

Design and Evaluation of Adaptive Feedback to Foster ICT Information Processing Skills in Young Adults

Beate Grawemeyer⁺, Konstantinos Karoudis⁺, George Magoulas⁺,
Marta Pinto^{*} and Alexandra Poulouvassilis⁺

⁺ Birkbeck Knowledge Lab, Birkbeck, University of London

^{*} Faculty of Psychology and Education Science, University of Porto



Supporting Lifelong Learning
with Inquiry-Based Education

Knowledge Lab



Digital Learning @

WWW 2017

3-7 April 2017

Acknowledgements

Information about the LIBE project

- This paper reports on work undertaken in the context of the **LIBE project – Supporting Lifelong Learning with Inquiry Based Education** – funded by the Lifelong Learning Programme of the European Commission, ref. no. 543058-LLP-1-2013-1-IT-KA3-KA3MP
- The LIBE project team was a multidisciplinary one: in addition to the authors' institutions, it involved the Dept. of Education at Roma Tre University (LIBE Project Coordinator); the Centre for Lifelong Learning at Lillehammer University College; and the Dept. of Research Methodology, Measurement and Data Analysis of the University of Twente. We thank all members of the LIBE project team for our very fruitful collaboration and for their invaluable help and insights
- Full information, project Deliverables, and other resources can be found on the LIBE project website: **libeproject.it**
- The e-learning courses developed by the LIBE project team can be freely accessed at: **www.libecourses.com**
- Details about the design of the LIBE courses and the LIBE VLE can be found in the **LIBE e-Booklet** at: **libeproject.it/?p=888**

Outline of this talk

1. Introduction and motivation – the LIBE project
2. The LIBE VLE
 - Adaptive Hints in LIBE
3. User Study
4. Main Findings
5. Conclusions and Further Work

1. The LIBE Project

- Low educational achievers encounter significant difficulties in tackling complex tasks that require efficient information processing in technology-rich environments
- Most such students are not expected to continue into higher education and they may face difficulties in a technology-rich society when it comes to integration into the workforce
- The **LIBE project – Supporting Lifelong Learning with Inquiry Based Education** aimed to address the needs of these students
- We developed a **Virtual Learning Environment (VLE)** tailored towards offering personalised open-access e-learning courses to **low-achieving 16-24 year olds who may be at risk of exclusion from further education and employment**

The LIBE Project

- The LIBE VLE enables the delivery of online courses targeting the development of four transversal competences:
 - **numeracy**
 - **literacy**
 - **IT literacy**
 - **problem-solving in a technology-rich environment**drawing on the competency specifications of the OECD's PISA and PIAAC studies and the IEA's ICILS
- The design of the LIBE courses drew on the interests and motivations of students on the basis of their daily experiences
- The aim was for students to be able to study in anonymity, where and when they choose, each at their own pace.
- The LIBE learning experience needed to be individualised and non-competitive, encouraging a sense of achievement and self-confidence with the aim of fostering engagement with longer-term learning.

The LIBE Project

- The LIBE VLE and 6 LIBE courses were designed and evaluated with the participation of groups of learners (some 50 students in total) and their tutors, in three countries: Italy, Norway, Portugal
- The design was informed by analysis of learners' needs, priorities and experiences through ten learner & teacher focus groups held across the three countries
- The technical remit for developing the LIBE VLE was to reuse as much as possible existing open-source e-learning software, as there was limited budget for new software development in the LIBE project

2. The LIBE VLE

- The LIBE VLE is an **Intelligent Tutoring System** that supports also **inquiry-based learning**
- ***Deliverable 4.1*** Inventory of Open Source Technological Solutions for E-Learning (June 2014)
 - focussed on functional features most relevant to the needs of the LIBE VLE, with the aim of aiding the project team in deciding which existing Learning Management System (LMS) to use as the basis for the LIBE VLE
 - the features considered included: **learning object support, ease of extension, sequencing support, inquiry-based learning support, personalisation**
 - conclusion was that one LMS stood out in almost all aspects – **Moodle**

The LIBE VLE

- **Deliverable 4.2** Inventory of Computerised Adaptive Testing (CAT) tools for e-learning (July 2014)
 - recommended to use the “Adaptive Quiz” Moodle plug-in as the basis for the LIBE VLE CAT tool
- **Deliverable 5.1.1** Initial User and Technical Requirements for the LIBE VLE (August 2014)
 - initial requirements were identified and prioritised by all project partners, relating to functional aspects such as:
 - **user interaction, user activity, user support, learning object support, personalisation, CAT, ease of user registration, accessibility, extensibility**
- **Deliverable 5.1.2 2** Final User and System Requirements (Nov. 2014)
 - More precisely articulated requirements relating to **course personalisation** and **CAT**

The LIBE VLE

- ***Deliverable 5.3.1*** (March 2015):
 - Design of the LIBE **Personalisation Database**
 - some 30 new database tables hold time-stamped information about how students are interacting within the LIBE VLE, and the assessments offered to students (students' actual test results are stored in Moodle's core database tables)
 - Design of the LIBE **Learner Profile**
 - contains a history of the student's estimated attainment scores and attainment levels with respect to the four transversal competences and with respect to specific learning objectives
 - these estimated attainment scores and levels are dynamically updated by the system as the learner works through the pre-test and then the course

LIBE VLE
entry page,
showing the 6
courses
developed
during the
project

You are not logged in. (Log in)

LIBE Virtual Learning Environment

Search courses

English (en) Show blocks Full screen

Available courses



Å få endene til å møtes - privatø...

