Designing E-Learning Services

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***Abstract*— Recently, increasing numbers of e-learning tools have been developed. However, the benefits of these tools cannot be fully used as they typically operate separately and do not communicate with each other. It is necessary to develop a solution to redeploy existing tools, and create new tools, in a more effective way. Our approach is to link and manage these e-learning tools together via a service-oriented architecture, in which the tools are grouped together and presented as a set of educational services, and which are implemented using service technologies. In this paper, we propose a set of e-learning services together with the approach we have adopted to develop them.**

***Index Terms* — Educational Services, E-learning, Service Oriented Architecture, Web Services.**

I. INTRODUCTION

E-learning has become increasingly popular, and the number of applications to support e-learning is growing [1]. However, these applications seldom interoperate effectively, and this restricts the benefits they offer. Support for interoperability using services offers a potential solution for this [2]. Our research focuses on exploring how service technologies can be best applied in the education domain. The application of service technologies to education presents a number of open research challenges.

How can we identify a set of services from complex learning and teaching activity?

Since there is no commonly agreed definition for a *service* (rather than Web service) in service oriented computing [3], and since many practitioners lack practical experience in service applications, the identification of services from complex learning and teaching processes is difficult [4], and few people are currently working in this area [5]. Our proposed approach is to identify services based on concrete processes and their data flows within complex learning and teaching activities.

How can we ensure these e-learning services can meet different users' requirements?

A number of educational services have been proposed [6, 7], however there have been few published papers which discuss the motivations for using these services, and how such services can meet both learners' and teachers' requirements. We have conducted a case study to identify fundamental tasks required to deliver learning and teaching activities, and have identified a number of practical challenges that both learners and educators are facing.

In this paper, we explore a possible solution to these two challenges. We first present our approach for abstracting e-learning services from learning and teaching activities, and using a case-study we derive a set of processes and data flows which describe those activities. We then propose a set of e-learning services developed from our processes and data flows.

II. DEVLOPING E-LEARNING SERVICES

Although the structures of universities are well understood, and there is a substantial body of literature on the individual processes which underpin such institutions, there are few useful studies which examine how those processes relate to each other and what data are transferred between them.

We adopt a three phase approach to identifying e-learning services. The first phase is to identify distinct learning and teaching processes from a case study, using staff interviews and literature reviews to collect data. The second stage is to identify data flows within and between these processes using a qualitative data flow analysis. The final phase is to abstract e-learning services based on those processes and data flows. Three research questions guide us.

- What are the main distinct processes which support a university's learning and teaching activities?
- What types of data are involved in terms of delivering these activities?
- What kinds of e-learning services would be required to deliver these activities?

In this section, we present the methods used at each stage, together with our proposed process and data flow diagram.

A. Learning and Teaching Processes

This research aims to gain a deeper understating of how learning and teaching are delivered in a university. We use the Department of Computer Science in the University of Warwick as a case study in order to obtain real data representing what is currently happening in a typical educational institution. The choice of a computing department is appropriate since its internal processes are likely to make good use of an IT infrastructure. The evidence we have collected comes from two sources. One is staff interviews and the other is a literature review. Staff interviews provide data to support a case study from a single university, which is used to generate our process model, and the literature review is conducted to strengthen our model by ensuring it is grounded in established administrative and educational practice.

The purpose of our research is to generate a possible set of e-learning services, and therefore a realistic case-

study at a single institution will provide sufficient data for our purposes. It is, of course, to be understood that processes will vary between institutions and between individual departments, in particular between social science and nature science subject areas, and an exploration of those differences is beyond the scope of this paper.

Staff Interviews

We interviewed a variety of academic staff involved in all aspects of the delivery of undergraduate and MSc courses in the Department of Computer Science. The interviews were semi-structured, and due to the nature of the information we were seeking, we adopted a hybrid analysis procedure informed by approaches for identifying and combining patterns rather than making judgments about hypotheses [8, 9, 10, 11]. This procedure consists of six stages.

Stage 1: Generating *general themes*. By reviewing the interview transcriptions, we identified the main themes that were common to most of the interviews. The themes are represented as key phases that describe aspects of a university's learning and teaching processes, and are:

- Procedures for designing modules
- Procedures for delivering modules
- Student assessment
- Student support
- Module evaluation
- Feedback
- Marking
- Teaching resources

Stage 2: *Classifying* the interview data according to these themes. We went back to the interview transcriptions again, and examined the data that were relevant to each key phrase we identified above. For example, for 'module evaluation', all of the interviewees discussed this activity, but each addressed different aspects of it, including reviewing learning performance, collecting feedback, updating modules, and so on.

