Application of innovation diffusion theory to the E-learning process: higher education context

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Abstract

This empirical study aims to identify the factors influencing the use of Moodle as a Learning Management Systems (LMS) in the academic context. To fulfil this objective, a quantitative study was carried out through a questionnaire directed to Portuguese university students, which obtained a total of 631 valid answers. The results obtained, based on structural equation modelling, show that the characteristics of Moodle LMS, proposed by Innovation Diffusion Theory and Personal Innovativeness in Information Technology influence the use of this tool positively. This research contributes to advancing the literature on this subject, and for practice the importance of elaborating student-centred LMS is highlighted. These and other implications and suggestions for future research are also presented.

Keywords E-learning · Higher education · Learning management systems · Moodle · Personal innovativeness in information technology (PIIT) · Innovation diffusion theory (IDT)

1 Introduction

With growing globalization, Information Technology (IT) tends to occupy a prominent place in modern societies (Oye et al. 2012). These tools have come to change how

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individuals live, work, communicate and learn (Khan 2005). Continuously developing IT provides a varied range of services online both to firms and universities, namely in the process of electronic learning (e-learning) (Wu et al. 2010). The term e-learning means distance, flexibility or virtual learning (Khan 2005), and according to Sridharan et al. (2010), e-learning refers to the application of IT so as to improve the teaching and learning process. In general, the literature considers that e-learning, as a learning process, incorporates the use of the Internet or Intranet to access pedagogical material or in lecturer and student interaction (Wu et al. 2010).

Universities have changed the teaching/learning concept from the traditional form to that of e-learning (Tan 2013; Yakubu et al. 2020). This teaching concept has allowed increased flexibility, eliminated geographical barriers and improved the effectiveness of individual and collaborative learning (Santhanam et al. 2008). Universities have adopted LMS (Learning Management Systems) software's packages (e.g., Moodle, Canvas, Blackboard) to support e-learning teaching process (Miah et al. 2020). LMS are web-based applications used to administer courses. They can provide the ability to track students' progress and facilitate the access to resources required for courses. Students can access course resources with any internet-ready device from anywhere as many times as they need (Jagadeesan and Subbiah 2020; Yakubu et al. 2020). LMS platforms can offer a transparent and fast students' evaluation as well as innovative teaching methods (Khlifi 2020). These tools may improve information technology skills (e.g., Samsudeen and Mohamed 2019; Phutela and Dwivedi 2020). Students need a strong personal discipline to complete schedule activities and may develop cognitive, psychomotor, and interpersonal skills (Theresiawati et al. 2020).

These Information Systems (IS) can make learning more efficient and lead to an improved learning environment, thereby improving students' attitude towards the learning process and the use of LMS (Wu and Hwang 2010). Nevertheless, according to Sridharan et al. (2010) and Ashrafi et al. (2020), there is a shortage of empirical research into the effectiveness of these platforms from the student perspective. In addition, the literature also reveals individuals are somewhat reluctant to accept and subsequently use this technology (Rym et al. 2013; Abdullah and Ward 2016).

In this context, an individual's personality traits have been described as possible enablers of IT acceptance and use, and as a way to predict these agents' behaviour in this process (e.g. Barrick et al. 2001; Barnett et al. 2015; Xu et al. 2016). Personal Innovativeness in Information Technology (PIIT) or individuals' natural aptitude to accept and use new IT can stimulate the use of those tools. Nevertheless, this personality trait has been little studied in the literature (Lu et al. 2005; Wijesundara and Xixiang 2017).

On the other hand, for decades, research on Innovation Diffusion Theory (IDT) has recognised that innovative individuals are more willing to accept new ideas and are able to cope with high levels of uncertainty (Rogers 1962, 1995, 2003). Although, the literature on this subject presents various studies about the influence of personality traits on the stimulus for internal motivation (e.g. Agarwal and Prasad 1998; Lee et al. 2007; Özbek et al. 2014). A limited number of those studies include personality traits in acceptance of technology and even fewer in the intention to use innovations in IT/IS (Lu et al. 2005; Watjatrakul 2020).

For e-learning teaching to be successful, the agents involved in this process must accept and use LMS (Hassanzadeh et al. 2012). Despite the proliferation of LMS in the

academic sphere and the attempt to identify the factors contributing to their success (Shee and Wang 2008; Kim et al. 2012; Miah et al. 2020), a limited number of studies include the IT characteristics proposed by IDT (Aizstrautaa et al. 2015).