Course >



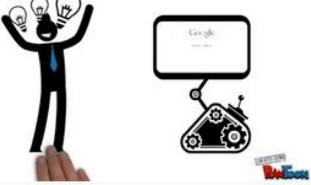
Terrengsykling i olympiske omgi...

Course >



Come scrivere un curriculum

Course >



Basta chiedere!

Course >



Salvar o mundo a partir do meu ...

Course >



Vamos comer! Consciência sobr...

Course >

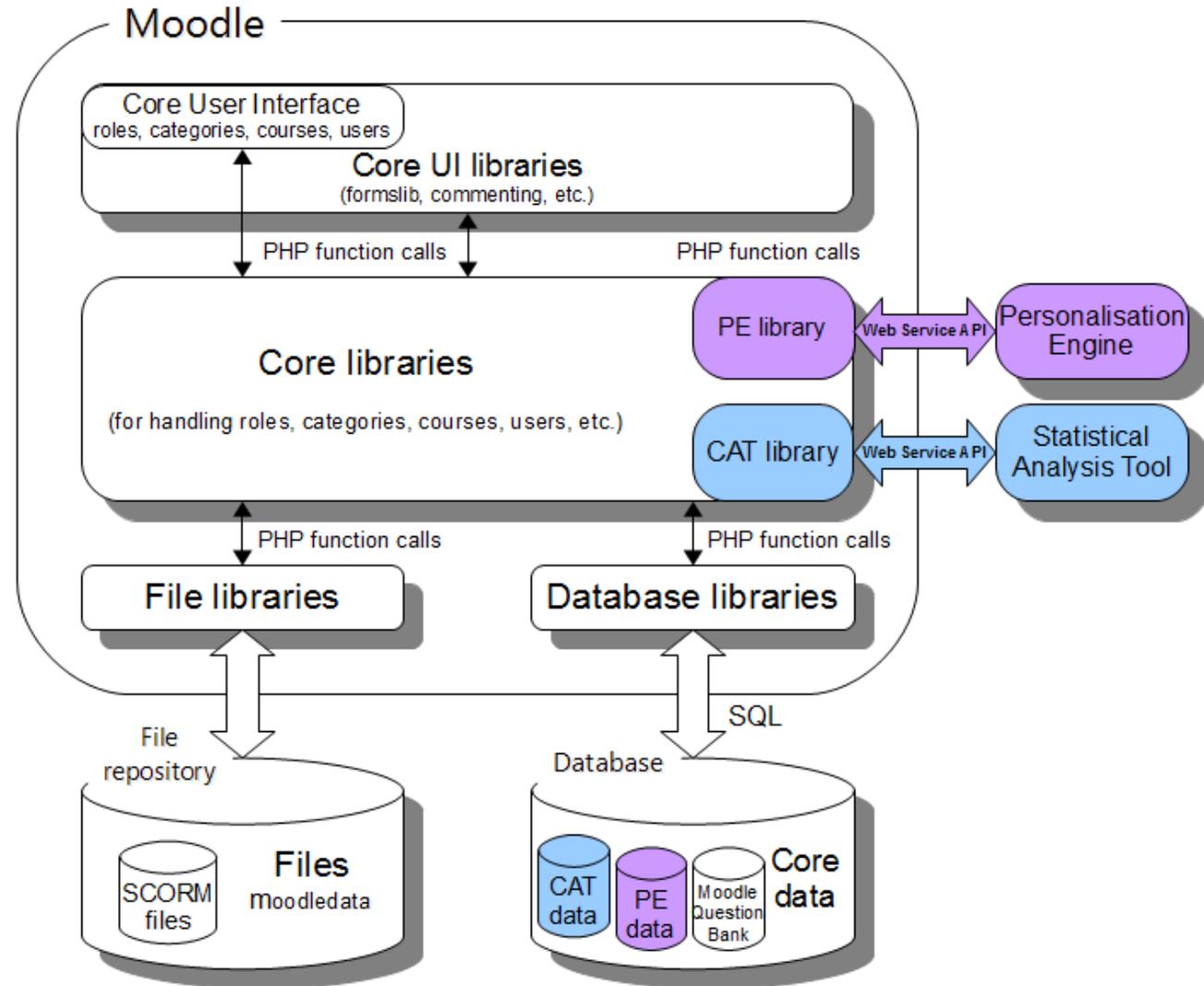
This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.
Il presente progetto è finanziato con il sostegno della Commissione europea. L'autore è il solo responsabile di questa pubblicazione (comunicazione) e la Commissione declina ogni responsabilità sull'uso che potrà essere fatto delle informazioni in essa contenute.
Dette prosjektet har blitt finansiert med støtte fra EU-kommisjonen. Denne manualen gjenspeiler synspunktene bare til forfatteren, og Kommisjonen kan ikke holdes ansvarlig for noe kan være taget av informasjonen inneholdt deri.
Projecto financiado com o apoio da Comissão Europeia. A informação contida nesta publicação (comunicação) vincula exclusivamente o autor, não sendo a Comissão responsável pela utilização que dela possa ser feita.