Stage 3: *Interpreting* the quotations to identify patterns. At this stage, we analyzed the interview data to identify the main learning and teaching processes and data involved. We examined the meanings of each quotation, to determine if one or more common learning and teaching related tasks are involved in each theme. We also identified the data required *before* each task, and data generated *after* each task. For example, for 'student assessment', we identified the tasks of 'delivering exams', 'delivering tests', and 'delivering assignments'; to perform these tasks, assessment materials are required, at the end of these tasks, student's pieces of work are generated. After we developed a full list of learning and teaching tasks from the quotations, we grouped together similar tasks as a single process. For instance, we developed the process of 'delivering assessment tasks' from the theme 'student assessment' which we have mentioned above. Finally, the eight general themes we identified form stage 1 are grouped in the following processes.

Process 1: Design and get approval for a module
- Procedures for designing modules

Process 2: Plan learning related activities
- Procedures for designing modules
- Procedures for delivering modules

Process 3: Develop learning related materials
- Teaching resources

Process 4: Deliver learning activities
- Procedures for delivering modules
- Feedback

Process 5: Deliver assessment tasks
- Student assessment
- Feedback
- Marking

Process 6: Deliver support
- Student support
- Feedback

Process 7: Evaluate the module
- Module evaluation
- Feedback

Stage 4: *Describing* findings. We used the interview data to help us arrive at a form of words for accurately describing each process and the data it requires or generates, and also to provide a short document which discusses and identifies the issues related to each process.

Stage 5: *Combining* the findings. This stage aims to study the relationships between these processes, in order to generate a whole picture of the process model. We went back to the transcriptions again to identify evidence that describes the *order* and *relationships* between different activities, such as '*…is a start point…*', '*…it is followed by …*' '*…is needed to be done before…*'. We then ordered these processes and illustrated them using a diagram to represent the process model.

Stage 6: *Validating* findings above. At this stage, we compared the findings against the interview transcriptions to check if we have misinterpreted any quotation, or have missed out any important quotation.

Literature Review

The staff interviews can only provide direct evidence of each process in a case study. We also need further evidence to support our proposed process model. We therefore conducted a literature survey to gain more understanding about the processes we identified, and these helped us to refine the definitions of individual processes, and to identify their relative importance. For example, Littlejohn and Pegler [12] have classified the differences between academic and non-academic support, and Inglis [13] and Forsyth [14] have explored the necessity for evaluating modules whilst they are being taught.

B. Data Flow Analysis

According to the findings from section A, data and data flows are identified by reviewing the learning and teaching processes. We conducted a qualitative data analysis, suggested by Watling [15] for research in educational management, as follows.

Stage 1: Identify *data* from process flows. We went back to the processes developed from section 2.1, and identified the following types of data.

- Module specifications
- Teaching plans (include plans for learning activities, supporting activities, and assessment tasks)
- Learning material
- Assessment material (include grading criteria)
- Supporting material
- Student coursework
- Marks
- Assessment feedback
- Plagiarism detection results
- Teaching feedback

Stage 2: Identify *linkages* between data. Based on the process descriptions, we then highlighted all the linking words to represent the data flows, such as '*…based on…*', '*…end's up with…*', '*after…*' and so on.

Stage 3: *Combine* data flows and the process flow diagram. Based on the data and data flows we have identified from stage 1 and 2, we then studied what and how the data are shared between different processes, and for each data item, how it was developed and what data are generated based on it.

Stage 4: *Simplify* the process and data flow diagram. At this stage, we reviewed our diagram again, to study if there are any similarities between data flows, and to identify any data flow cycles in the diagram. For instance, the data flows for delivering learning materials, assessment materials and supporting materials are similar to each other.

Stage 5: *Validate* the findings against the process flow diagram. We compared our results with the processes to check if we have missed out any important flows or misinterpreted any of them.

