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Acceptance of learning management system: The case of secondary school teachers

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Abstract There are many ICT tools that teachers can use to support teaching and learning. In recent years, Learning Management Systems (LMSs) have been present in most higher education institutions. However, the availability of LMSs in K-12 is more recent. Furthermore, we believe that LMSs are promising even for K-12 teachers in face-to-face learning contexts because they have many educational features that can support learning with students. The goal of this study is 1) to identify the factors that influence the acceptability of the LMS by teachers, 2) to see if teachers' ICT use influences their intention to use the LMS, and finally 3) to see if teachers' ICT use influences their perception of the affordances of LMS educational features. The LMS in our study was introduced in a school board of more than 35,000 students and approximately 2400 teachers. To study the acceptability of the LMS, we used the Technology Acceptance Model. The results obtained from the show that the perception of usefulness is a good predictor of the intent to use the LMS. As for ICT use and the affordances of LMS educational features, the results show that they are not a good predictor of the intention to use.

Keywords Learning management system (LMS) · Technology acceptance · Teacher · Secondary schools · Information and communication technologies (ICTs)

1 Introduction

Many studies and reports note the importance of effectively using ICTs in educational contexts in order to prepare students for twenty-first century skills (Ananiadou and Claro 2009; Ertmer and Ottenbreit-Leftwich 2010; OECD 2015; Somekh 2007;

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UNESCO 2008) However, the scientific literature regarding ICTs in education shows that teachers often face obstacles to integrating ICTs in the classroom (Bingimlas 2009; Drent and Meelissen 2008; Hew and Brush 2007). Furthermore, initial and continuous teacher training has significant shortcomings and the teachers themselves lack the necessary support, they often do not see the pedagogical value of ICTs or lack pedagogical models (Johnson et al. 2015; Tondeur et al. 2012). Consequently, we consider that the integration of ICTs is a complex process for teachers to use, since the dynamics of the contextual variables that influence an innovation in education are complex in themselves (Brown 1992; Wang and Hannafin 2005). Also, the possibilities of integrating ICTs in education are many, not to mention the fact that ICT innovations come and go quickly (Pynoo et al. 2011). We can therefore assert that the educational usage of ICTs remains a challenge year after year (Angeli and Valanides 2009; Bauer and Kenton 2005; Overbaugh and Lu 2008; Tondeur et al. 2012; Koehler and Mishra 2009).

To operationalize on-line training, the use of learning management systems (LMSs) is clearly essential. However, LMSs are not seen as critical in classrooms and teachers are also free to use other ICT tools, or to simply not use any at all (Schneckenberg 2009). Among the opportunities available to teachers to support teaching and learning with ICTs, learning management systems have many educational features to support teaching and learning. Thus, a given LMS may allow the dissemination of resources, the relocation of educational activities outside the classroom walls, or the establishment of tele-collaborative activities. Furthermore, their potential also resides in the fact that on-line hybrid learning is effective. Indeed, the meta-analysis carried out by Means et al. (2010) reveals that there is a positive advantage of online versus face-to-face learning.

This research project was carried out in a school board in the Montreal, Canada region. The latter has nearly 35,000 students and around 2500 teachers, with only one Web portal available. Therefore, access to an LMS in this environment is nonexistent. Although this portal may contain certain educational features, its aim is mainly to support administrative, rather than educational, processes.

In that sense, we wish to study the use of an LMS in secondary schools, and to what extent teachers understand the usefulness of this tool, and if they've understood its pedagogical functions. Thus, we sought to know 1) what are the factors that influence the acceptance of an LMS? As well as 2) Does the use of ICTs affect the intention to use an LMS? Finally, 3) Does teachers' ICT use influence their perception of the affordances of LMS educational features? The present text first presents the research context, followed by the theoretical framework. Next, we present the methodology, results and discussion. We end with a conclusion and the limitations of the research project.

2 Problems and context

This research project was carried out in a school board in the Montreal region. Although this portal may contain certain educational features, its aim is mainly to support administrative, rather than educational, processes. Among all of the technological tools that are available to secondary school teachers, the initial question that we

ask is: do secondary school teachers really need an LMS? In reality, teachers use the pedagogical functions at their disposal only rarely, if at all. Therefore, we believe that by putting at their disposal an LMS that is specifically designed to operationalize online pedagogical tasks, teachers will enrich their classes with ICT.

To answer this question, we used the Design-Based Research (DBR) methodological approach. This approach is relatively new in scientific literature. Its founding text by Brown (1992) regarding the design of a research project in a complex environment, put forward the idea of carrying out the experiments in situ while taking into account their theoretical foundations. Subsequent articles by The Design-Based Research Collective (2003), as well as Wang and Hannafin (2005) and of Barab and Squire (2004) allowed the formalization of DBR projects where the underlying theory and the iterative design of practical solutions are linked. An important feature of DBR research involves the collaboration of several participants in the field in order to test the proposed solutions and to evaluate them using recognized scientific methods (Plomp and Nieveen 2009). Thus, this article is part of a larger research project. The first iteration of the project has already been tested in the field; this iteration consisted of setting up a prototype LMS and to assess its relevance for teachers. The analysis of this phase using a focus group and a logbook entailed the identification of adaptations and changes that are necessary for the LMS to meet the needs of the context and of the actors involved. This approach is essential to encourage the acceptance of the LMS by teachers. After implementing the adaptations and changes that were identified during the first iteration, a new prototype of the LMS was deployed. The current iteration aims to identify factors that promote the acceptance of the LMS and, subsequently, to develop strategies to foster this acceptance. This approach has allowed us to validate if an LMS is useful to secondary school teachers, within the TAM framework.

