Designing Multifaceted Open Social Learner Models

Lei Shi, Alexandra I. Cristea and Suncica Hadzidedic

Department of Computer Science, University of Warwick,
CV4 7AL, Coventry, United Kingdom
{lei.shi, acristea, s.hadzidedic}@dcs.warwick.ac.uk

Abstract. Open social learner modelling (OSLM) approaches are promoted in order to assist learners in self-directed learning, towards a higher level of presence and engagement. Still, most approaches only focus on visualising learners' performance, or providing complex tools for social navigation. Our proposal, additionally, emphasises the importance of *visualising both learners' performance and their contribution to a learning community*. We seek also to *seamlessly integrate OSLM with learning contents*, in order for the *multifaceted OSLM*'s prospect for ubiquity and context-awareness to enrich the adaptive potential of social e-learning systems. This paper thus presents the design of *multifaceted OSLM* by introducing novel, personalised social features into Topolor, a social personalised adaptive e-learning environment. The umbrella target is to create and study aspects of social learner models. An experimental study is conducted to analyse the impact of the newly introduced features. The results are concluded to suggest future research and improvements.

1 Introduction

It is envisaged that learners, especially younger generations familiar with Web 2. 0 (as in social) and Web 3.0 (as in personalised and social [11]) techniques embedded in their daily lives, are expected to have the ability to create and maintain their own personal learning environments, to interact with peers as well as learning resources, and be actively engaged in social e-learning environments. However, the availability of massive open resources and the diversity of connections and interactions have led to many challenges. Successful social e-learning requires tools to assist learners in directing their own learning and having a higher level of presence and engagement in order to participate in meaningful interactions [10], similar to popular social software.

Towards tackling these challenges, *open learner modelling* (OLM) approaches - coined also as *scrutable learner modelling* by Judy Kay [9] - have been adopted in the existing studies. OLM makes it possible for a learner to observe her learning status, so as to promote metacognition (e.g., self-reflection, self-direction and transparency) [31]. It has been suggested that learners studying together may benefit from accessing peers' models and group models [15, 32]. Studies have been conducted to explore the use of OLM [3, 14]. Several of them take into consideration also the social aspect of learning [1, 8]. Yet, much further research needs to be performed to enhance OLM, especially in terms of social personalised visualisation and interaction, which can potentially improve the social e-learning experience.

Following from existing studies, the main research goal presented in this paper is to explore the design of *multifaceted* open social learner models (OSLM) in *a social personalised adaptive e-learning environment* [18]. Compared to existing studies, this research aims at enabling interactive visualisation of different OSLM angles, to potentially promote metacognitive activities. Unlike existing approaches that use OSLM visualisation only as a social navigation tool, our approach also seeks to seamlessly and adaptively integrate OSLM with the learning contents, so that its ubiquity and context-awareness can support new adaptation and personalisation methods for social e-learning. It is also noteworthy that, unlike existing studies that focus only on visualising learners' *performance*, we emphasise the possibility and (in our view) necessity of visualising both *performance* and *contribution*, reflecting not only a learner's role as a knowledge consumer, but also that of a knowledge producer, which can better integrate in the Web 2.0 and Web 3.0 era. Importantly, the visualisation is built on a Facebook-like appearance, and on features inspired from popular games, instead of on traditional learning environment visualisations.

In the remainder of the paper, section 2 details related work on OSLM and systems supporting social learner models visualising, explaining the need of a *multifaceted OSLM*. Section 3 shortly describes Topolor, the social e-learning environment and the basis for the new *multifaceted OSLM*. Section 4 elaborates on the newly introduced features. An experimental study is reported in section 5, analysing the impact of these features; and section 6 outlines conclusions and future work suggestions.

2 Related Work

A learner model often refers to a model of knowledge, or other characteristics of a learner, constructed from direct input or observation of learning activities in, e.g., adaptive educational hypermedia systems (AEHS), and updated according to the learner's current understanding of the target learning contents; while an open learner model has specific provisions for the learner to explicitly view the information in her model, so as to support self-observation and self-reflection of her own and her peer learning processes, as well as explain to her the reason of getting a recommendation [9]. OLM have been implemented using a wide range of modelling approaches, such as models constructed using conceptual graphs [16], fuzzy models [17], and transferable belief models [12]. Various educational benefits brought by OLM are thoroughly discussed in the literature, such as raising learners' awareness of their current knowledge levels and encouraging them to reflect on the learning process [6].