C. Process and Data Flows Diagram

This diagram shows the learning and teaching processes and their data flows (see Fig. 1), developed from the first two phases of our approach delivered in sections A and B. The rectangles represent the processes, and the arrows and box less texts box indicate data flows

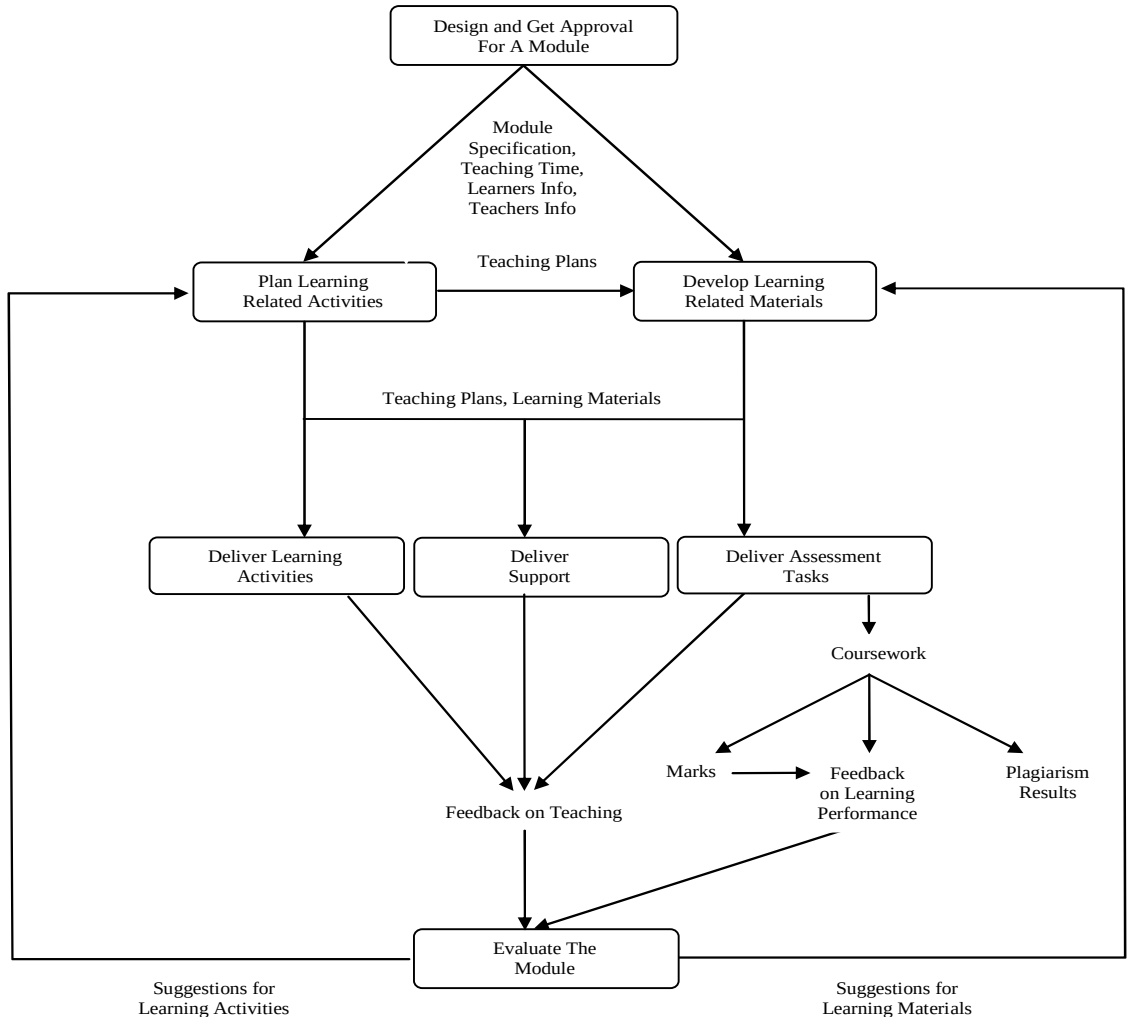

Figure1. Process and data flows diagram

between these processes. A module delivery cycle is included. Teaching and learning activities normally start with the *module designing* process, followed by the process of *module planning* and *developing learning related materials*, before the actual *delivery* takes place. When the module is delivered, it will be *evaluated* in order to identify possible future changes required to improve the module. Suggested updates obtained from the *evaluation* process will be used to guide the *module planning* and *learning material developing* processes that will take place in the next module delivery cycle.

D. Approach for E-Learning Service Analysis

We develop e-learning services by identifying major data flows between these processes. For each identified service, we describe its function and the motivation for using it, along with its input and output data. We have also made sure that each service meets all of the following service features [16].