Given these gaps, this research aims to determine whether PIIT and the characteristics of LMS influence the use of those platforms by students in the academic field, and thereby contribute to increasing knowledge about this subject.

The study is organised in 4 sections or chapters. The second section presents a review of the literature on factors contributing to acceptance and adoption of IT in general, and LMS, together with the research hypotheses developed. The third section describes the methodology used. Section 4 presents and discusses the results in the light of the theoretical framework of the subject studied. Section 5 highlights the contributions of this research to theory and practice, together with the limitations and future lines of research in this field.

2 Literature review and research hypotheses

2.1 Influence of the characteristics of Moodle LMS in their use

Moodle is the leading open source LMS used in European universities (Beatty and Ulasewicz 2006; Rahim et al. 2018). This tool is a course management system with the propose of creating an effective online community (Beatty and Ulasewicz 2006) and it can be downloaded, installed and used by everyone (Elmaghrabi and Eljack 2019; Sakala and Chigona 2020). Nevertheless, Moodle presents issues with information security, as any other LMS, which can be easily solved (Elmaghrabi and Eljack 2019).

The IDT developed by Rogers (1962) explains the process by which some individuals adopt new behaviour or acquire new products/services when they first go on sale, whereas others may possibly never acquire them. According to Rogers (1962, 1995, 2003), diffusion refers to the process whereby innovation is communicated through certain channels over time among members of a social system. The use of LMS refers to the frequency with which these tools are accessed and used (Al-Debei et al. 2013). According to IDT, the spread of innovations depends on the following characteristics: (1) relative advantage, (2) compatibility, (3) complexity, (4) observability and (5) trialability. If innovations or new IT have characteristics distinguishing them from others, are compatible with users' values, are user-friendly, are observed in institutions and can be tried out by users, they will be more easily accepted and used (Rogers 1962, 1995, 2003).

Relative advantage refers to the extent to which adoption/use of innovative IT is understood as an improvement on the previous version (Karahanna et al. 1999). In the same line, Davis (1989) considers in the TAM, the perception of usefulness offered by IT. These two points of view have the same meaning (Moore and Benbasat 1991) and represent individuals' belief that use of given IT could improve their performance.

In the academic context, the usefulness of systems or IT has been identified as a factor with great influence on students' choices and behaviours (Ozkan and Koseler 2009; Utomo et al. 2017). Here, various studies have attempted to determine students' perception of the effectiveness of LMS platforms (Webster and Hackley 1997; Volery and Lord 2000; Selim 2007). According to Shee and Wang (2008) and Lee et al.

(2009), LMS' design is a determinant factor of students' satisfaction and the success of these tools. In addition, perception of the usefulness of LMS is positively related to use of these tools (Pituch and Lee 2006; Liaw et al. 2007). At the individual level, system use is defined by an individual's use of one or more resources of a system to perform tasks (Al-Debei et al. 2013).

According to Binyamin et al. (2017) and Ashrafi et al. (2020), students perception of LMS usefulness has a positive effect on their use. However, the literature is not consensual as to the influence of users' perceived usefulness on adopting these platforms. According to Yuen and Ma (2008), students' perceived usefulness of LMS did not have a significant effect on the intention to use this tool.

Compatibility refers to the extent to which adoption of innovation in IT is congruent with what individuals do (Karahanna et al. 1999). According to the IDT presented by Rogers (1962, 1995, 2003), innovations should be consistent with users' beliefs, values, past experiences and needs. In the university context, it is necessary to understand the drivers leading to students' use of LMS, in order to devise effective e-learning environments (Konradt and Sulz 2001). The success of these platforms depends largely on implementing educational models that meet students' needs (Lee et al. 2009). The LMS should be personalized in terms of student's beliefs and real needs. By this, students perception of LMS ease of use would increase (Jagadeesan and Subbiah 2020).