In comparison with OLM, social OLM (OSLM) have pushed the research area of AEHS towards fostering diversification of learner modelling, richer visualisation and interaction of learner models [2, 32], and accumulating a great set of theories and techniques to build a variety of e-learning environments with personalised, adaptive and social features. Recent studies, as visited below, mainly focus on visualising the learning progress and providing social navigation support based on learner models.

IntrospectiveViews [8] provides parallel views on models of a learner and her peers. A learner can choose to compare her learning progress (completed, partially completed, pending, following) with either another peer's learning progress or the

average progress of the entire learning group. However, the comparisons have limited-level granularity representation of learning contents. QuizMap [1] has a 4-level hierarchical representation of a tree-map, and each level clusters different level of information in detail (from entire class's performance to individual's performance on a single question). A learner can also observe her own performance in comparison with the rest of the class. However, QuizMap cannot fit larger classes that generate too many cells on the TreeMap, causing it to become too crowded (information overload). ProgressiveZoom [13] is built upon the Google-Maps paradigm, seeking to address information overload issues, by enabling learners to zoom in or out in a multi-layer fashion. However, it has limited ability to control comparisons between learners.

To address these limitations, we thus seamlessly integrated *multifaceted OSLM* at all granularity levels of learning contents, i.e., at course level, topic level, resource level, etc. This addresses the limited-level granularity learning content representations in IntrospectiveViews, and the concern of too crowded user interface or information overload in QuizMap. Moreover, a *multifaceted OSLM* allows a learner to compare to individuals and groups, unlike in Progressive Zoom. Additionally, unlike these systems, we build *multifaceted OSLM* with Facebook-like and popular game-like visualisation, which potentially makes features easier to use by now-a-day's learners.

3 Topolor

Topolor is a social personalised adaptive e-learning environment. Its design refers to the connectivist learning theory [7], which argues that learning is process of creating networks of information, contacts and resources [30], and it is implemented based on requirement analysis studies [19]. The 1st version of Topolor [20, 27], launched in Nov 2012, was used as an online learning environment for MSc level students at two universities. It has been evaluated from various perspectives [21, 28, 29]. Based on prior evaluation results [22, 23, 25], the 2nd version Topolor has been developed. This is the environment in which we added and evaluated the proposed *multifaceted OSLM*. This section only presents those features related to *multifaceted OLSM*.

The backbone of Topolor is a hybrid network connecting learning contents and learners. Learning contents are organised in a classic *course-topic-resource* structure: a course consists of a set of tree-structured topics; a topic contains one or more resources, and could be shared by different courses. A learner can, e.g., register to a course, learn a topic, and share a resource. The *multifaceted OLSM* are seamlessly integrated at all granularity levels of learning contents beside learners' profile pages.

In Fig. 1, (1) and (2) illustrate a course page and a topic page, respectively. Learner models can be visualised in pop-up views by clicking buttons in (1.1) and (2.1) (see section 4 for details). A resource page, as shown in (3) in Fig. 1, contains (1.1) the author's information on, e.g., the number of resources and questions she shared. Fig. 2 shows a learner's profile page presenting her model. In the 'about' tab there are lists about her learning status, e.g., topics learnt, questions asked and answered. Clicking on tabs in (b) in Fig. 2 updates the sub-page below accordingly, so as to show her learning activities and the questions she asked, etc. In (a) in Fig. 2, by clicking on the button 'PK.' she can compare her learner model to the profile owner's learner model.