3 Theoretical framework

The Technology Acceptance Model (TAM) is inspired by the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975), which aims to predict and explain social behavior by using a small number of theoretical concepts. First of all, the behavior of an individual is primarily determined by the concept of "behavioral intention", since he is considered to be the direct cause of the behavior (Ajzen and Fishbein 1980). Therefore, a given behavior is based on the deliberate choice of the individual. This choice is motivated by an awareness of the individual given the information available to him and after assessing the consequences of his decision Fig. 1.

Developed in the late 1980s, the TAM model (Davis 1989) is an adaptation of the TRA model that caters specifically to the field of information technology. More specifically, the TAM model aims to predict users' acceptance of technologies (Davis

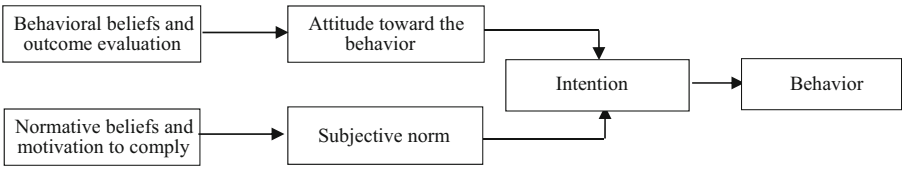

Fig. 1 Theory of reasoned action from Fishbein and Ajzen (1975, p. 16)

et al. 1989). In the same spirit as TRA, the Technology Acceptance Model aims to identify the acceptability of an information system using a reduced number of variables,

Among the many models found in the literature, the TAM model is widely used by researchers to study the acceptance of an information system (Brangier et al. 2010; Février et al. 2008; Kreijns et al. 2013; Park 2009; Van Raaij and Schepers 2008; Venkatesh and Davis 2000).

The TAM model is useful to explain the factors that contribute to the acceptance of a certain technology, as well as to identify what is acceptable and what is not acceptable from a user perspective. Thereafter, it is possible to modify specific elements of the technology in order to make it acceptable (Fig. 2). This process is defined by two factors: perceived usefulness and perceived ease of use. Perceived usefulness refers to what technology will improve for the user, whereas perceived ease of use is the idea that a user does not have to provide any effort to assimilate the technology.

The TAM model has undergone many additions, and following its evolution is not an easy task (Brangier et al. 2010). Benbasat and Barki (2007) argue that the many adaptations of TAM were carried out based on constant technological changes. These adaptations have contributed to a confusion in which it is not easy to find a model that is accepted and achieves a consensus in the research community.

A significant contribution to the model is undoubtedly the Unified Theory of Acceptance and Use of Technology (UTAUT), by Venkatesh and Davis (2000). Following criticism from many researchers (King and He 2006; Kreijns et al. 2013), Venkatesh and Davis (2000) revised the TAM model. Entitled TAM2, this revision takes into account external variables, contrary to the original TAM model in which intentions regarding technology use were linked to individual characteristics. More recently, TAM3 was proposed by Venkatesh and Bala (2008). It now accounts for factors related to self-efficacy and anxiety in the use of technology, since these factors can influence the perceived ease of use (Venkatesh and Bala 2008).

The TAM model and its derivatives have been used in much scientific research in a fair number of areas. The main criticism of these models are their divergent and contradictory results (Février et al. 2008; King and He 2006; Legris et al. 2003). A limitation that was raised by Legris et al. (2003) regarding the TAM model is that its prediction of the variance in intention to use is of 40%, despite improvements to the model and the addition of new variables. However, the results of the UTAUT model validation cover up to 70% of the variance in intentions to use (Venkatesh et al. 2003). Nevertheless, the TAM model has proven its utility in contributing to the understanding and explanation of intention to use during technological implementations (Legris et al. 2003). The meta-analysis of 88 research projects that employed the TAM model

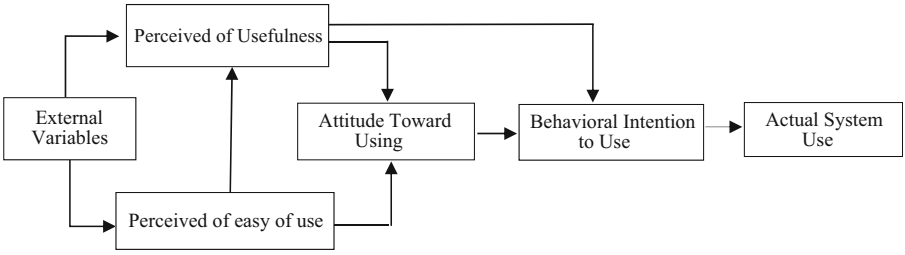

Fig. 2 Technology acceptance model (Davis et al. 1989, p. 985)

showed that measures of perceived usefulness for predicting the intention to use are reliable and can be used in many contexts. In the context of this research, the Davis' (1989) TAM model is more than sufficient to identify a limited number of factors based on which an intervention strategy can be implemented. Therefore, TAM is an appropriate approach to studying acceptance of LMS among teachers. It allows us to orient subsequent interventions and to add new dimensions, in our case for use of ICT and affordances, and has allowed us to better contextualize TAM and the intentions to use that ensued.

3.1 ICT use

In view of adopting an educational innovation, we considered that ICT use could constitute an interesting variable to consider in exploring the factors that can encourage the acceptance of the LMS. Since the TAM model allows the inclusion of contextual variables, it is therefore possible to test this specific contextual variable to see if it influences teachers' acceptance of the LMS. Consequently, we propose the following: the use of ICTs among teachers may be a good predictor of the intention to use dimension of the TAM model. Although it is not a central element of the present research project, we nonetheless considered ICT use among teachers in our model. However, we did not raise the notion of ICT use with the intention to employ it to constitute an inventory or a typology along axes that globally relate to the field of education (Basque and Lundgren-Cayrol 2002), but rather to specify them within an educational context.