Complexity concerns the degree to which the use of any system requires effort by the user (Karahanna et al. 1999). The TAM addresses the concept of IT's user-friendliness and which, according to Moore and Benbasat (1991), is similar to that of the complexity of innovations suggested by IDT. For Rogers (1962, 1995, 2003), easily understood and used innovations spread more quickly. Therefore, the complexity of a system has a negative impact on its use (Shih and Huang 2009). Similarly, Teo (2008) considers that the less complex a system is, the greater the likelihood of being adopted and used. Despite e-learning having the potential to improve performance in education, this tool will not be useful if students do not accept it and use it in the learning process (Lee et al. 2009). In this scenario, TAM has been approached as a way to predict students' behaviour in the e-learning context regarding the ease of using these platforms (Selim 2003, 2007). Results suggest that the complexity or ease of using these platforms by students may be an important factor in their use (Pituch and Lee 2006; Yuen and Ma 2008; Lee et al. 2009). Students do not resist LMS without a reason. If this tool is beneficial to them and they perceive it as favourable, they will use it (Binyamin et al. 2017; Ashrafi et al. 2020; Sakala and Chigona 2020).

Observability is a characteristic linked to the degree to which innovations are visible in organisations (Karahanna et al. 1999). A high degree of observability indicates that individuals may not only have the opportunity to observe an innovation being used, but also to communicate the information to others (Dupagne and Driscoll 2009). An individual's continuous exposure to an object can make that agent's attitude towards it more positive (Zajonc and Markus 1982). According to Yang (2007), systems or IT that can be observed or described by users tend to be perceived as useful and easy to use. In the academic domain, Lee et al. (2011) suggest there is a positive effect between the observability of LMS and their use.

Then again, **trialability** means the degree to which one can experiment with an innovation on a limited basis before making an adoption or rejection decision

(Karahanna et al. 1999), i.e., the trialability of innovations refers to this being done by stages (Lee et al. 2011). Although scarce on this issue, the literature suggests a positive effect of trialability on the use of systems or IT (Lee 2007). According to Yang (2007), a high degree of trialability also leads to a high degree of usefulness, ease and use of systems. From the arguments presented, the following research hypothesis is proposed.

H1. The characteristics of Moodle LMS influence their use positively.

2.2 Influence of personality traits on the use of Moodle LMS

For a better understanding of the acceptance of IT, Lu et al. (2005) consider that external factors (e.g. personality traits) should be more explored in the literature.

According to Lo (2014), a personality trait is defined as an individual characteristic that exerts a generalized influence on a wide range of behaviour relevant to that characteristic. Consequently, personality traits can be used as a way to predict and explain an individual's behaviour (Devaraj et al. 2008). The explanation of that person's behaviour will be found in themselves, rather than in the situation, therefore suggesting some kind of internal process or mechanism that can lead to a certain type of behaviour (Kovaleva et al. 2013; Khalid 2013; Özbek et al. 2014)

In the sphere of IT, Personal Innovativeness (PI) is a personality trait that may explain how individuals respond to innovations (Jeong et al. 2009). In this context, Agarwal and Prasad (1998) present the PIIT construct and explain its influence on adoption of IT. These authors define PIIT as the individual tendency or aptitude to try out new IT.

However, PI has been neglected in the literature as potentially influencing the adoption of IT. Agarwal and Prasad (1998) studied the role of Personal Innovativeness in Information Technology (PIIT) as a moderator between individual perception of new IT and its antecedents.

Although PIIT has been used in recent literature as a way to explain individuals' acceptance of technology, according to Nov and Ye (2008) the personality traits underlying that behaviour have been neglected.

For Rogers (1962, 1995, 2003), individuals' profile determines the spread of innovation and people can be classified and grouped according to their attitude towards the adoption of technology. Individuals with a high degree of PIIT tend to develop a more positive attitude towards new IT and tend to use it more quickly (Agarwal and Prasad 1998; Jeong et al. 2009), meaning that highly innovative individuals are more willing to adopt new IT in their daily routine and cope well with the uncertainties arising from its use (Lee et al. 2007).

Individuals with a high degree of PIIT are more open to risk (Agarwal and Karahanna 2000; Jeong et al. 2009). PIIT affects users' acceptance of new technology (Agarwal and Prasad 1998; Noh et al. 2014). Agents with a high level of PI will be eager to repeat a behaviour if they have recognised the benefits of the IT used. Therefore, these agents are likely to benefit more from new IT (Lin and Filieri 2015). For example, Aharony (2013) concludes that individuals with a high degree of PIIT and extroversion tend to use Facebook better. Similarly, Karim et al. (2009) consider there is a relationship between a high degree of extroversion and students' PIIT and well-intentioned use of the Internet.