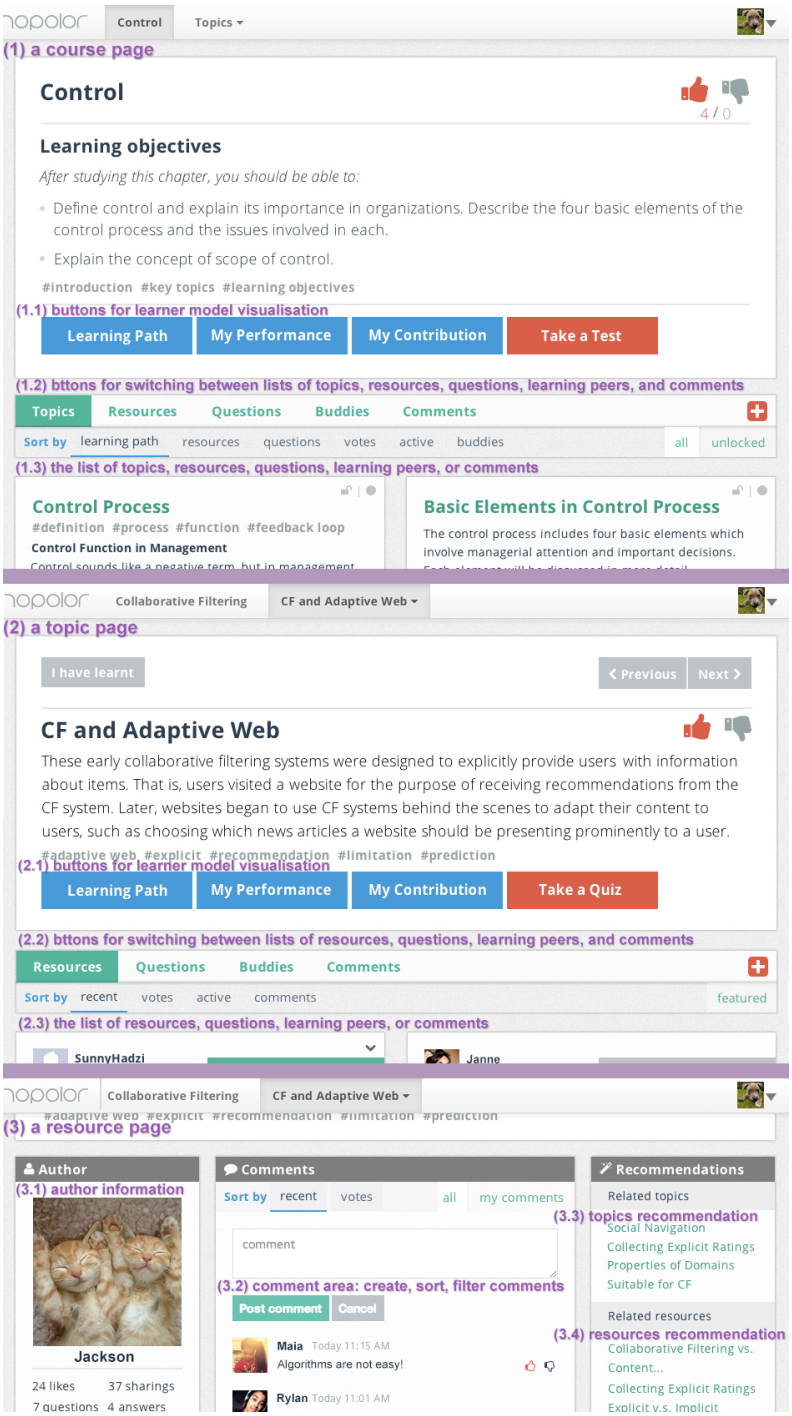

Fig. 1 Interface of (1) a course page, (2) a topic page, and (3) a resource page.

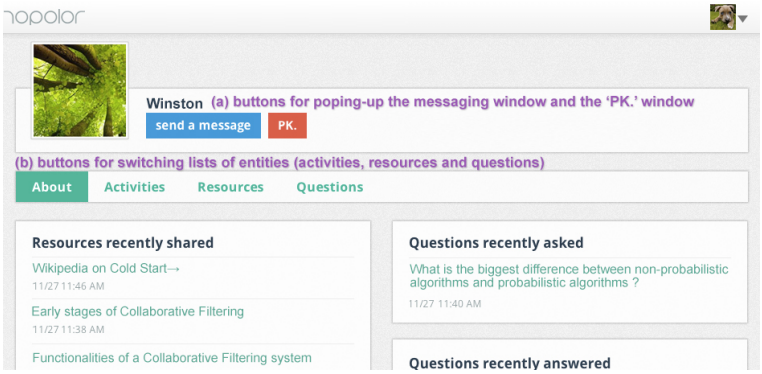

Fig. 2. A profile page.