- Services are independent of each other.
- Services are offered by multiple providers, consumers can easily make choices between them.
- Services are reusable.
- Services enable interoperability: data are shared and reused between services

Although some researchers [5,17] have stressed the use of UML diagrams to represent workflows between services, we note that there is no established methodology which we could apply to abstract services from concrete processes and data flows.

III. E-LEARNING SERVICES

Before we begin to describe our proposed services, we address related service concepts and possible standards to implement these services.

A. Services Concepts and Standards

A service is 'an abstract resource that represents a capability of performing tasks that form a coherent functionality from the point of view of providers entities and requesters entities' [18]. It is commonly agreed that a service contains a set of documents that describe the interface to and semantics of the service [19]. A service interface defines 'the messages and the message exchange patterns that are involved in interacting with the service, together with a logical grouping of operations' [20, 21]. A Web Service is a software component that supports interactions over a network [22] and which has an interface described by WSDL [23]. Other software components communicate with the Web Service using SOAP messages via the HTTP protocol [24].

The rest of the section discusses possible technologies to handle the different aspects of implementing services and their data communication, using existing standards [25].

To describe services

WSDL is an XML based language to describe service interfaces from a technical point of view [26]. A WSDL file defines a service as consisting of three layers.

- The first layer is the interface of a service. The interface describes operations and input and output data types used in the service.
- The second layer is the binding of a service. It defines the protocol that is used to provide the service.
- The third layer defines the physical address where the Web service is available.

To transmit data between services

SOAP is a protocol that defines rules to exchange structured information between applications. It relies on XML as its message format, and a transport protocol such as HTTP for data transmission. SOAP messages are used to carry data for communications between services [27]. It contains the following elements:

- An Envelope element that identifies the XML document as a SOAP message;
- A Header element that contains header information;
- A Body element that contains call and response information;
- A Fault element containing errors and status information.

To discover services over the network

UDDI is a directory for storing services information (web service interface). Service providers can register their services in a UDDI directory. Service users could then search the UDDI directory to find the service they went. When the interface is found, the user can communicate with the service immediately [28].

To combine services at run time

BPEL uses XML to describe service composition. The composition result contains a set of composed services. The data exchange is called an activity. There are many types of activity, include <receive> for defining operation name and input data, <invoke> for calling other services, <assign> for mapping and assigning data and <reply> to end the process and return output data [29]. BPEL contains the following elements:

- Process initiation: <process>
- Services in composition: <partnerLink>
- Variables within process: <variable>
- Top level execution: <sequence>, <flow>
- Data exchange activities: <receive>, <invoke>, <assign>, <reply>…
- Error handling: <scope>, <faultHandlers>

