Less is More! Preliminary Evaluation of Multi-Functional Document-Based Online Learning Environment

Ville Isomöttönen Antti-Jussi Lakanen Vesa Lappalainen
Faculty of Information Technology
University of Jyväskylä
Finland
ville.isomottonen@jyu.fi, antti-jussi.lakanen@jyu.fi, vesal@jyu.fi

***Abstract*—This work-in-progress paper in innovative practice category presents and evaluates a multi-functional document-based learning management system, TIM (The Interactive Material). This system is developed with the goal of integrating a rich set of features seamlessly into teachers' every-day pedagogical and disciplinary needs. The aim is that a single system ("Less") would provide all technological solutions necessary for online teaching and learning ("More"), hence the punchline "Less is More!" We illustrate the system and evaluate it based on feedback from teachers. This preliminary evaluation focuses on how teachers reacted to the multi-functional system and is discussed in the context of Technology Acceptance Model (TAM).**

***Index Terms*—learning management systems; educational technology; evaluation**

I. Introduction

In higher education, learning management systems (LMS) play an important organizational function. Organizationally recommended campus-wide systems arguably provide consistent user experiences across varying educational situations. The study by Coates et al. [1] nevertheless reminds that the adoption of a campus-wide LMS can change the character of not only the students' learning experience but also the teachers' experiences of delivering their teaching practices. Moreover, a LMS prescribed from above, to be used in all teaching, or transitions to a new such LMS, have potential to engender complaints from a faculty who has difficulties in adjusting to the change introduced [2]. Generally, reasons underlying resistance to technology have been theorized to originate in the system itself, the users, or the interaction between the system and the users, that is, how well the system suits its purposes (see, [3]).

In technology-centered fields, many educators have chosen to develop educational technology. Self-developed systems have been argued to allow flexible reaction to local needs of teachers and students [4], and they have focused on specific settings, such as introductory programming [5]. This paper introduces a locally (faculty level) developed, open-source learning management system TIM (The Interactive Material) that attempts to fulfill a large variety of pedagogical needs by emphasizing multi-functionality as its design goal. The paper describes the TIM system for extending its user base and presents a preliminary qualitative evaluation based on teachers' feedback. We are interested in experienced benefits and challenges with a multi-functional system, given that LMSs can alter teaching experience. The results are discussed in the context of technology adoption model (TAM) [6].

II. Theoretical framework

The theoretical grounding for this research draws from the technology acceptance model (TAM), which explains what drives people to accept technology [6], [7]. TAM suggests that when a user is introduced to a new technology, the two most notable determinants of whether the user actually intents to use the technology are (i) perceived usefulness and (ii) perceived ease of use. Perceived usefulness refers to the extent to which a person believes that using the system will enhance his or her job performance, while perceived ease of use refers to the extent to which a person believes that using the system will be free of effort. These beliefs are strongly connected with users' behavior. Davis [6, p. 333] highlighted that "users are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform those functions." TAM has since been refined in subsequent iterations [8], [9]. TAM has regularly been adopted to evaluate technological tools that attempt to facilitate teaching and learning [10]–[12]. Related to technology acceptance, there is also some evidence that user involvement in system development has a positive influence in users' internal beliefs and attitudes regarding their computer system usage behavior, which, in turn, can help in accepting these systems [13], [14].

III. TIM, The Interactive Material

A. Background and usage

TIM is used for creating and managing interactive learning materials (documents), and is suitable for distance and in-class education. TIM is actively used in STEM fields in our university and has been piloted at a high school level. We can currently identify roughly 60 active teacher users, almost 4,000 users who have created at least on document, and over 9,000

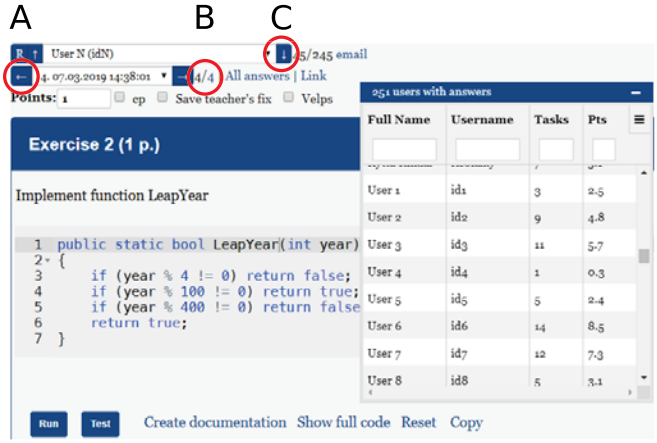

Fig. 1. Screenshot of a scenario of a teacher browsing through student submissions. A: Left and right arrows allow the teacher to browse submissions of one student. B: Current submission and number of one student's all submissions. C: Up and down arrows allow the teacher to select previous/next student. Note that this screenshot is a part of a larger, lecture notes-like TIM document that includes also other content, such as text, images, and video.