4 Multifaceted Open Social Learner Modelling

We call the OSLM in Topolor 'multifaceted', because, firstly, a learner can access her model and her peers' models ubiquitously, and Topolor adapts the visualisations to fit *various contexts*, corresponding to the hierarchy course pages, topic pages, resource pages and profile pages. Additionally, it provides various visualisation modes, e.g., comparison between individuals, to all other learners, etc. These modes of *multi-context* and *multi-cohort* comparisons require enhancements of both adaptivity and adaptability, and are expected to further promote metacognitive activities. Unlike existing systems providing a single complex view of OSLM with many criteria to manually select in order to adjust visualisations, We propose to *adapt appropriate views of visualisations automatically*, to potentially improve the system's usability; and to *visualise both learners' performance and contribution*, reflecting learners' roles as both knowledge consumers and producers; specific features are shown below.

4.1 Visualisation of performance

Visualisation of performance is a common feature in existing OSLM approaches, such as [1, 8], potentially promoting motivation [8]. Topolor emphasises the importance of a *timeline* by presenting, e.g., test score trends, and the importance of *comparisons*, e.g., via the comparison of success rate in test between learners. On a course page (see (1) in Fig. 1) or a topic page (see (2) in Fig. 1), by clicking on the button 'My Performance', a pop-up view shows a learner's performance on the current course or topic. Fig. 3 demonstrates the pop-up view on performance of a course page. The default view contains the test score trends and the comparison of success rates of tests. For brevity not all tabs are shown here, but in short: the tab-view 'Topic / quiz' shows a two column charts presenting the comparisons of the average quiz score between a learner, the whole class and the top 20% learners. The tab-view 'Liked / bookmarked' shows a two column charts presenting how many times the shared resources were 'liked' / bookmarked. The tab-view 'Activities'

shows a radar chart and a column chart comparing activities (Fig 4). Fig. 5 illustrates the respective pop-up view of performance in a topic page, showing on the left the comparison of quiz scores, and on the right, the learner's corrected quiz answers.

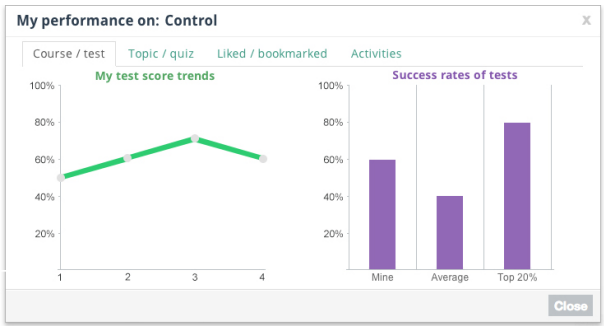

Fig. 3. Pop-up view of performance at a course level, also displaying its 3 other alternate tabs.

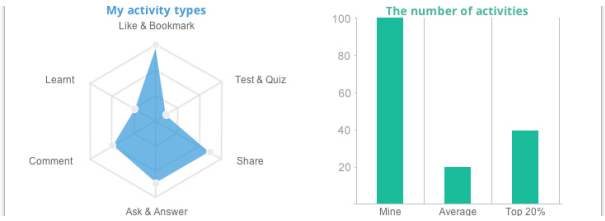

Fig. 4. Part of the pop-up view of performance, corresponding to a course level tab in Fig. 3.

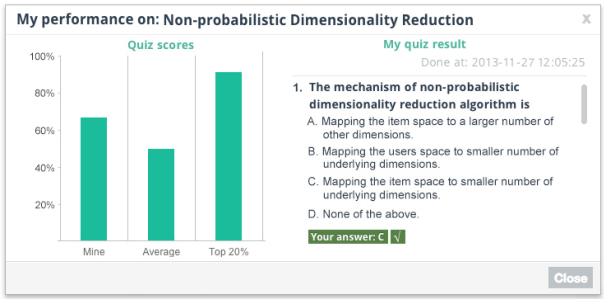

Fig. 5. Pop-up view of performance at a topic level.

4.2 Visualisation of contribution

In a social e-learning environment, learners act not only as learners, but also authors of learning contents. They contribute by, e.g., sharing, commenting, asking, and answering. *Visualisation of ones contribution* potentially encourages contributing more, as seeing each other's contribution may stimulate imitation and competition. By clicking on the button 'My contribution' on a course page or a topic page (see Fig. 1) a pop-up view of the contribution shows, as shown in Fig. 6, presenting comparisons of resources shared, the number of questions asked and answered, and comments.

