Abstract

The objective of this article is to develop a model for creating and delivering personalised e-learning to provide lifelong learning that analyses the knowledge and skills accumulated by the learners and, on this basis, to provide them with a personalised learning path.

The development of the model is based on the need to decompose the training content into small learning objects to be parameterised with descriptive data at the stage of e-learning creation.

For this purpose, a methodology has been chosen for describing decomposed knowledge with specific tags that are pooled under the general term "competences". As a result of the research and analyses, a model has been developed which, through an analysis complex based on case studies and questions, puts the learner in situations that have been previously described what competences and degree of reliability validate. Based on the decisions, responses or outcomes provided, each learner is assigned a competence profile.

Keywords: personalised education, learning management platforms, data-driven education.

1 INTRODUCTION

At the current stage of its development e-learning faces problems related to the creation of a customised learning environment that is tailored and adapted to the needs of each learner. All learners are unique; no two will achieve the same learning outcomes across a range of subject areas.

Confucius, a great thinker, philosopher and educationist of China, presented a philosophical statement about 3000 years ago [1]. His philosophy in teaching is known as: “teach students in accordance with their aptitude, adjust measures to local conditions” [2].

Nowadays, personalised learning services are a key point in the field of online learning as there is no fixed learning path which is appropriate for all learners. However, traditional learning systems ignore these services requirements and deliver the same learning content to all learners. This approach may not be effective for learners with different backgrounds and abilities. In order to design an adaptive learning content, we need to enable the delivery of learning content according to particular learner’s needs. [3].

Much of today’s research and development focuses on the creation and re-use of Learning Objects (LO) [4]. The learning objects present a new paradigm for the creation of teaching materials. In the old paradigm, training is organised in lessons and courses that meet predefined objectives of the course or lesson. In the new paradigm, the curriculum is divided into smaller, stand-alone units that can be used both individually and statically or dynamically combined with others.

Modern technologies provide opportunities for personalising of e-courses and the educational resources they contain according to the needs of each learner. The focus on modern forms of e-learning is on the different learners’ performance - depending on the achieved level and the results, the next steps in their training are defined, following their own learning pace throughout the course.

In order to achieve personalised e-learning activities adaptive authoring tools are required to run in the background. Adaptive authoring tools adapt the selection of learning activities or units of learning at run time to suit the diverse learning requirements of individual students based on information gathered from the student’s user model/profile.
2 METHODOLOGY

Learning environment is considered adaptive if it is capable of: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process [5]. There are a number of methodologies to provide e-learning based on the specific accumulated competences of individual learners, which we have used as a basis for our model [6]:

2.1 Prior Knowledge

The achievement of effective personalisation is dependent on the prior knowledge of the user and the appropriateness of the data stored in the user profile. In a survey of academics on personalised e-learning in higher education 55% of respondents were of the opinion that prior knowledge was the most important student characteristic on which to base personalisation, and 48% were of the opinion that personalisation based on prior knowledge would be the easiest to achieve.

Prior knowledge influences future understanding. By recording students’ performance, a set of parameters can be collated and used in formative or summative evaluations. Prior experience in a domain could be assessed using rapid tests of knowledge and cognition in order to allocate learners to appropriate stages of instruction.

2.2 User Modelling/Profiling

One of the problems yet to be resolved is how to adequately assess a student’s current knowledge, when details of this knowledge exists in various different incompatible systems, linked data approaches may go some way to alleviating this issue.

When appropriate methods are determined by the author to assess learners’ prior experience the resulting metadata is stored in a user profile. A user profile is a collection of keywords or concepts representative of a user’s interests and a place to store data on students’ grades and test results. To meet ethical requirements students should be asked for their permission to engage with adaptive systems before the author commences tracking their progress.

2.3 Adaptation Rules

A user model (UM) or user profile should be maintained for each student which stores and updates information on individual student’s levels of achievement in the system to date and their learning preferences. Learners progress will be monitored by the adaptive system and user models or profiles will be updated accordingly.

Adaptation rules should be devised, which adaptively select appropriate learning resources, to suit the cognitive style, and preferences of individual students. The adaptation model has to tailor the content, and the navigational path to suit the user’s requirements, based on the data collected on the user which is stored in the user model/profile.

2.4 Supporting Learner Diversity

The creation of personalised e-learning activities would provide students with alternative or additional learning activities to master threshold concepts and enhance the learning experience.

Many researchers are in accordance with the view that learning materials should be designed to suit all kinds of students and all kinds of learning styles.

From ancient wall drawings to today’s technologically afforded visual representations, the value of visualisation is well recognized as a form of communication, affording the meaningful portrayal of information in easy to understand formats.

An authoring tool for personalized e-learning would facilitate the use of a range of learning activities including both visual and verbal activities to increase learning. A learning design to support learner diversity is required which is easy for teachers to understand and utilise to improve the learning experience of a diverse range of students.
3 RESULTS

The presented in this paper customised e-learning model, which takes into account the accumulated competences of each learner, was developed on the basis of the Prior Knowledge model and includes several key stages shown in Fig. 1.