PIIT reflects individuals' willingness to change (Agarwal and Prasad 1998). Previous research indicates that highly innovative individuals tend to look for new experiences and have leanings towards innovative products based on new IT (Karahanna et al. 2002; Oreg 2003). Similarly, Nov and Ye (2008) found a positive relationship between PIIT and individuals' openness. According to Wang and Lin (2009) PIIT is an antecedent of perceived enjoyment in the acceptance of blogging. Additionally, PIIT has a positive effect on perceived ease of use and usefulness of massive open online course learning (Zhang et al. 2017).

Considering the literature review above, the second research hypothesis is presented.

H2. PIIT has a positive influence on the use of Moodle LMS.

3 Methodology

3.1 Context of the study

The Portuguese Higher Education is characterized mostly by traditional classroom environment, despite financial efforts made by government and institutions to implement e-learning platforms. According to Monteiro and Pedro (2017), the biggest obstacle to the full implementation of these platforms is the organizational component. According to the same authors, the organizational component consists in a set of processes and procedures that supports universities management, which includes the analysis of the different factors that are established, or not, in order to guarantee the use of e-learning platforms within a university. Following the previous idea, the e-learning platform implementation requires appropriate organizational structures and management mechanisms within Portuguese universities which encourages the implementation of this tool (Bacelar-Nicolau et al. 2009; Marques 2015).

Despite the previously reported difficulties of e-learning platform implementation, Portuguese universities are changing the traditional way of learning and adapting themselves to the learning online environment (Pinto et al. 2012).

Concerning open-source solutions, the most used and easy to use e-learning platform in Portuguese Universities is Moodle (Modular Object-Oriented Dynamic Learning Environment). Moodle offers a wide variety of tools, such as enabling the creation of a course website, allowing the exchange of information among students geographically dispersed and the creation of quizzes, online tests and surveys (Bacelar-Nicolau et al. 2009; Costa et al. 2012).

3.2 Sample

In order to identify the factors influencing the use of LMS platforms, the universe of this research, of a quantitative nature, was defined as Portuguese university students. A sample of convenience was selected due to factors of a geographical order. Universities in the north (University of Trás-os-Montes e Alto Douro), centre (University of Aveiro and University of Beira Interior) and south (University of the Algarve) of mainland Portugal were selected. Using this criterion, a greater diversity of responses was obtained and an acceptable sample of the population studied (Banerjee and Chaudhury 2010).

The respondents correspond to 430 female students and 201 males and the average age is 24,4 years. A considerably varied range was observed regarding students' academic level and academic subject (see Table 1). Generally, holders of a degree collaborated most, corresponding to 42% of the total answers.

3.3 Data collection and measurement of variables

The data-collecting technique was an anonymous structured questionnaire, divided in three sub-groups of questions. The first refers to the characteristics of the LMS, the second to PIIT, and the third assesses the frequency of using these platforms.

According to the IDT presented by Rogers (1962), innovations should have various characteristics (relative advantage, compatibility, complexity, observability and trialability) in order to be easily disseminated. Therefore, they form the construct of LMS characteristics (see Annex I). To test the influence of the relative advantage and complexity of LMS, the research by Lee et al. (2009) and Karahanna et al. (1999) was used to measure the variables of compatibility, observability and trialability. The scales used were adapted so that they could be applied to the academic context. The variables were measured on a Likert-type scale from 1- completely disagree, to 7- completely agree, with respondents having to indicate their degree of agreement with the statements presented.

Concerning measurement of PIIT, the scale presented by van Raaij and Schepers (2008) was used to measure the personal aptitude to adopt IT. The items were adapted

Table 1 Characterisation of students

Gender	Frequency	Percentage
Female	430	68,1
Male	201	31,9
Total	631	100,0
Academic qualifications		
Secondary Education	20	31,9
Diploma	12	1,9
Degree	265	42,0
Master	120	19,0
Ph.D. student	29	4,6
Other	4	0,6
Total	631	100,0
Academic subject		
Management	290	46%
Psychology	132	21%
Sociology	95	15%
Engineering	57	9%
Mathematics	51	8%
Others	6	1%
Total	631	100,0

and measured on a Likert-type scale from 1- completely disagree, to 7- completely agree.

Measurement of the construct of Moodle LMS use was based on the scale developed by Al-Debei et al. (2013), with the frequency of using this tool being measured on a scale from 1- never, to 7- always. The scales used underwent minor adjustments in order to be applied to the academic context and IT.