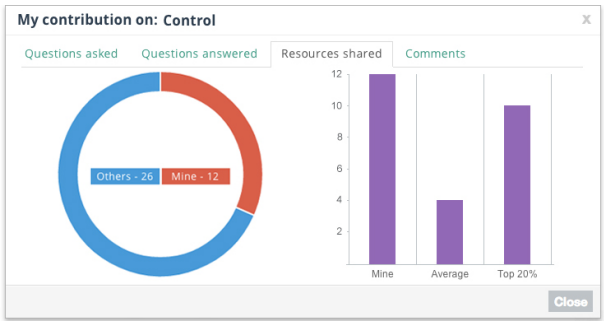

Fig. 6 Pop-up view of contribution, compared to others.

4.3 The PK. mode

The PK. mode is designed drawing from educational gamification [26], as an acronym for 'Player Killer'. On a profile page (Fig. 2), by clicking on the button 'PK.', a pop-up view shows, presenting comparisons of *performance* and *contribution* between a learner and the profile page's owner (Fig. 7). Contributions are questions asked and answered, resources, comments shared. Performances include correct tests, topic completion rate, the number of shared ('liked' and bookmarked) resources.

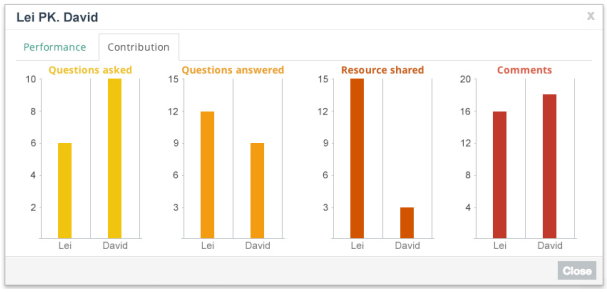

Fig. 7. The PK. mode: one-to-one comparison of contribution of two learners.

4.4 Visualisation of learning path

On a course page or a topic page (see (1) and (2) in Fig. 1), by clicking on the button 'Learning Path', a *learning path visualisation* view pops-up, as shown in Fig. 8. The tree structure graph represents the whole course structure, and the icons represent the learner's progress. For instance, a *hollow circle* means the learner has not learnt this topic yet; a *solid circle* means the learner has already learnt this topic; an *unlocked lock* means the learner is ready to learn this topic; a *locked lock* means the learner should finish learning all the prerequisite topics before start to learn this topic; and the *blue-coloured-background label* with the text 'Up next' recommends the learner that this topic is the most appropriate topic to learn for the next step.

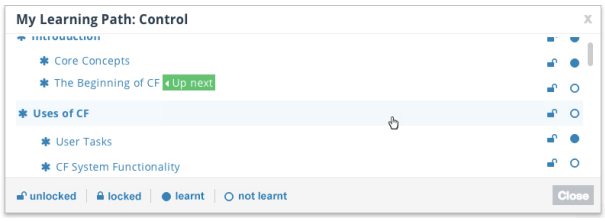

Fig. 8. Pop-up view of learning path.

4.5 Visualisation of activities

Topolor exposes learners' activity logs to learners, and they can 'like' and comment on each other's activity logs. This feature is designed based on our hypothesis that *observation of activity logs of a learner and her peers' can stimulate interactions, hereby improve the system's engagement*. There are two ways of viewing learners' activity logs. One is on the Topolor home page, as shown in Fig. 9, where a learner can filter to view her own activity logs or to view all learners' activity logs; the other is on a profile page (see Fig. 2) by clicking on the button 'Activities', where a learner can view the profile owner's activity logs, to allow various paths to information.