- Stage 1 - Decomposing the learning content into small learning objects;
- Stage 2 - Describing the learning objects with competences;
- Stage 3 - Linking the learning objects;
- Stage 4 - Creating evaluative/analysing components;
- Stage 5 - Developing a Competent Profile;
- Stage 6 - Providing access of the individual learners to the learning content based on the competence profile.

Below we have described each of the stages of our model:

3.1 Decomposing and describing the learning content

Educational content is divided into small structural units called Learning Objects. There is a broad understanding among the members of the LO community about the functional requirements a LO should have [7]:

- **Accessibility**: the LO should be tagged with metadata so that it can be stored and referenced in a data base.
- **Reusability**: once treated, a LO might be used in different instructional contexts.
• **Interoperability**: the LO should be independent of both the delivery media and learning management systems.

For the purpose of the model in this article, learning objects are used as small structures of learning content (typically one slide) that allow them to be described within a few tags / labels of what competences they provide. The term "Competence" is used as a unifying concept of knowledge, competence, skill or ability. The use of the competence description is not mandatory, but the provision of adaptive e-learning requires the parameterisation of the learning objects, on the basis of which the current knowledge of the learners is determined, and according to these results they are provided educational content as close as possible to their specific needs.

In order to facilitate the use of the model, it is necessary that the user describing the training course, the learning content or the assessment tool should be facilitated in choosing competence. Ideally, designing a software solution to provide personalised learning based on user competences should analyse the text part and, on this basis, provide competence suggestions.

Describing the learning objects with competence labels is a resource-intensive process and therefore the e-learning author should be offered pre-described and structured competences, which are labeled as standard competences in the model. For this purpose the possibilities of using open databases with competences for different professions have been analysed. Worldwide the opportunities are:

**Occupational Information Network (O*NET)** [8] - Central to the project is the O*NET database, containing hundreds of standardised and occupation-specific descriptors on almost 1,000 occupations covering the entire U.S. economy. The database, which is available to the public at no cost, is continually updated from input by a broad range of workers in each occupation.

The Content Model is the conceptual foundation of O*NET. The Content Model provides a framework that identifies the most important types of information about work and integrates them into a theoretically and empirically sound system.

The Content Model was developed using research on job and organisational analysis. It embodies a view that reflects the character of occupations (via job-oriented descriptors) and people (via worker-oriented descriptors). The Content Model also allows occupational information to be applied across jobs, sectors, or industries (cross-occupational descriptors) and within occupations (occupational-specific descriptors). These descriptors are organised into six major domains, which enable the user to focus on areas of information that specify the key attributes and characteristics of workers and occupations.

![Figure 2. O*NET Content Model.](image)
From all structured data in O*NET for the purposes of describing a learning object, the following are used:

- **Tasks** - Occupation-Specific Tasks
- **Technology Skills** - Information technology and software skills essential to the functions of an occupational role.
- **Knowledge** - Organised sets of principles and facts applying in general domains
- **Skills** - Developed capacities that facilitate learning or the more rapid acquisition of knowledge
- **Abilities** - Enduring attributes of the individual that influence performance
- **Work Activities** - Work activities that are common across a very large number of occupations. They are performed in almost all job families and industries.
- **Detailed Work Activities** - Specific work activities that are performed across a small to moderate number of occupations within a job family.
- **Work Styles** - Personal characteristics that can affect how well someone performs a job.

Each of the records in the database of these eight categories can be used as a label for describing learning content.

**ESCO (European Skills, Competences, Qualifications and Occupations)** [9] - European multilingual classification of Skills, Competences, Qualifications and Occupations.

ESCO works as a dictionary, describing, identifying and classifying professional occupations, skills, and qualifications relevant for the EU labour market and education and training. Those concepts and the relationships between them can be understood by electronic systems, which allows different online platforms to use ESCO for services like matching jobseekers to jobs on the basis of their skills, suggesting trainings to people who want to reskill or upskill etc.

ESCO provides descriptions of 2942 occupations and 13.485 skills linked to these occupations, translated into 27 languages (all official EU languages plus Icelandic, Norwegian and Arabic). Over time, it will also display the qualifications awarded in the education and training systems from Member States, as well as qualifications issued by private awarding bodies.

Each competence or skill is represented by: Description, Definition, Scope notes, Alternative label, Skill type, Skill reusability level, Broader skills/competences, Narrower skills/competences, Essential skills and competences, Essential Knowledge, Optional skills and competences, Optional Knowledge, Essential skill/competence of, Optional skill/competence of.

For the purposes of our model, both databases present a rather comprehensive and structured set of competences and could be used. ESCO's benefits are that much of the database has been translated into 27 languages, and Skills, Competences, Qualifications and Occupations are presented and described in a more relevant way to use in describing learning content.

When describing learning objects, in addition to standard competences, content authors can use as well customised competences to allow the description of areas of knowledge that are highly specific or detailed.