ICT use among secondary school teachers can be confusing since, on the one hand, there are many views regarding the subject and, on the other, because the existing literature is not explicit. Several researchers address the use of ICTs depending on their context, on a typology, or simply by categorizing the different uses. Furthermore, some researchers even mention usage ability in cases where teachers have access to the necessary infrastructure and training in order to implement educational use of ICTs (CEFRIO 2015). For others, ICT use is characterized by the frequency of use by either teachers or students (Cuban et al. 2001; Wastiau et al. 2013). In our case, we divided ICT uses in an educational context into three types: the first type combines uses of various technologies by the teacher for the design of educational materials; the second type refers to the use of technology for teaching purposes; the third type refers to activities in which students actively use ICTs.

3.2 Affordances

The term "affordances" was first proposed by Gibson in 1977 and in 1979. It defines the concept of the affordances of an environment as "[...] what it offers the animal, what it provides or furnishes, either for good or ill" (Gibson 1979). Gibson's ecological approach is also presented as the set of possibilities between the environment and the actors (John and Sutherland 2005; Norman 1999). The concept of affordance has subsequently been reused in many contexts, and particularly in the domain of design.

Referring to the concept of affordance can permit a better usage and understanding of technology in terms of its applications for learning and for teaching (Conole and Dyke 2004). However, this approach leads us to ask several questions, including: "Practitioners are still exploring the potential of new technologies, and the current uses of technologies

often do not take full advantage of the medium. Therefore, how can practice take full advantage of the affordances of ICT? " (Conole and Dyke 2004).

Therefore, it is possible to bring teachers to be more aware of the affordances of ICT. To this end, Kirschner (2002) argues that the work of Norman (1999) and Gaver (1991) is useful in the design of learning management systems.

In this perspective, the concept of affordance enables us to explain a facet of the difficulty of educational integration of ICTs among teachers. According to Gaver (1996), new technologies tend to undermine existing practices while generating new ones. Since the technological environment influences behavior, the design process requires extra caution to establish new practices within a target community (Kirschner 2002). This is important in our case because it allows us to determine if the pedagogical functions are seen. Teachers, therefore, are in a position to see to what extent an LMS is useful for them. Otherwise, they'd be speaking out on a tool that has no clear representation for them.

3.3 Learning management systems

As part of our research project and due to the lack of a consensual definition, we consider that an LMS is an integrated software that supports the development, dissemination, evaluation and administration of in-person classes, with the possibility of implementing blended or distance learning (Wright et al. 2014). More specifically, an LMS is an application that runs on a Web server and that is accessible via a Web browser over an Internet connection (De Smet et al. 2012). In our case, the LMS is not used in a context of blended or distance learning, but rather given the extent of its potential to support the teaching-learning process of in-person classes. In this regard, we define an LMS as: an on-line learning system that enables communication, the dissemination of resources, and the implementation of learning activities with the use of the educational features included in the LMS, all this to a group of learners within a secure space managed by a teacher while being accessible by any type of technological device connected to the Internet.

This definition allows us to pinpoint an LMS among the many ICT tools available to teachers. We agree that the features included in an LMS can be found in different applications accessible to teachers. However, the simple fact of gathering these features in an on-line learning system while aligning them with the school context enables us to justify the idea that an LMS can represent a technological innovation for secondary school teachers.

An LMS seems appropriate, but we must ensure that it adequately responds to the needs of secondary school teachers. TAM allows us to validate if this tool is perceived as being useful, if it's easy to use, and what are the intentions to use. The flexibility of the TAM model also allows us to investigate if other variables influence the intentions to use an LMS, such as the affordances and use of ICT.

4 Methodology

4.1 Participants

For this research project, we deployed the LMS with all teachers of the school board. To inform teachers of its existence, various communication strategies were established.

In addition, a limited number of teachers received training on using the LMS. We then called upon the teachers who were trained to use the LMS and those who were aware of its existence for our study, in order to see the extent to which these teachers were susceptible to use the platform. The goal was to identify, using the TAM model, the factors that promote the acceptance of an LMS by teachers. At the same time, we also interviewed teachers regarding how they use the LMS, as well as their view regarding its affordances. To meet these objectives, a questionnaire was used in order to measure to what extent perception of usefulness, ease of use, external variables, perceived affordances and the use of ICTs influence the acceptance of the platform.

The teachers involved were from all secondary school levels and disciplines. 246 out of a total of more than 1000 secondary school teachers from the school board where we carried out the research were invited to answer an on-line questionnaire. This sample corresponds to teachers who use the LMS or those who have already explored it. More specifically, 80 teachers received LMS training, while the other 166 teachers only attended a presentation regarding the LMS.

Of the 246 invitations sent to teachers, 129 participants responded to the questionnaire, while 24 participants were removed because their questionnaire was incomplete. Therefore, we had 105 participants who completed the questionnaire in full, which represents a 42.7% response rate. Given that there are roughly 1000 school teachers in this school board, it is not surprising that the number of respondents corresponds to approximately 10% of all teachers, since the LMS was available for only one year before the completion of the questionnaire. Also, we note that the number of participants was also limited because we were in an innovative context.

4.2 Data collection

The instrument that we used for data collection was a questionnaire based on the Davis' (1989) TAM model. This questionnaire was translated and adapted. The adjustments we made were minor and consisted of simply substituting one type of technology. The instrument has a section regarding the profile of respondents, with six items designed to paint teachers' sociodemographic profiles (Tables 1 and 2). With regards to the TAM model, the sociodemographic profile is considered an external variable. Both the section on the perceived ease of use and that on perceived usefulness contain six items, whereas a final section on intentions to use contains two items. The questionnaire items that we have presented are part of the TAM model. According to Davis (1989), the model is flexible and other items can be added to better fit the context. Therefore, we added questions regarding the perceived affordances of educational features in the LMS (eight items).