With the questionnaire completed, a pilot program was carried out on 8 January 2018 with students from different course, aiming to identify failings, problems with interpretation or possible improvements to be introduced. The suggestions indicated by the students were considered and introduced to the questionnaire.

On 21 January 2018, the questionnaires were sent by e-mail to students at the universities selected. In a second phase, the paper-based questionnaires were applied face-to-face, given the low rate of response obtained initially (10%) (students from the selected universities were identified randomly to answer the questions on the question-naire). After applying the data-collecting instrument by e-mail and face-to-face, a total of 631 valid answers were obtained. The institution collaborating most in this research was the University of Beira Interior, with approximately half the answers received (49,1%), whereas the University of Trás-os-Montes e Alto Douro provided only 6,3% of responses.

The consistency of each dimension was measured through the Cronbach Alpha and Composite Reliability. The Cronbach Alphas varied between 0,790 and 0,923, values above what is acceptable (0,70) (Hair et al. 2010), thereby showing suitable levels of internal consistency (see Table 2). Table 2 also presents the mean, standard deviation and correlations between variables. The highest mean is found in the observability variable (mean = 5121), and the lowest in the construct of LMS use (mean = 5180). The standard deviations indicate the greatest dispersion of answers in the construct of Moodle LMS use (SD = 1725) and the least in the complexity variable (SD = 1199). Analysis of Table 3 reveals that the most correlated dimensions are relative advantage and observability (0,593), with least correlation being found between compatibility and Moodle LMS use (0,194). However, all the dimensions are correlated at a 1% level of significance.

The Composite Reliability (CR) values indicate good internal consistency for levels above 0,70 (Hair et al. 2010). Analysis of Table 3 shows all the CRs to be suitable, as the lowest value is found in the observability variable (CR = 0,82), and the highest in the variable of relative advantage (CR = 0,92).

3.4 Data analysis

After obtaining the data, these were treated with SPSS vs 24 and Amos vs 24 software. The hypotheses were tested using structural equation modelling (SEM). SEM is a multivariate statistical technique allowing simultaneous assessment of relationships between various constructs and testing a causal order between the variables (Aizstrautaa et al. 2015), facilitating the discovery and confirmation of relations between diverse variables. The most important characteristic of SEM is the capacity to check relationships between the various latent constructs, which can be examined in order to reduce the error in the model (Hair et al. 2010). This characteristic allows

Table 2 Mean, standard deviation, Cronbach Alpha and Pearson correlations between dimensions

Dimensions	Mean	Standard deviation	Cronbach Alpha	1	2	3	4	5	6	7
1. Relative advantage (RA)	5069	1263	0,923	1						
2. Compatibility (CP)	4959	1292	0,914	0,361**	1					
3. Complexity (CX)	4986	1199	0,834	0,745**	0,391**	1				
4. Observability (OB)	5121	1418	0,821	0,593**	0,320**	0,563**	1			
5. Trialability (TR)	4499	1444	0,880	0,477**	0,479**	0,486**	0,335**	1		
6. PIIT	4518	1314	0,868	0,496**	0,284**	0,483**	0,318**	0,492**	1	
7. Use of Moodle LMS (UML)	4180	1725	0,790	0,320**	0,194**	0,339**	0,208**	0,358**	0,418**	1

$N = 631$

**Correlation is significant at the 0.01 level

Table 3 Loadings and extracted variances

Latent variables	Manifest variables	Loadings	AVE	CR
Relative advantage (RA)	RA1	0,875	0,801	0,92
	RA2	0,891		
	RA3	0,794		
Compatibility (CP)	CP1	0,802	0,787	0,91
	CP2	0,951		
	CP3	0,902		
Complexity (CX)	CX1	0,841	0,719	0,840
	CX2	0,855		
Observability (OB)	OB1	0,806	0,698	0,82
	OB2	0,865		
Trialability (TR)	TR1	0,841	0,717	0,88
	TR2	0,903		
	TR3	0,794		
PIIT	PIIT1	0,874	0,647	0,88
	PIIT2	0,752		
	PIIT3	0,904		
	PIIT4	0,665		
Use of Moodle LMS (UML)	UML2	0,796	0,641	0,84
	UML3	0,903		
	UML4	0,69		

assessment and elimination of variables with weak measurement, thereby bringing the structural model closer to the situation studied (Chin et al. 2008; Hair et al. 2014).