Personalisation requirements

- To maintain LIBE learners' **attention, motivation** and **self-confidence**
 - their performance should be **continuously – but unobtrusively – monitored through the VLE; and**
 - **course content and feedback should be adapted to learners' attainment levels**
- This paper explores these requirements, focussing in particular on the provision of **hints that are adaptive to students' attainment levels**
- Providing such adaptive feedback is particularly important in the LIBE context, where low-achieving students may have difficulties in understanding certain unfamiliar terminology or concepts, and feedback formulation needs to take this into account

The LIBE VLE Architecture

The LIBE VLE consists of a **Moodle** installation, together with a new **Personalisation Engine, Personalisation Plug-in (comprising the PE Library and PE data)** and several externally developed free plug-ins (see Appendix)

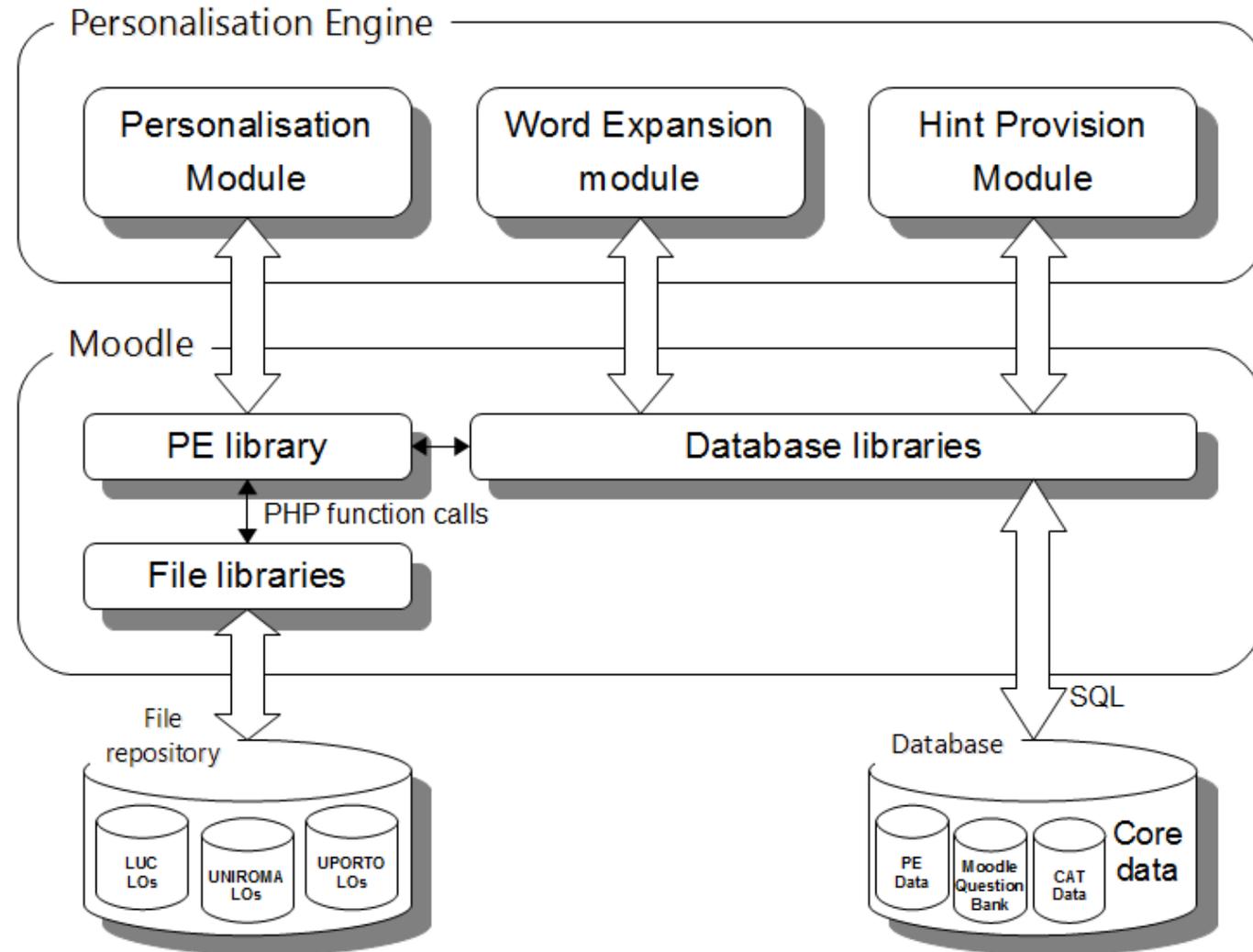


The LIBE Personalisation Engine

- The **Personalisation Engine** consists of the three modules:
- **Personalisation Module:** estimates the student's current attainment levels based on the activities completed so far, their difficulty levels, and the student's test results; and updates the LIBE database accordingly
- **Word Expansion Module:** provides explanations of predefined words according to the student's estimated attainment level in Literacy.
- **Hint Provision Module:** provides hints according to the student's estimated attainment level in the competence and/or the learning objective targeted by the current activity.

The LIBE Personalisation Engine

LIBE Personalisation Engine Architecture



The LIBE Personalisation Engine

- The Personalisation Engine maintains within each learner's profile an estimate of the learner's current levels of attainment in
 - **numeracy**
 - **literacy**
 - **IT literacy**
 - **problem-solving in a technology-rich environment**
- These attainment levels are initialised using students' performance on a pre-test that precedes each course
- Attainment levels are dynamically updated as students tackle each of the activities within the course itself
- The LIBE VLE is configured with an extensible set of Learning Objectives relating to each of the above four competences
- Each activity within a course is associated with one of the four competences and, optionally, with a specific learning objective