The completion of the questionnaire took place in November 2014 using an online data collection tool. We sent invitations to teachers via email, asking them to respond anonymously to the questionnaire, which was accessible via a hyperlink. Therefore, a month after the first invitation, teachers who had not responded to the questionnaire were reminded of the fact via email. We were not able to send out other reminders since another research project regarding ICTs was about to start with teachers. Finally, following this data collection, it was easy to export and process the data using statistical analysis software such as SAS and SPSS.

Considering that our questionnaire was translated and adapted to our context, we validated the internal consistency of its items by carrying out a Cronbach's alpha

Table 1 Sections of the questionnaire and number of items per section

Questionnaire sections	Number of items
Sociodemographic profile	13 items
Perceived ease of use	6 items
Perceived usefulness	6 items
Intention to use	2 items
Perceived affordances of educational features	8 items
ICT use	3 items

analysis. Therefore, when we obtained a coefficient above the minimum threshold (within a range of 0.60 to 0.70), we can consider that the internal consistency of the data is acceptable (Nunally 1978). Thus, for the dimensions of the TAM model such as ease of use and usefulness, we obtain coefficients that exceed the 0.90 threshold.

4.3 Data analysis

First, we conducted a principal components analysis (PCA) to see which dimensions were the most important. This approach is useful to reduce the number of variables to a limited number of components (Tabachnick and Fidell 2013). The PCA was performed in a confirmatory perspective with the TAM model regarding the dimensions of ease of use and usefulness. Thus, the results of this analysis allowed us to better target our next iteration. Subsequently, to test the TAM model with our data and to ultimately identify which one of its dimensions influences LMS acceptance, we conducted a path analysis. Originally developed in the 1920s (Schumacker and Lomax 2012), this type of statistical analysis is part of the family of structural equation models and is still widely used today (Kline 2011). Path analysis is useful to confirm relationships between variables and to validate whether they fit well with a theoretical model (Hatcher and O'Rourke 2013). In this sense, as noted above, the TAM model essentially shows that the ease of use influences the perceived usefulness, which in turn directly influences the intention to use (Davis et al. 1989).

Finally, path analysis is useful to empirically test the relationship between the dimensions of the TAM model. Consequently, this type of statistical analysis allowed us to see if our data fit with the Davis' (1989) TAM model and therefore to identify which factors influence teachers' acceptance of the LMS. In addition, the statistical

Table 2 Cronbach's alpha analysis

Dimensions	Number of items	Cronbach's alpha
Ease of use	6	0.95
Usefulness	6	0.95
Intention to use	2	0.89
Perceived affordances of educational features	8	0.87
ICT use	3	0.65

analysis approach is appropriate when manifest variables, that is to say variables which are directly measured, are present.

In our case, the relationship between the variables that we want to test based on our specific objective (which is to identify the factors favoring teacher's acceptance of the LMS) are presented below (Fig. 3). More specifically, our hypotheses are:

H1- External variables (EV) influence the perceived usefulness (U).
H2- External variables (EV) influence the perceived ease of use (EOU).
H3- ICT Use (IU) influence the perceived usefulness (U).
H4- ICT Use (IU) influence the perceived ease of use (EOU).
H5- ICT Use (IU) influence affordances (P).
H6- Perceived ease of use (EOU) influences the perceived usefulness (U).
H7- Perceived usefulness (U) influences the attitude towards use (A).
H8- Perceived usefulness (U) influences the intention to use (BI).
H9- Attitude towards use (A) influences the intention to use (BI).
H10- Perceived ease of use (EOU) influences the attitude towards use (A).
H11- Attitude towards use (A) influences affordances (P).

In terms of processing statistical data, we used SPSS software for descriptive statistics and SAS version 9.3 for path analysis, since SAS contains all the necessary tools to perform a path analysis.

5 Results

5.1 Descriptive analyses

With regards to respondents' profiles, 57% were women and 43% were men. Essentially, 45% of respondents were aged 30 to 39 years and 40% were in the 40 to 49 age group. All teaching subjects were represented. However, we had the largest number of mathematics teachers, whereas no physical education teacher completed the survey.

For items of our questionnaire which were relative to the TAM model, we observed that the central tendency was represented by the respondents who, most of the time, fully agreed with all of the statements using a 7-level Likert scale (Table 3). Moreover,

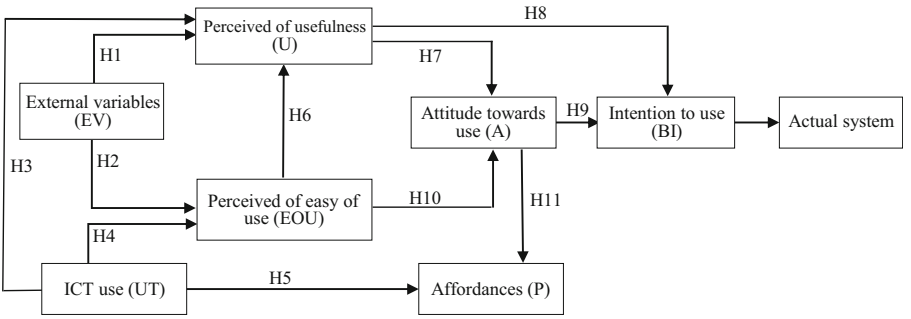

Fig. 3 The relationships between the variables

there were no items where the average score was represented by teachers who fully disagreed with the statement. With regards to the standard deviations of different items, we noted a low dispersion for all of our data, which means that participants' responses were situated near the average value.

5.2 The principal factors that influence LMS acceptance

In a confirmatory perspective between our data and that of the TAM model, we performed a principal components analysis (PCA) and a principal axis factoring (PAF) to confirm that we obtained the same dimensions as the TAM model. Our analysis shows that our items fit well with the TAM model and with the dimensions that we have evaluated, i.e. the perceived ease of use, usefulness and intention to use. First off, we identified that the correlations between the items and the Kaiser-Meyer-Olkin (KMO) value show a very good match with a value of 0.9, where a value of 0.8 is already considered excellent (Table 4).