### 3.2 Interaction between the learning objects

Once the learning objects have been described with the necessary competences, it is necessary to determine the dependence of each learning object by the other learning objects. This defines the baseline of learning content as well as possible alternatives. With more complex variations of the model, it is possible to build different LOs to present to different learners at different levels of knowledge of the relevant competences linked to the learning object.

Content authors also determine which of the learning objects are mandatory to pass, regardless of the results of the learners' passing through the analysis complex.

The establishment of interconnections and the definition of mandatory learning objects aims to make the process of personalised e-learning and information presentation more structured and based on the teaching methodology.
3.3 Construction of an analysis complex

The construction of an analysis complex is the creation and consecutive linking of evaluation objects (EO). There are different types of evaluation objects, each of which has a different degree of validity in data validation and therefore requires different development time. The main types are shown in Table 1.

Table 1. Types of evaluation components.

<table>
<thead>
<tr>
<th>Type of Evaluation Object</th>
<th>Description</th>
<th>Degree of Validity</th>
<th>Type of Development</th>
<th>Priority</th>
<th>Total Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed test question</td>
<td>Only one question (with one or multiple possible choices)</td>
<td>Low</td>
<td>Low</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Open test question</td>
<td>A question for the user to answer with text submission</td>
<td>High</td>
<td>Low</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Interactive test questions</td>
<td>Drag&amp;Drop, Matching, Fill in the Blank</td>
<td>Average</td>
<td>Average</td>
<td>Yes</td>
<td>Average</td>
</tr>
<tr>
<td>Test with closed questions</td>
<td>A combination of many different test questions. This EO can be used to check more competences with one pass.</td>
<td>Average</td>
<td>Average</td>
<td>Yes</td>
<td>Low</td>
</tr>
<tr>
<td>Micro case study</td>
<td>Variation of an open test question, but placing the user in a certain situation where he has to make his own decision. This EO can be used to check more competences with one pass.</td>
<td>High</td>
<td>Average</td>
<td>No</td>
<td>Average</td>
</tr>
<tr>
<td>Book Game (Labyrinth)</td>
<td>A series of situations that require a response from the learner, after which a new situation is revealed on the basis of the decisions taken, with a different level of competence coverage being determined on the basis of each of the outputs. This EO can be used to check more competences with one pass.</td>
<td>Average</td>
<td>High</td>
<td>Yes</td>
<td>High</td>
</tr>
</tbody>
</table>

Essential for achieving a high level of performance of the analysis complex and implementing a personalised e-learning model based on learning competences is the motivation of the learners. If the analysis complex is game-based (labyrinth), this would greatly motivate the learners to pass through the knowledge check. When using common test questions, the learner is likely to quit and go directly to the learning content.

Each EO describes the competences it examines, thus validating the link competence - learning objects, i.e. in complex analysis complexes, it is possible for one competence to be checked by more than one component, which requires when defining the total validity of competence to determine the percentage weight for each EO. The degree of validity of the relevant component type shall be taken into account when determining the weight of each learning object. In a complex examination of one competence with more assessment components, it is necessary to determine the minimum score by which it would be marked as achieved by the learner.

While building the analysing complex, it is necessary to evaluate all the competences included and describing the training content of Stage 2.

3.4 Developing Learner Competence Profile

As a result of the completion of analysis complex the learner is given a competence profile, which reflects the degree of knowledge of each of the competences involved in the training. On this basis, and taking into account the interrelationships between the individual learning objects defined in step 3, an individual path through the educational content is constructed for the learner.

The development of an individual learner competence profile allows, after passing the training, a comparison of the learner's competences before and after the training, thus analysing the quality and
effectiveness of the e-learning. The initial creation of a learner profile can help to better analyse the target group and better plan and structure the training for each subsequent reuse.

Application of the model requires an extremely powerful and yet easy to use authoring tool to significantly facilitate the content authors. Building an analysis complex that is attractive and motivating for the learners is a complex, time-consuming process that implies its use in creating learning courses designed for a large audience.

4 CONCLUSIONS

Personalised e-learning based on learner pre-qualification analysis is key to enhancing online learners' motivation and enhancing the effectiveness of e-learning.

This article analyses existing models to provide personalised e-learning, outlining their main disadvantages. The development of the model is based on the need to decompose the learning content into small learning objects to be parameterised with descriptive data yet at the stage of e-learning creation. For this purpose, a methodology has been chosen for describing decomposed knowledge with specific tags that are pooled under the general term "competences". To provide a database of competences to validate the knowledge in the article, open competences databases are analysed, including specific knowledge, skills, abilities and tasks applicable to the widest possible range of professions.

As a result of the research and analyses in the article, a model has been developed that, through a case-based and problem-based analysis complex, puts the trainee in situations that have been previously described what competencies and the degree of reliability validate. Based on the decisions / responses / outcomes provided, each learner is assigned a competence profile.

The developed in this paper model for creating and delivering of personalised e-learning to ensure lifelong learning provides an effective way to go through the actual learning content based on the learner's acquired competence profile, the pre-programmed logic of interrelation, and the degree of importance of the separate segments of e-learning course.

REFERENCES