Example of Learning Objective assignment and Competence mapping

| Course No. | Learning Activity No. | Activity Type | Learning Objective | Competence |
|------------|-----------------------|--------------------------|---|--|
| 1 | 2 | Cloze test | Select the appropriate word in context | Literacy |
| ... | ... | ... | ... | ... |
| 2 | 3 | Multiple choice question | Understand how a search engine works | IT literacy |
| ... | ... | ... | ... | ... |
| 3 | 8 | Open-ended | Divide quantities in simple arithmetic problems | Numeracy |
| ... | ... | ... | ... | ... |
| 6 | 9 | matching/ simulation | Use information / Recognize critical elements in a given setting | Problem-solving in a tech-rich environment |
| ... | ... | ... | ... | ... |

LIBE Courses

- Six courses were developed during the LIBE project, designed after analysis of the ten focus group discussions
- Each course presents a topic that was identified as being of broad appeal to these young people:
 - writing a CV
 - searching for information on the internet
 - managing personal finances
 - sports
 - the environment
 - consumer awareness
- Each course focusses on one or two of the four competences
- The six courses developed are freely accessible at www.libecourses.com

LIBE Courses



How to write a resume like a wizard

Literacy
e-skills



Everything you want is out there waiting for you to ask

Literacy
Computer and information Literacy



Making ends meet

Private economy
Numeracy



Mountain biking in Olympic surroundings:
How fast can you go downhill?

Numeracy



Saving the world from my neighbourhood

Problem solving in technological rich environments



Let's eat!
Consumer awareness about food

Problem solving in technological rich environments

A multiple choice quiz from the “Making ends meet” course, targeting the learning objectives “understanding of numberlines” and “calculation of percentages”



Making ends meet - Private economy

Hjem



LUC

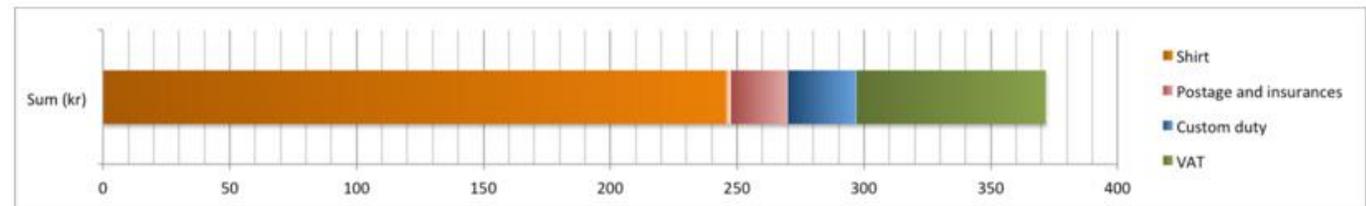
Making ends meet - Private economy

Lesson 3

Activity 4.4 (moderate)

Forhåndsvisning

The last charge to add is the VAT. In Norway, it is 25 per cent (%) for almost all commodities, including shirts. Without the VAT, the price of the shirt sums up to **297 kr**. The VAT is calculated after postage, insurances and Custom duty has been added.