As for Bartlett's test for homogeneity of variances, our results are significant because we have obtained a value of 0.00 ($p = <0.05$). In addition, inter-item correlations are very satisfactory because we have found several correlation coefficients above 0.8. Therefore, it is possible to bring out factors that are significant with our data. On the other hand, if all the coefficients obtained had been low, the PCA would not have been helpful.

In order to confirm that we have the two relevant factors, we used Cattell's scree test. Figure 4 shows the accumulation of the variance for our data, where we can observe the eigenvalues for each of the components. Thus, we see that the break is clear between

Table 3 The average answer values for TAM model items

Items	Average	SD
Moodle can be useful for accomplishing tasks faster (communicating, disseminating resources, making on-line learning activities, etc.).	2,75	1,83
Moodle can be useful for improving my work as a teacher (better communication with students and parents, file repository, accessible at all times, etc.)	2,67	1,66
Moodle can be useful for increasing my productivity (reusing resources, sharing them with colleagues, rapid implementation, etc.).	3,13	1,74
Moodle can be useful for effectively performing my teaching work (handing back work, consultation, handing back notes, etc.).	3,08	1,64
Moodle can be useful to enable me to do my work as a teacher more easily.	3,15	1,62
I find *Moodle* to be useful for my work as a teacher.	3,12	1,75
Learning to use *Moodle* would be easy for me.	2,49	1,5
It would be easy to access *Moodle* and to do what I want to do.	2,84	1,46
It would be easy for me to navigate in *Moodle*.	2,77	1,43
What I would do with *Moodle* could be clear and understandable for users.	2,78	1,38
It would be easy for me to become proficient in using *Moodle*.	2,57	1,54
I think that the majority of my colleagues could easily use *Moodle*.	3,36	1,49
I recommend using *Moodle* to my colleagues.	2,86	1,7
I intend to regularly use *Moodle*.	2,98	1,67

components 2 and 3. Also, components 1 and 2 have eigenvalues greater than 1, whereas we have no significant values for the other 10 components.

In order to facilitate interpretation of the factors, we conducted a series of exploratory factor analyses. First, we conducted a principal component analysis with a varimax and direct oblimin orthogonal rotation. This rotation is the most common (Tabachnick and Fidell 2013; Costello and Osborne 2005) and is useful for interpretation purposes: "Ideally, you would like to review the correlations between the variables and the components, and use this information to interpret the components" (Hatcher and O'Rourke 2013). In other words, we seek to establish which variables appear to measure the first factor and which are the variables that appear to measure the second factor. When doing an orthogonal rotation, there's a chance of losing information when factors are correlated, while the direct oblique oblimin rotation allows for more theoretical accuracy while also being more reproducible (Costello and Osborne 2005).

In order to validate the dimensions pertaining to the different factors, we also conducted a series of exploratory analyses using the principal axis factoring (PAF) extraction method with an orthogonal (varimax) and oblique (direct oblimin) rotation. The identification of the "U" items corresponds to the perceived usefulness, whereas the "EOU" items correspond to the perceived ease of use. Table 5 illustrates that items U_01 to U_06 relate to one factor, that is to say, the perceived usefulness, while the second factor consists of items related to ease of use (EOU_1 to EOU_6). Thus, among the twelve items that were analyzed, the first six provide one type of information while the other six provide another type of information. In our case, they are linked to the dimensions of the perception of ease of use and of usefulness from the TAM model. Therefore, the PCA clearly shows that these two factors are well circumscribed, since the items are not mixed between perceived ease of use and perceived usefulness.

For the PCA and PAF with orthogonal extraction, the results indicate that inter-item correlations are excellent (>. 8). Therefore, we can clearly theoretically associate that factor 1 is the TAM dimension that is linked to perceived usefulness of LMS and that factor 2 is linked to perceived ease of use. As for the oblique rotations, we observe that only a single factor is correlated. The dimension pertaining to perceived usefulness is poorly correlated (< .50) to the second factor. Notwithstanding the unacceptably poor quality of the second factor, we observe that the factor measure the same dimension. Finally, the exploratory factor analyses are consistent with the dimensions of the TAM model.

5.3 Model adjustments

The evaluation of the goodness of fit to the model was carried out by examining the relationships between the different dimensions of TAM and those that we added to it (Fig. 5). However, let us recall that TAM is based on predicting the acceptance of a technological tool characterized by its ease of use and its usefulness. According to Davis (1989), the model is flexible and it is possible to add contextual variables to it. In our case, we added two new elements to it: ICT use (IU) and affordances (P). Therefore, we wanted to see to what extent the addition of these variables affected the dimensions of the TAM model and, as a result, the prediction of teachers' acceptance of the LMS. We observe that the majority of links to TAM are consistent, but it can also be noted that the perceived ease of use has relatively low coefficients.

Table 4 Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12
Moodle can be useful for accomplishing tasks faster (communicating, disseminating resources, making online learning activities, etc.)	1.000											
Moodle can be useful for improving my work as a teacher (better communication with students and parents, file repository, accessible at all times, etc.)	.884	1.000										
Moodle can be useful for increasing my productivity (reusing resources, sharing them with colleagues, rapid implementation, etc.).	.746	.725	1.000									
Moodle can be useful for effectively performing my teaching work (handing back work, consultation, handing back notes, etc.).	.730	.757	.732	1.000								
Moodle can be useful to enable me to do my work as a teacher more easily.	.709	.715	.733	.837	1.000							
I find *Moodle* to be useful for my work as a teacher.	.722	.747	.677	.763	.785	1.000						
Learning to use *Moodle* would be easy for me.	.568	.536	.419	.498	.468	.512	1.000					
It would be easy to access *Moodle* and to do what I want to do.	.562	.473	.453	.546	.537	.551	.819	1.000				
It would be easy for me to navigate in *Moodle*.	.516	.477	.387	.496	.447	.514	.823	.889	1.000			
What I would do with *Moodle* could be clear and understandable for users.	.588	.605	.471	.646	.605	.648	.746	.757	.827	1.000		
It would be easy for me to become proficient in using *Moodle*.	.601	.551	.501	.613	.609	.582	.882	.822	.842	.802	1.000	
I think that the majority of my colleagues could easily use *Moodle*.	.468	.505	.448	.503	.608	.645	.518	.553	.578	.660	.651	1.000