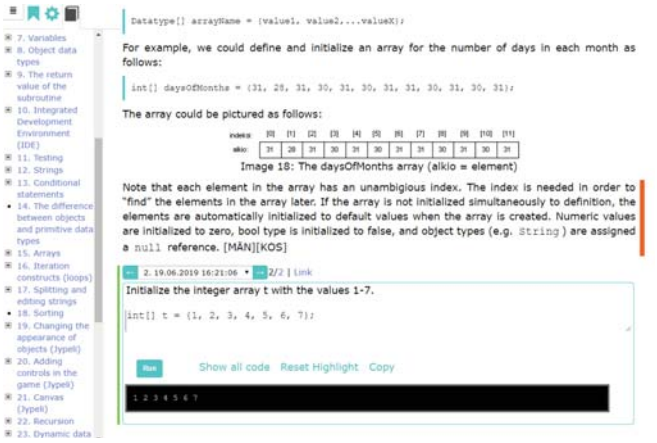

Fig. 2. An example of a TIM document. On the left hand side, a contents view is provided. The right hand side is the main area where theory and a related programming exercise are interleaved. Program output is displayed in the black box. Paragraphs currently unread are shown with red indicators until the user clicks on them.

logged-in users. TIM includes more than 20,000 documents consisting of teacher-prepared materials and various student submissions; most of the documents are student submissions. TIM has been used in introductory programming, databases, data networking, introductory physics, calculus, statistics, etc. Usage contexts have varied from small-populated courses to massive (e.g. 300+ participants), fully online courses.

B. Features

We identify several distinct features in TIM. First, it allows *teachers to effortlessly create* their own learning materials in the system itself. Creating and editing learning material means creating a document (rather than a "course area"). Therefore, TIM user experience emphasizes more content presentation and delivery than course management. An example of this emphasis is the paradigm of unifying a particular subject's theory and exercises together as one "flow," accessible as a single page rather than a selection of links to multiple pages, see Figure 2. Second, a document can be used in different scenarios. Students can use a TIM document for self-studying, or export it to a printable PDF for offline use. Teachers can use the same document during a lecture by transforming it into a slide presentation, adding clicker questions, or setting up a real time discussion. Hence, TIM supports both self-study and in-class work. Third, TIM implements automatic assessment (AA) for several exercise types and allows users to implement their own AA tools. TIM also includes a Latex engine for maths expressions and provides access to discipline-specific plugins. These features benefit science, engineering, maths, and computing teachers. Figure 1 gives an overview of the situation where a teacher is reviewing student submissions for a programming exercise. Below, we present some of the most used features in more detail.

Creating a new document begins from a blank or (user-made) template, or by borrowing segments of content from other documents. Content can include text, image, video, drawing, Latex formulas, or a more complicated "component" (see Components below). Templates are useful, for instance, when all students create content with a similar structure, such as a design document or a lab report. "Borrow" feature makes it possible to maintain content in one place and use that same content in multiple documents. Changes made to the root document are mirrored to the borrowing documents.

Access to and visibility of the documents can be defined per-user or per-group. Access and visibility can be time-restricted. Further, even content within a document can be defined or randomly generated with different user rights. For instance, by defining per-user rights for documents or within one document, teacher can create different "views" for different learners, thus differentiating teaching according the needs of learners. Similarly in a research context, different views could be created for target and control groups in controlled experiments. These flexible access and visibility features also support collaborative learning material production together with teachers and students. Yet another examples, taking advantage of randomly generated content and time-restricted access, are preparing exams, entrance exams, and contests.

Tracking of (un)read sections feature means that the user can monitor how they have interacted with the document. Paragraphs in the document are initially indicated as unread. The user can mark paragraphs as "read", which removes the "unread" indications. This helps user to proceed reading linearly or non-linearly and facilitates self-regulated learning. The texts that have changed (e.g, by the course teacher or other students) after the user has marked them as "read" are shown with a "changed" indicator.

User can comment documents for personal purpose or for other users. User can order email notifications about document changes and new comments. Teacher-student communication through comments writing has proved to be one of the most

utilized TIM communication feature. In addition, teachers can provide feedback for an assignment in the form of pre-defined phrases where grading cannot be automated.