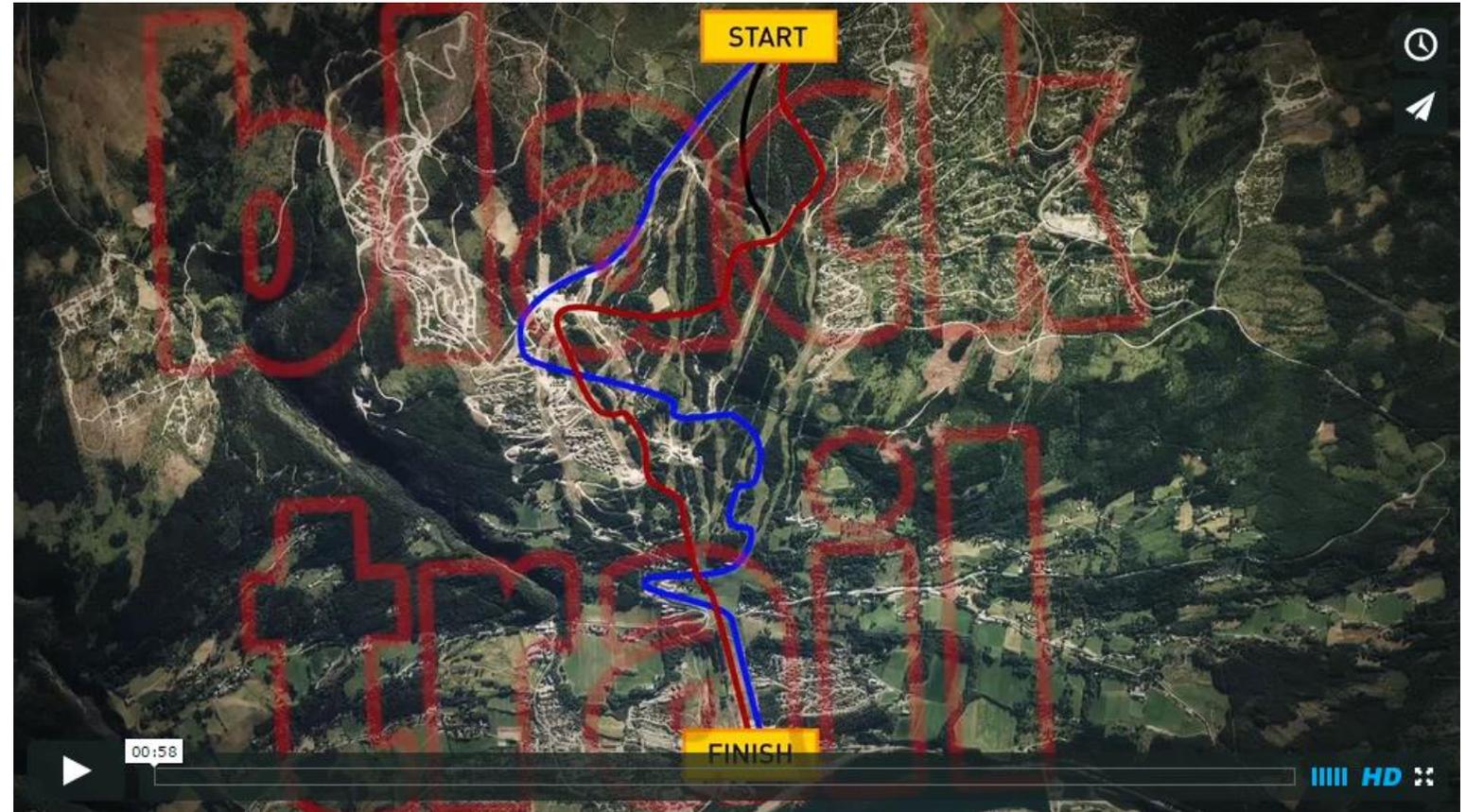
The chart shows the accumulated costs, including the shirt, postage and insurances, Custom duty and VAT.

What is the final price for the shirt, including all additions?

Velg ett:

- 247.50 kr
- 270.00 kr
- 297.00 kr
- 371.25 kr

An exploratory activity, from the “Mountain Biking” course. The learning objectives include “estimating distances by reading a map”, “understanding the relationship between diameter and circumference”, “calculating with time, distance and speed”.



A construction activity from the “Saving the world from my Neighbourhood” course: create an information poster about how to reduce waste, reuse and recycle.

Have a heading: Choose the main message and present it with a memorable title.

Fill in the middle:

- Choose one or more images related to the main message and fill the poster.
- Information you want the reader of the poster to receive, presented in short text.

Have a footer: Choose secondary information you want the reader of the poster to receive.

RECYCLE

When you recycle, used materials are converted into new products. Recycle materials such as glass, paper, plastic and metal.

REUSE

When you no longer need an item, you can offer it to others so that they can get some use out of it. Reuse by giving away clothes, shoes and books to extend their life.

| | Paper | Nappies | Food | Plastic bottles, pots, tubs & trays | Glass bottles & jars | Clothing & textiles | Metal tins, cans & aerosols | Cartons & Tetra Pak |
|----------------|-------|---------|------|-------------------------------------|----------------------|---------------------|-----------------------------|---------------------|
| RECYCLE | yes | no | no | yes | yes | no | yes | yes |
| REUSE | yes | no | no | yes | yes | yes | no | no |

Recycling and Reusing items in your daily activities is simple!