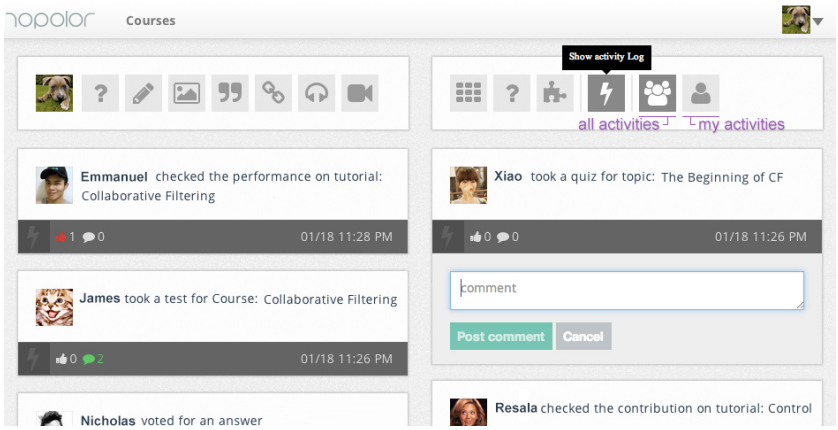

Fig. 9. List of activity logs on the Topolor home page

5 Experimental Study

Learners' perception of technology is among the determining factors for successful e-learning environments. The technology acceptance model [5], incorporating learners' perception on the technology's *usefulness* and *ease of use* has the ability to investigate learners' intention to use a system as a result of a group of perceived qualities, hence interpreting learners' desired outcomes. Following this model, this paper focuses the results of perceived *usefulness* and *ease of use* of the proposed *multifaceted OSLM*.

5.1 Experiment and survey

The experiment involved 15 students registered for an MSc module 'Dynamic Web-Based Systems', at the University of Warwick, learning a lesson on 'Collaborative Filtering' using Topolor, and familiarizing themselves with the *multifaceted OSLM* features. The experiment was divided into four stages: two time-controlled one-hour learning stages (students sat in the same classroom), one not time-controlled learning stage (students accessed Topolor at their preferred time and location), and finally the survey stage (coordinator-led optional questionnaire answering, feature by feature, to make sure they knew clearly which question referred to which feature). Students were explicitly told that their participation in the survey had no impact on module results. Ten of them submitted questionnaires. The questionnaire contains 165 questions, each of which applies a 5-Likert scale from 1 (*very useless* / *very hard to use*) to 5 (*very useful* / *very easy to use*) to evaluate the selected feature's *usefulness* and *ease of use*. Table 1 compresses only the 48 OSLM-related features, and with their visualisation modes; e.g., feature 13 visualises the comparison of the number of activities performed by a learner to the whole class, and the top 20% learners, as a bar chart.

Table 1. The evaluated *multifaceted OSLM*-related features.

Home page	01 filter by everyone's activities	02 Filtering by my activities
Course	03 view learning path - Tree view[@]	04 view my performance
page	05 view my contribution	06 view score trends - Line Chart[@]
	07 view test success rates - Bar Chart[*]	08 view average quiz score - Bar Chart[*]
	09 view topic completion - Bar Chart[*]	10 view 'Liked' - Bar Chart[*]
	11 view 'Bookmarked' - Bar Chart[*]	12 view activity types - Radar Chart[@]
	13 view # of activities - Bar Chart[*]	14 questions asked - Doughnut Chart[&]
	15 questions asked - Bar Chart[*]	16questionsanswered-Doughnut Chart[&]
	17 questions answered - Bar Chart[*]	18 resources shared – Doughnut Chart[&]
	19 resources shared - Bar Chart[*]	20 comments - Doughnut Chart[&]
	21 comments - Bar Chart[*]	
Topic	22 view the learning path - Tree view[@]	23 view my performance
page	24 view my contribution	25 questions asked - Doughnut Chart[&]
	26 questions asked - Bar Chart[*]	27questionsanswered-Doughnut Chart[&]
	28 questions answered -Bar Chart[*]	29 resources shared - Doughnut Chart[&]
	30 resources shared - Bar Chart[*]	31 comments - Doughnut Chart[&]
	32 comments - Bar Chart[*]	33 view quiz scores - Bar Chart[*]
	34 view my quiz results	
Resource page	35 Having author's information (author's name and stats)	
Profile	36 check my performance	37 check my contribution
page	38 PK., compare me with another	39 list of resources recently shared
	40 list of questions recently asked	41 list of questions recently answered
	42 list of courses currently learned	43 list of topics currently learned
	44 list of topics recently learnt	45 Statistics for the profile's owner
	46 waterfall list of activity logs	47 like an activity log
	48 comment on an activity log	

[@]: my data; [&]: comparison between me and the rest of the class;
[*]: comparison between me, the whole class and the top 20% of the class.