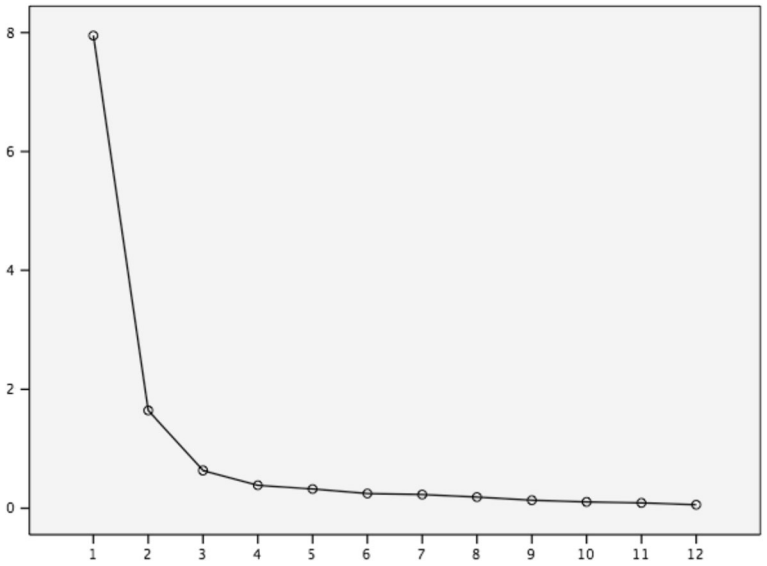

Fig. 4 Scree test

Thus, the use of predictors other than ICT use (IU) and affordances (P) in the LMS would entail that the model could be better adjusted. Consequently, the dimensions relating to ICT use and to affordances were not used to assess the quality of the adjustments.

To test the fit of our data with the TAM model, we have selected indicators that come from three different perspectives: absolute measurement indices, parsimony indices and incremental indices.

Table 5 Exploratory factor analysis

Rotation method	PCA (Varimax)		PCA (Direct oblimin)		PAF (Varimax)		PAF (Direct oblimin)	
Item	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2	Factor 1	Factor 2
U_01	.819	.347	.830	.320	.795	.351	.867	−.601
U_02	.851	.296	.817	.379	.830	.299	.882	−.565
U_03	.850	.191	.744	.454	.799	.215	.824	−.474
U_04	.835	.335	.833	.340	.817	.336	.883	−.595
U_05	.843	.315	.825	.360	.825	.315	.883	−.578
U_06	.802	.371	.834	.290	.781	.369	.861	−.614
EOU_01	.266	.875	.800	.444	.289	.842	.563	−.890
EOU_02	.290	.876	.818	.428	.308	.850	.584	−.904
EOU_03	.217	.927	.800	−.515	.226	.923	.533	−.945
EOU_04	.426	.794	.858	−.275	.443	.761	.680	−.866
EOU_05	.372	.864	.868	−.362	.386	.850	.657	−.931
EOU_06	.458	.573	.727	−.093	.456	.520	.609	−.645

The absolute measurement indices allow us to analyze to what extent the theoretical model adequately reproduced the data we collected (Schumacker and Lomax 2012). To evaluate model fit, we used two chi-square indicators, SRMR and RMSR. As for the parsimony index, we used the RMSEA index. This index is useful to see if the model was overall fitted (Schumacker and Lomax 2012). As for the incremental indices, we used Bentler's Comparative Fit Index (CFI), and the Bentler-Bonnet NFI (or Tucker-Lewis Index). These indicators enable us to measure the fit by comparing the tested model and the reference model (Schumacker and Lomax 2012).

The results of these analyses allow us to affirm that the modified TAM model remains appropriate (see Table 6 for a synthesis of the adjustments made). First of all, the values that we have obtained for the chi-square test are 38 with a degree of freedom of 6 and a *p*-value of <.0001. These values indicate they are significant. On the other hand, this indicates that the model data does not fit with our own data. Thus, for the model to fit well with our data, we should have obtained a null hypothesis (Hatcher and O'Rourke 2013; Schumacker and Lomax 2012). We note that the quality of this indicator is debatable since it is sensitive to sample size: when the sample size decreases, the value of chi-square decreases and the *p*-value increases. Therefore, the resulting effect is that the data obtained reproduces the tested model (Hatcher and O'Rourke 2013). In our case, our small sample could explain the similarity between the tested model and our data.

Furthermore, the SRMR normalized index is 0.0879. As Hu and Bentler (1999) recommend, a good fit is a value below 0.06, but not above 0.09. In our case, the SRMR indicator shows that we are very close to the acceptable threshold with regards to the model. It is also the same situation for the RMSR quadratic average index, which has a value of 0.0847. It is considered that below 0.09, the index is considered valid. Of the three indicators that permit us to determine the similarity between the tested model and our data, two of them indicate that the model fits, with thresholds near acceptable limits. As for the chi-square, it seems to have been influenced by the small sample we had.