Components for implementing different exercise types include a live programming environment (compilers available for more than 30 languages), multiple choice questions, maths tools (GeoGebra, Sage, Maxima, Octave, Stack, and MathCheck), drag-and-drop components, digital logic circuit simulation, and many more.

Automatic assessment can be utilized with several of the components. Teachers can prepare their own assessment components in the provided platform. For instance, the assessment scheme for programming exercises can be based on program output, unit tests, structures used, and/or code formatting rules.

Performance points are displayed in each document for users who have submitted their answers to the exercises. This display can act as a part of "gamified" learning experience. Points can be sourced from automatic assessments or self-evaluations. A summary of points is displayed at the top of the document, and each exercise displays exercise-specific points. By attending a shared TIM session, several users can work together on an exercise in a way that all collaborators are awarded points.

Comprehensive data tracking records all submissions for each exercise and logs how the user interacts with the document (e.g., idle periods at particular points and mouse movements). This can help teacher in forming an overall picture of students' learning processes and can be used for research purposes.

Additionally, there exists a large number of smaller features that attempt to facilitate different use cases that cannot be covered here (multi-language documents, gamification, macros, etc.).

IV. Evaluation

A preliminary qualitative evaluation that sought to inform future development and research was conducted. A questionnaire was issued to 55 teachers who were currently recognized as active TIM users, that is, convenience sampling was used. A total of 14 teachers responded, giving the response rate of 25%. All the respondents had self-selected to use the system based on the introductions to TIM provided in the campus or other users' recommendations. Examining their answers, we assumed them to be relatively experienced users of TIM and relatively self-efficient in terms of general computer usage. The respondents were teachers in physics, chemistry, maths, statistics, computer science, and information systems. The questionnaire consisted of the following open-ended questions:

- What would you raise as useful aspects in TIM? Consider the system use in relation to your own teaching.
- What features do you particularly use or value?
- What challenges have you encountered with TIM? Consider challenges in relation to your own teaching.
- Can you identify unneeded features in TIM? What and why?
- What new features would you hope to be implemented in TIM?

Through these questions, we attempt to illuminate teachers' intentions with TIM, and then compare these intentions with TAM. Hence, following the 'conventional' research setting in qualitative content analysis [15], TAM did not direct analysis but provided a ground for reflecting on the categories identified in the qualitative data.

The evaluation is summarized in Table I. The basic usage of TIM—that learning material can be shared flexibly and produced by editing a book-like document directly where it is published—was favorably evaluated; see categories *manageability* and *accessibility*. The idea of a linear document and the basic use were also deemed easy; see categories *conceptual simplicity* and *simple basic use*. TIM was perceived as a platform that gives users *freedom to enact intended pedagogy*. *Multi-functionality* was valued in a way that the system was favorably deemed *self-contained*. One and the same system was experienced to *diversify student learning*. *Specfic features* illustrate how a locally developed system incorporated critically needed functions matching the pedagogic and specific disciplinary needs. In our interpretation, these outcomes demonstrate the "Less is More" design goal.

The challenges reported were a *learning curve* needed, and relatedly the *lack of clear instructions*, *inconsistent user experience*, and *non-modern UI*. When compared with the benefits reported, these challenges appear a reverse side of the coin: TIM's development work has included active responding to the user community, which seems to have created a trade-off between perceived usefulness and ease of use, in particular beyond the basic use that was deemed easy. In this connection, an interesting detail was the teachers' experience of quick reaction to user requests as compared to an organizationally recommended LMS; this has been deemed necessary for the dissemination of the system and is known to engage users [13]. The participants also referred to TIM favorably when they compared its linearly growing book appearance with the layout of the organizationally recommended LMS (Moodle).

An interesting detail was the participants' hope for a course-level summative assessment functionality. This hope was grounded in university-level changes in information systems: Another locally developed system is being replaced with a new acquired system. This locally developed system allows teachers to define assessment functions (how to calculate course grades over multiple course components). The current TIM users seemed to hope this feature to be included in TIM based on their realization that it will not be available in any of the organizationally supported campus-wide systems. This implicates that teacher preferences (acceptance and resistance) should be understood in the continuum of how previous, current, and prospective systems are perceived as for their usefulness. While such continua are acknowledged in information systems research (e.g. [16]), the foregoing suggests that a case study on co-existing LMSs could valuably inform the acquisition of these systems. As an aside, the feature hoped by teachers is currently in test use in TIM.