This poster is a courtesy of the Green Neighbourhood Youth Association.

User Trials

- Towards the end of the LIBE project, the 6 courses were piloted with over 600 young adults in Italy, Norway and Portugal, to evaluate their quality and appeal
- Learners expressed generally positive attitudes towards their learning experience across all courses and towards the overall user friendliness of the LIBE VLE:
 - See ***Deliverable 6.3***: Evaluation of LIBE e-learning delivery and student learning.
- However, due to lack of time before the end of the project, there was no specific investigation of personalisation in these trials
- Hence the subsequent User Study that we report on in this paper.

3. User Study

- In this user study, we wanted to investigate the relationships between learners' accessing of adaptive hints, their motivation and their performance
- To investigate these, we conducted a study with 23 student volunteers at a Vocational Training Centre in the region of Porto (Portugal)
- The study related to the first part of the "Saving the World from my Neighbourhood" course designed by the University of Porto, targeting Literacy
- Student data was collected (through the LIBE VLE) on:
 - a course pre-test;
 - the main course activities;
 - a post-course questionnaire including questions relating to students' motivation, learning experience in using the VLE, and how difficult they found the course

User Study

- The pre-test comprised six activities relating to Literacy. The results were used to initialise the students' attainment scores and levels within their learner profiles
- Feedback messages within the main course were tailored to level of attainment in Literacy, dynamically updated as students progressed through the course
- The computation of students' Literacy attainment scores was based on a simple averaging of the student's performance over all the test activities undertaken thus far
- A score of 0-33% was classified as Low attainment level; 34-66% as Medium attainment level; 67-100% as High attainment level

User Study

- For this user study, the following simple logic was implemented within the Personalisation Engine for the adaptive hints provision:
- Two hints were designed for each of three attainment levels (Low, Medium, High) in Literacy for three of the seven activities that students undertook from the main course
- If a student currently at level x for Literacy requests a hint, they are shown hint 1 relating to attainment level x ; the student is then expected to attempt the question – if they request a hint again without attempting the question, they are shown again hint 1
- If the student's first attempt is wrong, they can request another hint, in which case hint 2 relating to attainment level x is shown
- Any subsequent requests for a hint for that question result in hint 2 being shown again
- A hint is shown only if the student explicitly requests one, by clicking on a clearly visible “Hint” button

User Study

- For example, suppose a student currently at Medium attainment level is working on course Activity 3.1 (see paper) and requests a hint before attempting that question
- The student would be shown the hint “**Estas a reutilizar objetos quando os transformas em itens novamente uteis**” (“Reusing objects means transforming them into items that are useful again”)
- The student would then be expected to attempt the question - if they pressed the Hint button again, they would receive the same hint
- If the student's first attempt is wrong, they can request another hint; in this case, this would be “**Ao transformar um objeto antigo em um novo e desejavel, estas a reutilizar o objeto**” (“When you transform an old object into a new and useful item, you are reusing the object”)
- See the paper for details of the **pre-test and main course activities used in the study, the data gathered, and the data analysis**

4. Main Findings (see paper for details)

- **Relationship between pre-test performance and main course performance?**
 - students classified with High attainment level in Literacy after completion of the pre-test outperformed students classified with Medium attainment level (there were no students with Low attainment level in the study group)
 - hence students' estimated attainment levels can be used to predict subsequent learning performance, and therefore can provide robust information about which level the hints need to be adapted to
- **Relationship between level of attainment and accessing of hints?**
 - no statistical difference in the number of times hints were accessed between the two different groups
 - may imply that when hints are adapted to attainment level, students find such hints supportive even if their attainment level is high – this requires further investigation

Main Findings

- **Relationship between accessing hints and performance on activities?**
 - we did not find a relationship between the number of times hints were accessed and students' learning performance
 - a reason for this might be that students already had relatively high attainment levels: only medium and high levels of attainment were found from the pre-test activities (with 19 high-attainment and 4 medium-attainment students)
 - further investigation is needed with students showing a broader achievement range
- **Relationship between accessing hints and motivation on course subject and content?**
 - students with higher motivation are more likely to be engaged in performing a difficult learning activity, trying to overcome difficulties by seeking help via the hints

Main Findings

- **Relationship between accessing hints and learning experience?**
 - students who accessed the hints more often felt more positively about the VLE itself and would like to use it more often in the future
 - indicates the potential of providing hints tailored to the attainment level of the student, as this adaptation may have helped to create a better learning experience for students who accessed the hints more often
 - improving a student's learning experience is an important factor in learning as it is more likely that the student will use the VLE again for further learning
- **Relationship between motivation on course subject and content and performance?**
 - students who are motivated and interested in a particular course subject may perform better in activities centred on this subject

5. Conclusions

- The LIBE project was novel in addressing the development of key ICT information processing skills for those who need them most, namely young adults with low educational achievement
- This paper explores for the first time the provision of adaptive hints in this context, adapted to students' levels of attainment as they work through LIBE courses
- We investigated in particular the relationships between learners' accessing of hints, their motivation and their performance