4 Results

4.1 Assumptions of analysis with structural equations (SEM)

According to Hair et al. (2010), violation of the assumptions of normality and linearity can cast doubt on the credibility of the results obtained. The assumption of normality was tested using measures of asymmetry (Sk) and kurtosis (Ku). The results revealed that the |Sk| values vary between 0,841 and 0,135 and the |Ku| values between 1225 and 0,006, suggesting non-violation of the assumption of normality. Linearity was analysed using the Pearson correlation coefficients (see Table 2), recording significant linear relationships between all the variables and confirming the assumption of linearity.

The variance inflation factor (VIF) and tolerance values (T) can identify the existence of multi-collinearity. According to Hair et al. (2010), values of $T > 0,1$ and $VIF < 10$ indicate a low level of multi-collinearity. All the indicators calculated in this study revealed the non-existence of multi-collinearity, $T > 0,361$ and $VIF < 2664$.

4.2 Validation of the measurement model

The measurement model was validated using Confirmatory Factor Analysis (CFA), which indicates the model's degree of adjustment to the data. This process aims to eliminate errors of high measurement, less than or equal to 0,25 and low factor loadings, under 0,5 (Hair et al. 2010). After carrying out this procedure/adjustment and eliminating items in those situations, Table 3 shows that the loadings are relatively high, above 0,665 and that the variance measured by the Average Variance Extracted (AVE) is above 0,641, therefore acceptable indicators, according to Hair et al. (2010).

After concluding the process of validating the measurement model, the next step was to analyse individual reliability (R^2), finding that ($R^2 >\, = 0,25$). Analysis of Table 4 also reveals that the loadings ($\lambda > 0,5$) fall within the acceptable levels indicated by Hair et al.(2010).

According to Table 4, the measurement model presents suitable adjustment (CMIN/DF = 2984, GFI = 0,932 and RMSAE = 0,56). Similarly, the CFI = 0,966 and the measures of parsimony (PGFI = 0,661 and PCFI = 0,758) are within the acceptable levels according to Hair et al. (2010). Consequently, the measurement model was considered acceptable.

4.3 Validation of the structural model and obtained results

After validating the measurement model, we turned to the structural model in order to reject or accept the research hypotheses suggested in the literature review. The absolute measures (CMIN/DF = 1939, GFI = 0,902 and RMSEA = 0,075) indicate suitable adjustment. Similarly, the relative measures (CFI = 0,935) and parsimony measures (PGFI = 0,696 and PCFI = 0,797) are also within acceptable limits (Hair et al. 2010). Therefore, the structural model presented in Fig. 1 is accepted.

Figure 1 illustrates the relationship between the characteristics of Moodle LMS, PIIT and use of these LMS in the higher education context.

The results indicate that the characteristics of Moodle LMS are statistically significant in the use of these platforms. Since ($\beta = 0,218$) and ($p < 0,001$), we can conclude

Table 4 Model's adjustment measures

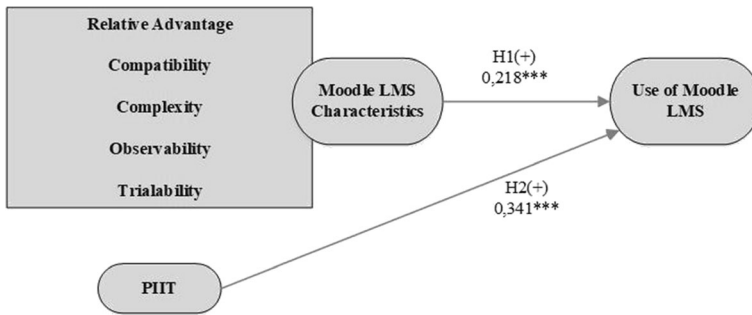| Adjustment measures	Values	Level of acceptance (Hair et al. 2010)
Absolute measures		
CMIN/DF	2984	<2 (good) 5 (acceptable)
GFI	0,932	>0,9 (good) 0,95 (very good)
RMSAE	0,56	<0,05 (very good) 0,08 (good) 0,1 (poor)
Relative measures		
CFI	0,966	>0,9 (good) 0,95 (very good)
Parsimony measures		
PGFI	0,661	>0,6 (reasonable) 0,8 (good)
PCFI	0,758	>0,6 (reasonable) 0,8 (good)

Fig. 1 Structural model with standardized coefficients. Note: *p < 0,05, **p < 0,01 and ***p < 0,001

that besides significant, the effect is positive. Therefore, research hypothesis H1 is accepted, according to which the characteristics of Moodle LMS influence their use positively.