TABLE I
TEACHER EVALUATIONS OF TIM

Benefits	Example phrases
Freedom to enact intended pedagogy	[P8] The platform can be subordinated to pedagogic use as one wants to. The platform is like a tabulae rasae on which intended pedagogy can be built on.
Conceptual simplicity	[P2] Another thing I appreciate is the book-like appearance. I have had to use [in particular context] Moodle, which I think is confusing. In jumping between the links [in Moodle] you are all the time searching for particular information whereas in TIM the chronology [cf. linear presentation] helps picturing the material. [P8] TIM page is an empty document whose structure is fully observable directly from "source code." [...] A counter example is Moodle in which you click here and there and the overview is lost.
Simple basic use	[P5] Producing the basic frame for the material is very easy with TIM.
Self-contained	[P14] Learning material, exercises, all you can think of, is in the same place. [This] facilitates logistics of teacher and students. [P4] You can include interactive components. Moreover, videos and all other material linked becomes available, and also exercises can be returned to the same system. So, everything is in the same place.
Multi-functionality	[P3] Multi-functionality, if you are skillful you are able to create varying contents.
Manageability	[P] Good material management together with students. [P] Modifiablity, and the possibility to distribute for those concerned.
Accessibility	[P3] Ease of use due to the fact the material is directly edited in the [publication] site. [P6] TIM delivers on its promises well. For instance, I have edited learning materials during a bus trip.
Diversification for leaners	[P1] TIM material can be filled with interactive components and visualizations that diversify student learning.
Low threshold for student experimentation	[P2] In my own teaching, the good thing is the possibility to run programs directly in the material. This lowers threshold for students' experimentation [with code].
Teacher workload reduction	[P1, talking about automatic assessment features:] In my teaching, compared to previous hand-work, I have been able to substantially increase the number of exercises while reducing the time needed for assessment
Specific features	Maths expressions with Latex, export to printable, interactive components, visualizations, running code in browser, all submission data stored
Response to users	[P3] Quicker responses from support compared to Moodle.
Challenges	**Example phrases**
Learning curve	[P12] Many features require relatively lot of practice of a teacher.
Inconsistent user experience	[P1] You do not necessarily find all the useful features and their deployment can be difficult if the feature do not always function in a similar way. [P4] Before the material with lots of maths symbols rendered slowly. After this was fixed and symbols are rendered as figures, they are always black [compared to previously available colors].
Lack of clear instructions	[P5] Part of instructions are rather technical text [...] I would prefer to have more lucid exposition on what is being done and why.
Non-modern UI appearance	[P8] Currently, it looks and feels archaic, 90s website. A modern appearance and user experience would make TIM a tempting platform also outside the university.
Summary of unused features	
Rather than feeling complicated, participants very consistently noted that it was not problematic to have more features available than currently in use: [P5] As observable in titles in TIM instructions, there is nothing that I could not be using some day, regardless that they are currently unused.	
Summary of hopes	
Hopes reflected the challenges (instructions, UI clarity) or gave a detailed improvement suggestion for a particular functionality. In addition, one hoped for a peer review functionality and yet another suggestion was adaptive user interface according to use frequency of features. Many respondents hoped for the possibility to define a course-level summative assessment function.	

The above is in line with the theorization of TAM, that perceived usefulness is more important aspect of adaption than ease of use, while difficulties in usage can complicate initial adoption [6]. The participants had themselves selected to use TIM and from that perspective seemed to have overcome the experienced challenge with a user experience. Nevertheless, their critical evaluations help us to pay attention to ease-of-use as TIM continues to grow, in particular to be able to invite new user communities with less technical background.

V. CONCLUSION

This preliminary evaluation revealed useful aspects. Teachers' critique on user experience help us to focus development work. This criticism was accompanied with favorable comparisons with organizationally available LMSs. Therefore, the present evaluation also suggests that co-existence of locally developed and organizationally recommended LMSs is needed and can be rather necessary for some users. In line with TAM, we thus observed that some users are willing to cope with difficulties in use in a locally developed system if this system provides critically needed functions that are not available in an organizationally recommended system. This observation encourages more research on acceptance and resistance in co-existence scenarios. More research is needed to understand inter-operability and potential duplicate data in different systems, and the effects of these issues on perceived usefulness and ease of use. Moreover, we believe that future work should study how users can be involved in the development processes and how to improve the funding bases of locally developed systems.

Of the positive evaluations, we would emphasize that teachers reported that they experienced freedom to enact their personal pedagogy and concurrently reported on the ease of basic use; this outcome validates the design goal of TIM. Altogether, based on the feature set introduced and positive evaluations from teachers, the authors hereby disseminate TIM for extending its user base and evaluation.

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