The resulting absolute RMSEA index is 0.2265. However, only a value inferior to 0.09 is considered to be a good value, so we can consider that the RMSEA index is well beyond what is acceptable (Hatcher and O'Rourke 2013; Hu and Bentler 1999). As for Bentler's Comparative Fit Index, we obtained a result of 0.88, a coefficient that is near

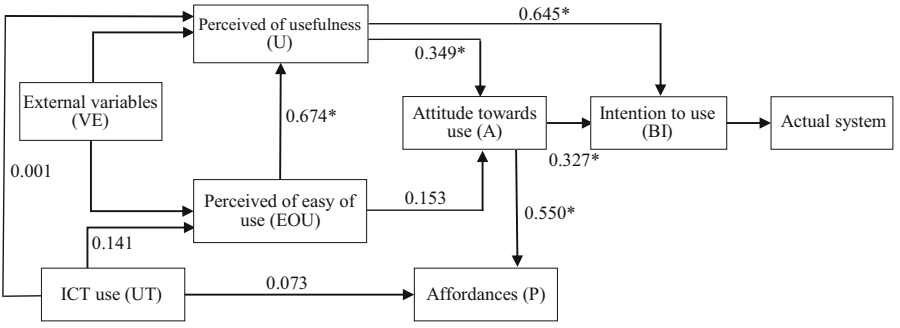

Fig. 5 Analysis of the relations between the variables of the modified model. * = significant

Table 6 Synthesis of the adjustments

Chi-square	DDL of Chi-square	Pr > Chi-square	SRMR	RMSR	RMSEA	CFI	NFI (TLI)
38.0046	6	<.0001	0.0879	0,0847	0.2265	0.8873	0.8729

to an acceptable level. In fact, the CFI is considered to be at a good level when it exceeds the 0.90 threshold (Hu and Bentler 1999). As for the Bentler-Bonett NFI (TLI), the acceptable level is <0.90 (Hu and Bentler 1999). We received a value of 0.8729. In this situation, we consider this indicator as good, since it is close to the acceptable threshold.

In our case, the path analysis is useful to confirm the relationship between the variables based on the theoretical TAM model, since our sample size of 105 respondents is sufficient to perform a path analysis. According to Hatcher and O'Rourke (2013), at least 100 cases must be available to perform a valid path analysis.

Regarding hypotheses 1 and 2, which aim to see whether external variables influence the usability and ease of use of the LMS, the results obtained are neither consistent nor appropriate for path analysis, especially because some of the variables are continuous variables. For verification purposes, we tested the variables separately by creating groups by age, years of experience, gender and disciplines. The low sampling paired with items which have a wide range of responses did not allow us to achieve satisfactory results to test hypotheses 1 and 2. For these reasons, the external variables are not included to test these hypotheses 1 and 2 nor for the analysis of the TAM model structure.

The third hypothesis that we tested aimed to measure whether ICT use influenced perceived usefulness. The results showed that the variables associated with ICT use are not good predictors of the perceived usefulness of the LMS. Thus, we cannot establish a relationship between these two elements. Such a relationship could allow us to predict the intention to use the LMS by teachers. We also tested ICT use based on the perceived usefulness and affordances (H4 and H5), and once again found that ICT use is not a good predictor for the various components of the TAM model (Fig. 5). Also, according to our data, (H6) the perceived ease of use shows that this dimension is a good predictor of perceived usefulness.

Hypotheses 7 to 10 are directly related to Davis' TAM model. First, we tested whether our data fit well with the original TAM model. Initially, the results of the perceived ease of use analysis show that this dimension influences the perceived usefulness (Table 7).

With regards to our 8th hypothesis, concerning the influence of perceived usefulness on the attitude towards LMS use, we find that the usefulness successfully predicts the attitude. We can make the same observation for the 9th hypothesis regarding usefulness, which is a good predictor of intention to use. As for the attitude towards the intention to use, our 10th hypothesis, it was confirmed by our results, but the strength of the coefficient was lower than for the previous two hypotheses. Finally, the 11th hypothesis aimed to see whether the attitude influenced the perception of affordances, and our analyses have shown that the t-value was not significant. Finally, we wanted to

see if the attitude towards use correctly predicted the perception of affordances (P) in the LMS: the result produced statistically significant values. Thus, it is the only hypothesis that produces a significant result among the elements we have added to the TAM model. Therefore, we can say that ICT use (IU) among teachers was not a factor that can influence perceived usefulness or ease of use, nor affect the affordances (P).

6 Discussion

The choice of the original version of the TAM model for this research is justified by the fact that we aimed to see whether the tool, an LMS, was relevant for teachers. This approach has been addressed in an individual perspective, in order to see to what extent teachers are in favor of adopting the LMS as a tool to support the teaching and learning process. In this case, using one of the many versions of the TAM model was not helpful because the institution did not intend to oblige all teachers to use this tool. Moreover, teachers are always free to choose their preferred means to disseminate educational resources and to conduct learning activities. Also, we considered the following fact: we had not identified a research objective that puts teachers in a situation where they interact with each other, as a social network does. Instead, it is the utilitarian function of the LMS that was evaluated. In view of this, the original use of the LMS still remains as relevant as before, especially with regards to the latest technological developments and in particular in the context of Web 2.0. We aimed to assess whether the proposed tool would be accepted. On the other hand, if we had put forward an iteration that specifically targeted an educational feature linked to the use of social networking functions (microblogging, social networking, exchange and sharing of content, etc.), the individual perspective of the TAM model would have been inadequate.

Finally, had the use of the technological tool been mandatory, it would have been relevant to consider another version of the TAM model, such as the UTAUT (Venkatesh and Davis 2000). The latter contains other dimensions that are taken into

Table 7 Synthesis of the hypotheses tested

Hypotheses tested	Coefficients	T value
H1 External variables → Perceived usefulness (EV-U)	–	–
H2 External variables → Perceived ease of use (EV-EOU)	–	–
H3 ICT Use → Perceived usefulness (UT-U)	0.001	0.018
H4 ICT Use → Perceived ease of use (UT-EOU)	0.141	1462
H5 ICT Use → Affordances (UT-P)	0.073	0.895
H6 Perceived ease of use → Perceived usefulness (EOU-U)	0.674*	12.356
H7 Perceived usefulness → Attitude towards use (U-A)	0.349*	−3.076
H8 Perceived usefulness → Intention to use (U-BI)	0.645*	12.527
H19 Attitude towards use → Intention to use (A-BI)	0.327*	−5.531
H10 Perceived ease of use Attitude towards use (EOU-A)	0.153	1132
H11 Attitude towards use → Affordances (A-P)	0.550*	8.070

account (subjective norms, influence of other users, performance expectations, etc.), and these would have been useful in this study.