The results also indicate the relationship between PIIT and the use of LMS. Since PIIT is statistically significant in the use of LMS ($\beta = 0,341$) and ($p < 0,001$), we can conclude that the effect is positive. Therefore, research hypothesis H2 is accepted, according to which PIIT has a positive influence on the use of LMS.

To summarize, the research hypotheses proposed in this research, namely H1 (The characteristics of Moodle LMS influence their use positively) and H2 (PIIT influences the use of Moodle LMS positively) were corroborated. This strengthens the theory on this subject, which suggests that PIIT and the characteristics of new IT contribute to acceptance and use of those tools. This study demonstrates that the characteristics of LMS, specifically, have a positive influence on students' use of them in the academic context.

5 Discussion of the results

Technology and LMS, are an important tool in every domain of the society. In the academic context, they can provide countless advantages to students, mainly faster and easier access to important information, as well as, increased flexibility and affordability (Phutela and Dwivedi 2020; Puška et al. 2020).

For students to accept and use the LMS provided by universities, these tools must offer them relative advantages. Use of this type of tool must bring benefits, which will mean an improved or easier learning process for students (Samsudeen and Mohamed 2019; Chen 2015).

According to Yusuf and Widyaningsih 2020, the implementation of LMS can improve the learning quality and students' metacognitive skills through lesson study activities. The perception of self-efficacy and learning autonomy are effective strategies to encourage the use of virtual platforms. The use of these educational platforms strengthens the perception of students self-efficacy, skills and abilities necessary for a proper management of these types of educational technologies (Valencia-Arias et al. 2019; Pham and Tran 2020). This perception of the relative advantages to be obtained is also defended by the technology acceptance model TAM (Svendsen et al. 2011; Chang & Yang, 2013; Özbek et al. 2014; Chen, 2015).

The literature states that compatibility between IT and its users' values is determinant for acceptance and use (Rogers 1962; 1995; 2003; Karahanna et al. 1999). Similarly, in the academic context LMS should agree with students' values (Olasina 2019; Mpungose 2020; Wang et al. 2020). The complexity characteristic of IT has been defended in the literature, more specifically by TAM, as determinant for the acceptance of new IT (Svendsen et al. 2011; Chang and Yang 2013; Özbek et al. 2014; Chen 2015; Olasina 2019; Wang et al. 2020).

The fact of users perceiving ease of use, or not needing to expend efforts in using the technology is also fundamental for IT adoption (Teo 2008). In the academic context, the same situation is found. LMS should be easily to use by students (Zhang et al. 2020). According to Chopra et al. 2019, LMS should be easy to use as well as planned in terms of layout and navigation, which helps students in learning easily through these platforms. Therefore, these agents will accept and use LMS, according to the literature on this subject.

The observability of IT is referred to as positive in the use of new IT. If users have visual contact with IT, this makes them assimilate and consider its use as normal in performing their tasks (Yang 2007; Lee et al. 2011). The same situation occurs in this study with university students. Students' seeing other agents at the universities using LMS determines the acceptance and use of this tool. Observation of, and contact with LMS is seen to be a driver of the use of this IT in the academic context.

The last characteristic of IT, trialability, is stated by the literature to be an incentive to use. The possibility of testing IT, even before its implementation is considered definite, so that users can explore its potential, is a determinant of its acceptance (Karahanna et al. 1999; Lee 2007; Yang 2007; Lee et al. 2011). In the universities, students being able to LMS before they came into service was found to be a driver of their subsequent acceptance and use.

Summarizing, the characteristics of IT set out by IDT were shown to be determinant for its acceptance and use (Rogers 1962, 1995, 2003). Similarly, this study revealed that the characteristics of Moodle LMS have a positive influence on students' use of them. The empirical evidence obtained agrees with the literature on the subject.

Regarding the influence of PIIT, individuals with a high degree of Personal Innovativeness tend to accept and use new IT (Agarwal and Prasad 1998; Jeong et al. 2009). These agents have a high degree of openness and an innate tendency to experiment, without fear of failing, as these people have great self-confidence (Lee et al. 2007). According to Widyanti et al. 2020, the use of LMS by university students may shape theirs personality traits. In this type of learning students are required to be active, independent, self-reflective, and collaborative. Following the same line, the results of this research revealed that students with a high degree of Personal Innovativeness are more likely to use LMS, as suggested by the literature.