5.3 Results

The blue (dark) columns in Fig. 10 present the responses for *usefulness*. The mean values rank between 3.6 and 4.7, with standard deviations between 0.422 and 0.994. All the reported values are larger than 3 (the neutral response), suggesting students' attitudes to be generally positive. The yellow (light) columns in Fig. 10 present the responses for *ease of use*. The mean values rank between 4.0 and 4.7. The standard deviations are between 0.483 and 0.816. As all the mean values are greater than 3, we infer that most students found the *multifaceted OSLM* to be relatively easy to use.

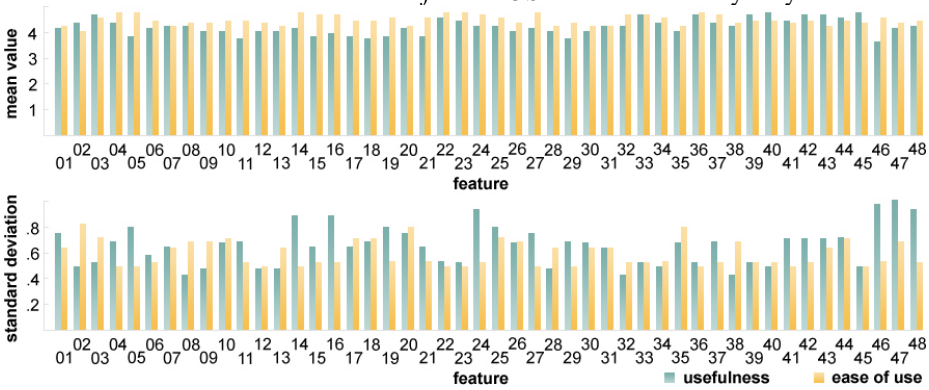

Fig. 10. Mean value and standard deviation of responses for *multifaceted OSLM* features.

Cronbach's alpha is adopted to measure the reliability of the test. A *Cronbach's Alpha* of 0.8 is considered as highly reliable [4]. The values of *Cronbach's Alpha* for the questions are shown in Table 2. Values for both *usefulness* and *ease of use* are considerably larger than 0.8, suggesting a high level of reliability of the results.

Table 2. Cronbach's Alpha (Reliability Statistics)

	Cronbach's Alpha	Std. Alpha	Number of items
Usefulness	0.963	0.965	48
Ease of use	0.978	0.979	48

6 Conclusion and Future Work

We introduced a *multifaceted open social learner model (OSLM)*, and populated it with features. The *multifaceted OSLM* visualises not only learners' *performance* but also their *contribution* to a learning community, potentially better catering for social e-learning, where learners are both knowledge consumer and producer. Additionally, the *multifaceted OSLM* provides various comparison modes that allow for visualising the differences between learners' learning history (e.g., in terms of test score trends), between her and another learner, and between her and a group (i.e., the whole class and the top 20% of the class). Moreover, the *multifaceted OSLM* is integrated and

adapted to learning contents, so that its ubiquity and context-awareness could enhance any system's adaptivity and adaptability, which potentially improves usability.

We also reported on an experimental study and evaluation, which illustrates a generally high level of learner acceptance of our proposed *multifaceted OSLM* features. This result may appear possibly counter-intuitive, due to the high number of features introduced, which may seem complex to a learner. In fact, in our previous study [24], we have found that using a Facebook-like appearance, and a game-inspired paradigm, quickly transforms learners into system experts. The study limitation is the low number of participants, although *Cronbach's Alpha* suggests a high level of reliability of the results. Moreover, Topolor has been opened to public (*www.topolor.com*), with larger learner cohorts expected in the near future, allowing for feedback, use data and suggestions collecting, in further studies. Other evaluation perspectives are on our agenda, e.g., if learners feel in control in interactions with *multifaceted OSLM*; if and how *multifaceted OSLM* leads learners to access recommended learning contents and to communicate with others, if and to what extent it promotes metacognition and makes Topolor more engaging.

Finally, we suggest new challenges for future work: (1) privacy management to allow learners to expose data to different groups in different ways; (2) metacognitive activity visualisation to promote self-reflection, self-direction and transparency; (3) visualisation-mode adaptation to provide personalised visualisation of the same data.

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