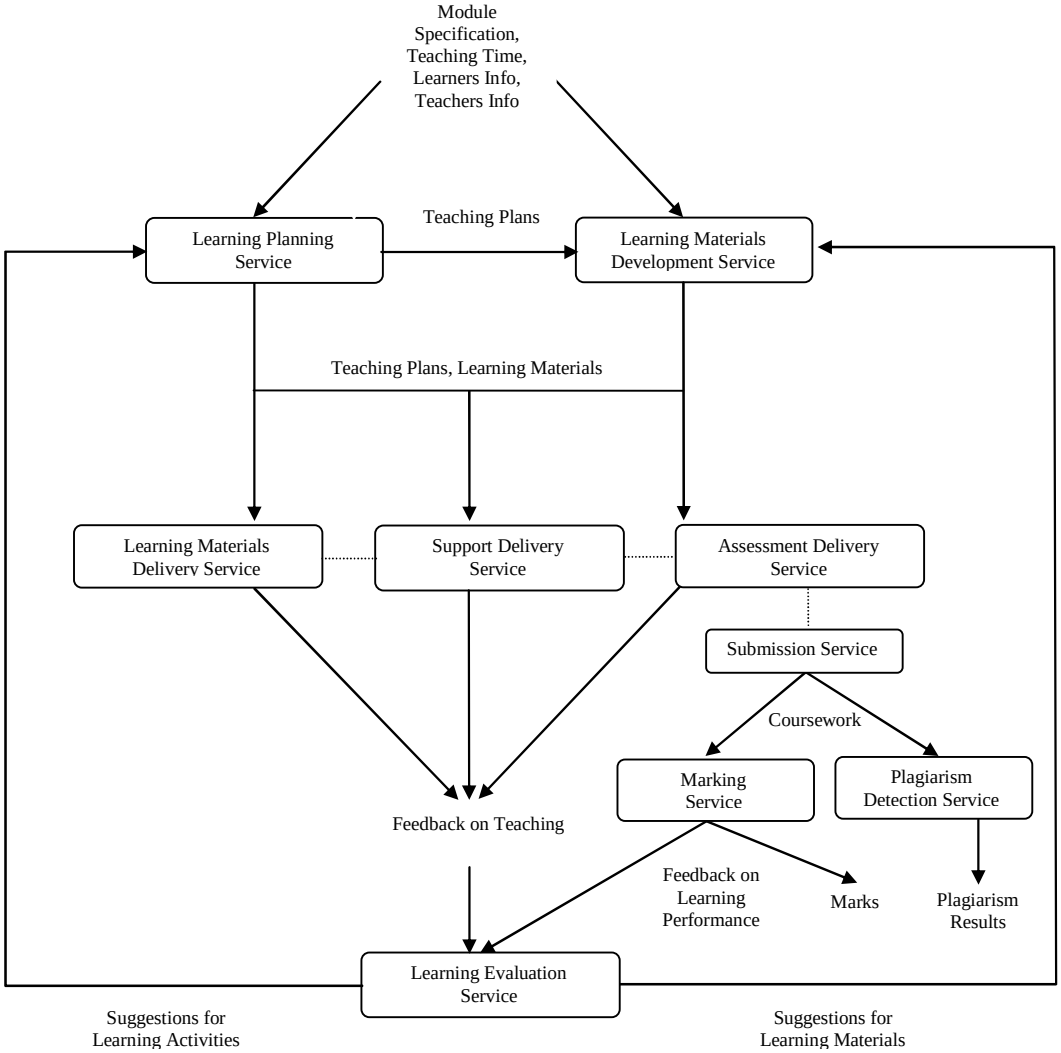

Figure 2. E-learning Service Diagram

B. Proposed Services

The following nine e-learning services have been identified, and a service diagram is included below (see Fig. 2). The rectangles represent the e-learning services, and the arrows and unboxed texts indicate data flows between these services; the dashed lines mean services might be combined.

Learning planning service

Motivation: Learning and teaching activities vary between modules, and planning these activities can be done in varied ways, and various planning approaches exist [30]. Having such a service enables educators to easily make choices between the available services offered by multiple vendors, according to their needs.

Functionality: This service aims to assist module designers to develop a module delivery plan. By using basic factual and educational details, this service will allow selection and planning for all learning, supporting and assessment activities for a particular module. A list of available services can be discovered from UDDI, however, there are few products that currently support this.

Input data:

- Module specification
- Available teaching time
- Teachers' information
- Learners' information
- Change suggestions for learning activities

Output data:

- Teaching plan for learning activities
- Teaching plan for supporting activities
- Teaching plan for assessment tasks

Learning materials development service

Motivation: This service first enables the sharing and reuse of learning resources, and provides an environment to support educators to develop learning materials [31]. Additionally, some services might enable support for specific development approaches, such as Biggs' Constructive Alignment [32]. A service instance might, for example, enable validation of learning materials by

performing an automatic check to ensure consistency with other module components including the intended learning outcomes and learning activities.

Functionality: This service aims to handle computer based learning related materials for learning, assessment and support. It assists module designers to search and select a number of existing computer-based learning and assessment materials, and also supports the creation of new computer based materials. The developed materials can then be easily wrapped as SOAP messages, to be passed to other services, such as the learning materials delivery service, which will be covered later on.

Input data:

- Module specification
- Available teaching time
- Teachers' information
- Learners' information
- Change suggestions for learning materials
- Teaching plan for learning activities
- Teaching plan for supporting activities
- Teaching plan for assessment tasks

Output data:

- Learning materials
- Support materials
- Assessment materials

Learning materials delivery service

Motivation: Many Learning Management Systems (LMS), such as Moodle [33], have been developed and are becoming mature [34]. This service will reuse these existing products and allow teachers/learners to select between them.

Functionality: This service aims to deliver learning materials based on the pre-defined learning and teaching plan. A computer based learning environment is provided, which allows varied learning materials to be delivered, where learners can easily get access to and make use of them at any time. Existing LMSs can be wrapped as services by adding WSDL interfaces to each of them.