6 Conclusions, limitations and future lines of research

This research aimed to analyse the influence of the characteristics of Moodle LMS and PIIT on use of these platforms in Portuguese academic context.

According to IDT, an innovation will be spread more easily if it has characteristics of relative advantage, compatibility, complexity, observability and trialability. The

results of this study reinforce theory about the characteristics of innovations, in the particular context of universities and in relation to Moodle LMS.

The literature indicates that high levels of PIIT in individuals lead to greater acceptance and use of innovations. This study strengthens the theory on PIIT, through Portuguese university students' use of Moodle LMS. Therefore, based on IDT and setting out from a structural model, the results obtained revealed that the characteristics of Moodle LMS and students' PIIT stimulate the use of these platforms.

This research also contributes to practice, in that it emphasizes the need to develop student-centred LMS, in order to match their needs and characteristics. According to Pinho et al. (2018), the development of personalized User Interfaces (UIs) focused on the user is a factor in the success of institutional websites.

For students to derive greater benefit from these platforms, universities could provide curricular units and/or short courses devoted to developing students' soft skills and transversal competences. Based on students' degree of PIIT, universities can make a more conscious and correct investment in teaching. If students' PIIT is high, universities can concentrate their investment on e-learning, or otherwise invest more in the traditional type of teaching. Consequently, knowledge of students' PIIT can lead universities to improve the efficiency and effectiveness of internal processes.

This research presents some limitations. Although sufficient to carry out the intended study, the sample could have been more representative of the population, so suggested as a future line of research is to extend the sample to all Portuguese universities. The Portuguese higher education system is formed of state and private universities and polytechnic institutes. While state universities are funded exclusively by the state, private universities obtain a significant part of their funding through private financing. Polytechnic institutes can be state or private, but the essence of their teaching differs from that of universities. They have a more practical focus and courses directed to the labour market. Due to the considerable differences between these higher education institutions, another line of research could be to make a comparative study.

The study of student's profile, including gender, academic qualifications, academic subject, age and hours of LMS utilization could be included in future research. With this, universities could work on training those students who have more probability to be LMS resistant. To overcome this issue, universities could train them on LMS usage.

Annex I

Construct	Items used		Scale	Authors
LMS characteristics				
	RA1..They improve the results of my learning			

Construct	Items used	Scale	Authors
Relative advantage (RA)	**RA2**..They are very useful to me **RA3**.They help me to learn effectively	1- completely disagree, to 7- completely agree	Lee et al. (2009)
Compatibility (CP)	**CP1**.For me to adopt LMS, they would need to be compatible with most aspects of my learning **CP2**.For me to adopt LMS, they would have to match my learning style **CP3**.For me to adopt LMS, they would need to match my way of learning	1- completely disagree, to 7- completely agree	Karahanna et al. (1999)
Complexity (CX)	**CX1**.The study methods are easy to understand **CX2**.The platforms are easy to use	1- completely disagree, to 7- completely agree	Lee et al. (2009)
Observability (OB)	**OB1**.At my university we see students using the LMS on many of the institution's computers **OB2**.At my university, I saw many students using the LMS on personal computers	1- completely disagree, to 7- completely agree	Karahanna et al. (1999)
Trialability (TR)	**TR1**.Before deciding to adopt LMS or not, I would use them to test them **TR2**.Before deciding to adopt LMS or not, I would be able to test them suitably **EX3**.I would be authorised to use LMS to test them over a long period to explore their potential	1- completely disagree, to 7- completely agree	Karahanna et al. (1999)
Personality traits			
PIIT	**PIIT1**. If I hear about new IT, I look for ways to try it out **PIIT2**. In my group of fellow-students, I'm generally the first to explore new IT **PIIT3**.I like to try out new IT **PIIT4**.I'm generally hesitant about trying out new IT	1- completely disagree, to 7- completely agree	van Raaij and Schepers (2008)
Use of Moodle LMS (UML)			Al-Debei et al. (2013)
	Frequency of use		
	UML1. I access digital content	1 = never, to 7 = always	
	ULP		
	ML2. I attend classes		
	UML3. I communicate with fellow-students		
	UML4. I participate in forums		

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