of course, many questions over whether an online course can ever replace a face-to-face course. If technology is to support Salomon's view of education as requiring a live community of learners and scholars, and involving mentoring and tutelage, then there may still be a long way to go. This paper demonstrates some progress towards making web-based education less passive. A tool such as Web Eden enables more exploration and experimentation, and provides a supporting environment for such activities that can realise some of the qualities of face-to-face mediation between the material and the learner in a limited way.

There is much potential for using Web Eden (together with Moodle or other virtual learning environments) in online computer science courses, but also in a wider range of online learning and blended learning activities. Previous work has demonstrated the potential for EM to be applied in mathematics education [21], in the humanities [22], and in other science disciplines [10].

This paper has introduced the Web Eden tool and given a brief case study detailing how it has been deployed and applied in an online course. In particular, it has focussed on new forms of interaction, involving exploration and construction, which can be enabled in web-based education. The 'introduction to databases' course ended as this paper was due for submission. Future work will build on the case study with student feedback and empirical results.

Acknowledgements

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