Furthermore, the literature has shown that ICTs are complex to implement (Law 2009; Ross and Collier 2016). Furthermore, the use of ICTs in an educational perspective still remains a challenge for teachers (Angeli and Valanides 2009; Koehler and Mishra 2009; Tondeur et al. 2012). Thus, we initially thought that an LMS was no exception to this rule. Therefore, the evaluation of the ease of use dimension of the TAM model was essential to validate to what extent the LMS was perceived as difficult or as easy to use, since the scientific literature shows that ease of use is a predictor of intended use. Additionally, it is by identifying the dimensions of the TAM model that we were able to target appropriate interventions to promote the adoption of the LMS. The evaluation of additional dimensions would not have been useful for us to meet our goal.

Bear in mind that the analysis of the data from this second iteration enabled us to determine that it fits well with Davis' (1989) TAM model. Thus, we observed that the "usefulness" dimension is a good predictor of the attitude towards use and the intention to use of the technological tool. This analysis, using the TAM model, confirms that the LMS is useful for secondary school teachers. The findings obtained from the focus group conducted during the first iteration lead us to the same conclusion. If the results had shown us otherwise, it would not be appropriate for us to continue such deployment, or else it would have been necessary to further examine the reasons why teachers did not perceive the usefulness of an LMS.

Ease of use seemed to be an important element of the TAM model for us to examine. A priori, we thought that it would have been an important factor to consider for encouraging the acceptance of the LMS. However, the analysis of our data showed that this was not a concern. Obviously, if the LMS were more complicated to use, the results would have been different. Therefore, interventions during the first iteration most likely contributed to increase the ease of use of the LMS. Thus, if the teachers had the task of requesting the creation of a course, of registering participants (both students and parents) in addition to having to set the parameters of the course, the teachers would have seen the concept of ease of use in a new light and, therefore, the usefulness of the LMS would most likely have been perceived differently.

Based on our context, we have added dimensions such as ICT use and affordances to the TAM model. Our analysis showed that ICT use was not a good predictor for all dimensions of the TAM model, which was also the case for the affordance dimension. On the one hand, it was surprising that ICT use is not a good predictor of the perceived affordances of educational features in the LMS. Thus, ICT use subtends a minimum mastery of ICT skills, an obvious prerequisite, but it is insufficient to enable teachers to see the possibilities of LMS integration in planning their teaching and learning activities. On the other hand, this finding indicates that offering training and support is needed to promote the judicious use of the educational features of the LMS.

We must consider the technological skills of our sample during this second iteration. The context of the study did not allow us to target only the teachers who had not previously been in contact with the LMS. However, we would like to add a nuance to this statement. It is not to be excluded that some teachers feel at ease with ICTs and want to further exploit them in the classroom. That being said, we favored teachers who felt less qualified. Nevertheless, it is conceivable that these teachers, despite their

limited perception of their own skills, amount to the first adopters of the innovation and that they are not hampered by the technological aspects of an ICT tool. Finally, if the questionnaire had been sent to teachers who represent the late majority of adopters(Rogers 2003), the results might have been different in terms of the LMS ease of use dimension.

Therefore, using an LMS and taking advantage of its educational features represent a novelty for the teachers from our sample. From the outset, they were able to identify what they could achieve with the LMS, either because it corresponded to a task that they used to doing differently, or because the feature enabled them to be more effective. However, foreseeing what they do not yet know how to do in the LMS limits their perception of its ease of use, either because it is a new task that is not part of their current teaching practice or because a simulation of the functionality is required. As a matter of fact, when teachers were asked regarding educational features, several mentioned the possibilities of the tool, while others said they did not know how to take advantage of them.

However, with regards the basic features included in the LMS (sharing files, communicating, creating learning activities, etc.), we can consider that teachers find them easy to use and see them as relevant to their teaching. This opens the door to the use of other educational features related to active teaching approaches (wiki, peer review, discussion forums, etc.) with which our sample of teachers was not familiar. The potential of the LMS is therefore only partially utilized by teachers in real context, as they have not intuitively found effective ways to use its learning-centered educational features.

7 Conclusion and limitations

The goal of this study was to analyze the acceptability of an LMS by teachers according to the TAM by Davis (1989). This study showed that LMSs are useful for K-12 teachers to support both teaching and learning. The analysis of the results with the TAM model shows that the perception of the usefulness of the LMS is a good predictor of intention to use. However, this study has not enabled us to establish that ICT use and the perception of the affordances of the LMS's educational features is not a good predictor of intention to use. Despite the fact that the number of participants was limited, acceptability was not evaluated with the entire sample available. However, it was not appropriate to do at the time of the study, since several teachers were not familiar with the LMS and therefore could not have answered the questionnaire adequately.

LMSs that aim to support teaching and learning are among the many technological tools that teachers have at their disposal. Thus, the relevance of studying them in context is essential. Furthermore, considering the complexity of the ecosystem in which information systems are implemented, the analysis of the acceptability of ICT makes it possible to adequately justify the strategies to be implemented. To better understand the factors influencing the adoption of an LMS, TAM allows for other variables to be used to see to what extent they can influence the intention to use. For example, teachers were not asked about their teaching practices. Thus, we were unable to see if there are conditions favorable to the intent to use with regards to the types of teaching practice

used by teachers. Also, we did not assess teachers' ICT skills. This would be an interesting factor to consider in order to identify whether teachers' ICT skills could be a good predictor of LMS intent, to later develop appropriate interventions.

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