Conclusions

- Our main findings were that:
- Estimated attainment levels can be used to predict subsequent learning performance and therefore can provide a robust basis for the adaptation of hints provision
- When students are highly motivated in the course subject they are more likely to access the hints available for a difficult task, which may in turn help them to complete the task
- Students who accessed the available hints more often felt more positively about the LIBE VLE itself and would be more likely to use it again the future, with important implications for lifelong learning

Further Work

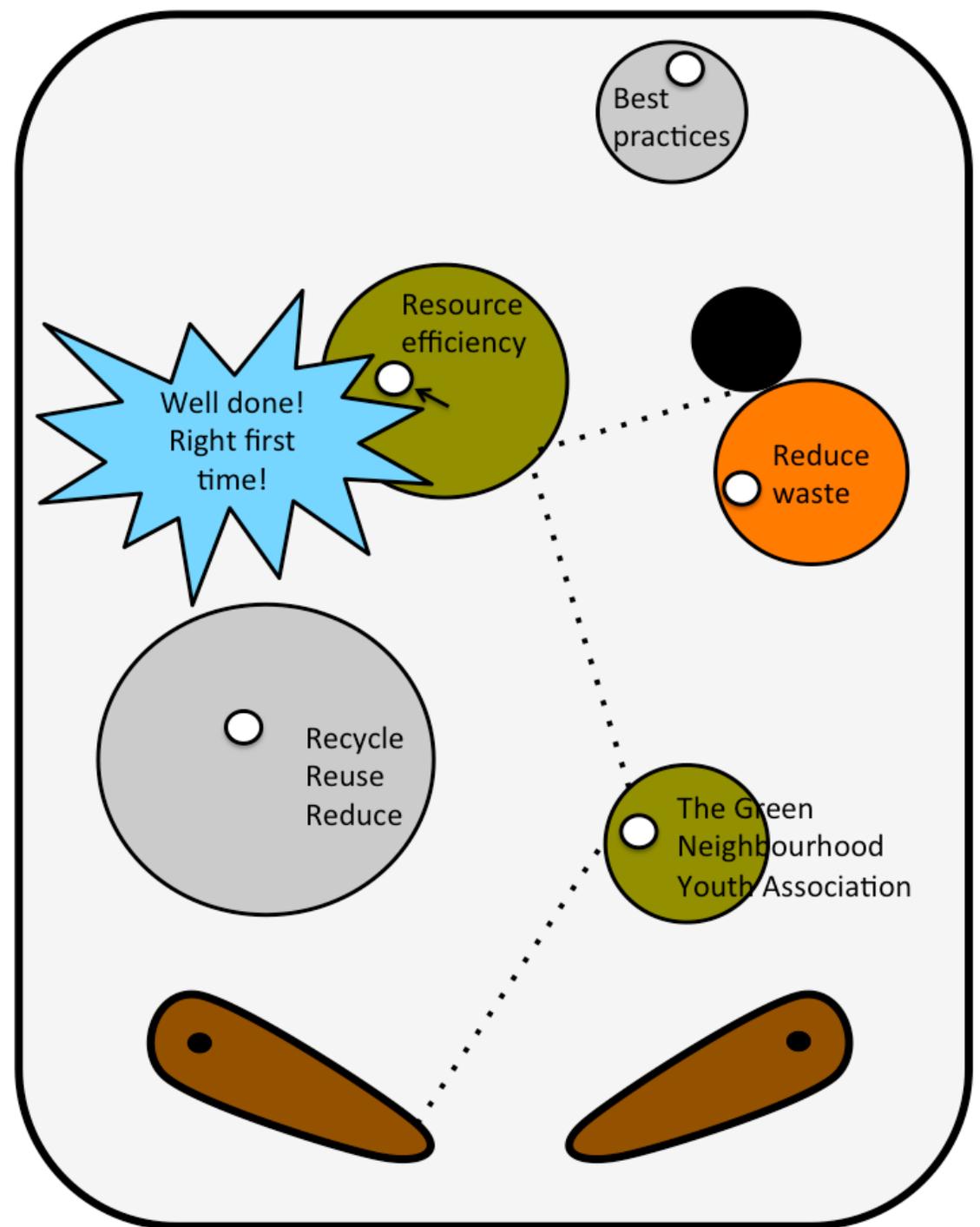
- The user study reported in the paper is small-scale and the results are preliminary findings
- Further research on the provision of adaptive feedback is required, including **more trials with student groups of broader achievement ranges**
- Also trials targeting the other LIBE competences too, beyond Literacy
- For these new studies, participants will be selected based on their performance in the targeted competence(s), aiming at an equal proportion of low, medium and high achieving students. This will help to investigate in more detail the association between students' achievement level and their accessing of hints
- We will also design an extended final questionnaire and also conduct post-session focus groups, so as to explore in more detail students' perceptions of the usefulness of the hints provided to them by the system