Input data:

- Teaching plan for learning activities
- Learning materials

Output data:

- Feedback on teaching

Support delivery service

Motivation: Research results from our interviews suggest that students increasingly expect high levels of support, and this is particularly true of first year students who have recently graduated from high school [35]. This service is designed to address this issue, so users can freely make choices between varied support providers. Currently few appropriate tools are available.

Functionality: This service provides a computer based supporting environment to deliver academic support, based on learners' requirements. Learners can easily get access to and make use of support materials, and also communicate with tutors and/or peers any time and anywhere.

Input data:

- Teaching plan for support activities
- Support materials

Output data:

- Feedback on teaching

Assessment delivery service

Motivation: Many Learning Management Systems can be used to deliver assessment materials [36]. This service will reuse these existing products and also allow teachers/learners to make selection between them from different LMS developers.

Functionality: This service aims to deliver assessment tasks based on the pre-defined learning/teaching plan. Similar to the learning delivering service, a computer based delivery environment is provided, which contains a number of varied assessment materials for learners. Both learners and teachers can easily get access to support materials any time and anywhere. Again, existing LMSs can be wrapped as services by adding WSDL interfaces to each of them, which can then be combined with a learning materials delivery service via BPEL.

Input data:

- Teaching plan for assessment activities
- Assessment materials

Output data:

- Feedback on teaching

Submission service

Motivation: Many pieces of coursework are required to be handled every year. This service enables students to submit their work anytime and anywhere. Instructors can choose an appropriate submission service for each assessment task from multiple service providers.

Functionality: This service allows coursework to be submitted in an electronic format. Teachers can easily get access to students' work via this service. Such a service might take the form of a component of an LMS, or might be a specific product (such as BOSS [37]).

Output data:

- Coursework

Marking service

Motivation: Many pieces of assessment work are required to be marked every year, our interviews have suggested us that this is a time consuming task for markers. This service enables marks to be generated easily based on grading criteria, and both individual and overall learning performance will be analysed.

Functionality: This service assists markers to handle the marking job easily. Marks and Feedback on students' learning performance are generated by this service. Many e-marking systems have been developed, such as Scoris for marking e-tests and e-exams [38] and could potentially be presented as services.

Input data:

- Coursework

Output data:

- Marks
- Feedback on learning performance

Plagiarism detection service

Motivation: Many pieces of coursework are required to be handled every year, and detecting plagiarism is a time consuming task for human beings [39]. This service enables the detection task to be done by machines. Instructors can choose appropriate plagiarism detection services for different assessment tasks from multiple service providers. Furthermore, software for detecting plagiarism already exist, including the Turnitin products for essays [40] and JPlag [41] and Sherlock [42] for computer programming assignments.

Functionality: This service assists markers to detect plagiarism easily. It compares students' assessments against each other's, and also against available web resources.

Input data:

- Coursework

Output data:

- Plagiarism detection results

Learning evaluation service

Motivation: Modules are required to be updated all the time. In practice, there are a few formal procedures for this task [43]. The learning evaluation service allows educators to easily choose to receive suggestions on improvements for delivering either learning activities or learning materials or both.

Functionality: This service aims to evaluate the delivery of learning activities, learning materials and students' learning performance. Two types of feedback are considered, one is teaching feedback, which refers to the quality of learning, support and assessment activities and materials. The other is feedback on student's learning performance. Examples include how well an individual student has done for a particular assignment or overall semester performance. Evaluation results can be used to guide the updates of existing learning activities and materials either immediately or for future delivery.

Input data:

- Feedback on teaching
- Feedback on learning performance

Output data:

- Suggestions for learning activities
- Suggestions for learning materials

IV. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a novel approach to develop e-learning services from complex learning and teaching activities. We have also proposed 9 distinct e-learning services that can be easily reused by learners and instructors. Some of them are particularly useful for addressing challenges relating to current practice. Also, both learners and teachers can easily make selections between services from multiple services vendors. These services are fundamental components to support our educational services framework in the future, and our proposed approach will be useful for developing other e-learning services.

In the near future, our research will focus on the technical and implementation aspects of our services framework. We will be interested in how to specify these educational data in detail from a technical perspective, and we are also going to develop an implementation plan to describe how to turn our framework into a prototype, and how to evaluate our model after it is built.

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