Further Work

- Finally, feedback from the focus groups held after the large-scale piloting phase at the end of the LIBE project included two key recommendations relating to further development of the LIBE VLE itself:
 - one focus group in Norway suggested that including a “timeline” showing a learner’s progression within the current course would help learners see “how far along they are”
 - one focus group in Portugal suggested that including a “scoring system” showing the learner how many correct and incorrect questions they had answered so far on the course would be a way of motivating them to do better
- These recommendations point to the need for research into the design of **Open Learner Models** in the LIBE context of developing ICT information processing skills for low-achieving young adults

Further Work

- Preliminary work in participatory design sessions with teachers has resulted in a game-like OLM proposal: a pin-ball machine
- Each course activity is represented by a circle
- Different colours show different levels of achievement in that activity



Appendix: LIBE VLE Plug-ins

| Plug-in Name | Description |
|---|--|
| Adaptive Quiz | Allows development of activities that are adaptive tests, comprised of questions selected from a question bank and tagged with a difficulty score. The questions are chosen to match the estimated ability level of the current test-taker. https://github.com/middlebury/moodle-mod_adaptivequiz |
| Questionnaire | Allows teachers to create a wide range of questions in order to obtain students' feedback on a course, activity, or the VLE itself https://moodle.org/plugins/view.php?plugin=mod_questionnaire |
| SWF | Useful for deploying M3U (playlists), SMIL, XML, and MPEG-7 multimedia learning interactions https://moodle.org/plugins/view.php?plugin=mod_swf |
| Authentication: Google/Facebook/Github/ Linkedin/Windows authentication | This plugin adds the "Sign-in with Google / Facebook / Github / Linkedin / Windows Live / VK / Battle.net" buttons onto the login page. https://moodle.org/plugins/view.php?plugin=auth_googleoauth2 |
| Restriction by language | This makes it easy to show a resource developed in a particular language only to students who speak that language. https://moodle.org/plugins/pluginversions.php?plugin=availability_language |
| Configurable Reports | This block is a Moodle custom reports builder. It allows the creation of custom reports without requiring knowledge of SQL. It is a tool suitable for administrators and teachers. https://moodle.org/plugins/view.php?plugin=block_configurable_reports |
| Sharing Cart | This is a block that enables sharing of Moodle content (resources, activities) between multiple courses. https://moodle.org/plugins/view.php?plugin=block_sharing_cart |
| Generico | This is a simple filter for creating templates of code snippets and text that can be inserted into Moodle text areas. https://moodle.org/plugins/pluginversions.php?plugin=filter_generico |
| Personalisation | Personalisation features developed specifically for the LIBE VLE. |
| Drag and drop into text | A drag and drop question type where missing words need to be dragged into gaps in a paragraph of text. https://moodle.org/plugins/view.php?plugin=qtype_ddwtos |
| Drag and drop markers | Allows the student to drag markers to indicate key features in an image. https://moodle.org/plugins/view.php?plugin=qtype_ddmarker |
| Drag-and-Drop matching | Question type similar to the matching question type but with a drag and drop interface for the students. https://moodle.org/plugins/view.php?plugin=qtype_ddmatch |

LIBE VLE Plug-ins (cont'd)

| | |
|--------------------------|--|
| Drag and drop onto image | Allows use of text and / or images as drag items onto defined drop zones on a background image. https://moodle.org/plugins/view.php?plugin=qtype_ddimageortext |
| Gapfill Question | A cloze question type with very simple question creation syntax. Supports drag drop, dropdowns and gapfill questions https://moodle.org/plugins/view/qtype_gapfill |
| Ordering | A question type that displays several short sentences in a random order, which are to be dragged into the correct sequential order. https://moodle.org/plugins/view.php?plugin=qtype_ordering |
| Select missing words | A question type that allows students to complete a paragraph of text by selecting the missing words using drop-down menus. https://moodle.org/plugins/view.php?plugin=qtype_gapselect |
| BCU | This is the theme from the Moodle site of Birmingham City University. It allows for extensive customisation and provides some features that help improve Moodle's usability. https://moodle.org/plugins/pluginversions.php?plugin=theme_bcu |
| Bootstrap | This is a Moodle theme based on the Bootstrap CSS framework. It has minimal styling and can be used to create User Experience optimized themes. https://moodle.org/plugins/view/theme_bootstrap |
| TinyMCE: Cloze Editor | An interface that integrates with Moodle's existing HTML editor (HTMLArea in 1.9 and TinyMCE in 2.x) to support teachers in creating Cloze (embedded answers) questions in the GIFT syntax. It can also read and edit existing Cloze items. https://moodle.org/plugins/view.php?plugin=tinymce_clozeeditor |

LIBE uses the BCU (Birmingham City University) theme, which allows course designers to select the preferred language, the visibility of blocks on the right hand side of the web pages (e.g. for Administration), and full screen mode. The BCU theme was modified for the purposes of LIBE using custom CSS to match the branding of the LIBE project. To support specific LIBE course needs, the functionality of some of the courses was also enriched with additional features using JavaScript.