Education Tech Research Dev (2021) 69:1271–1297
https://doi.org/10.1007/s11423-021-09941-2

CULTURAL AND REGIONAL PERSPECTIVES

A cross-cultural study on the influence of cultural values and teacher beliefs on university teachers' information and communications technology acceptance

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Accepted: 11 January 2021 / Published online: 25 January 2021

Abstract
This study examined how cultural values and teacher beliefs influence Chinese and Spanish university teachers' acceptance of ICTs by combining Hofstede's cultural values theory with technology acceptance theories. Four hundred and twenty-five university teachers from China and 385 teachers from Spain participated in the study. The proposed research model was tested by using samples from both countries and the multigroup analyses were performed to test moderating effects of cultural variables. Results confirmed the validity of the model in both samples and the effects of cultural values on the adoption of ICTs, and significant differences were observed between the two samples.

Keywords Cultural values · Higher education · Technology acceptance · In-service teachers

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Introduction

The use of Information and Communication Technologies (ICTs) in higher education is already a consolidated reality in many countries, and teachers now have a growing number of technological resources at their disposal in their institutions (Duţă and Martínez-Rivera 2015). However, the provision of ICT infrastructures to educational institutions is not the only factor necessary to ensure teachers' technology acceptance (Gil-Flores et al. 2017).

Teachers are key players in the integration of ICTs in educational contexts (Teo et al. 2008). Therefore, to design successful initiatives to promote technological innovation, it is essential to know the factors that affect teachers' acceptance of these resources (Teo et al. 2008). Technology acceptance models are among the most commonly used tools for studying these factors.

In the educational field, numerous studies have used technology acceptance models to analyse the influence of factors related to the internal and external barriers (Ertmer 1999) that condition ICT acceptance among both pre-service and in-service teachers (Kiraz and Ozdemir 2006; Sánchez-Prieto et al. 2017; Stols and Kriek 2011).

In particular, a number of cross-cultural studies have focused on the effects of culture on the technology adoption process in the educational field (Arenas-Gaitán et al. 2011; Ritchie et al. 2011; Huang et al. 2019a, b, c). These studies have indicated that cultural values condition the views and opinions of individuals. Cultural values are ones' commonly held standards or principles of what is acceptable or unacceptable, important or unimportant, right or wrong, workable or unworkable, etc., in a community or society (Hofstede 2008). Cultural values form the basic lenses through which we view our own actions and action of others; values also influence our thinking and behaviours. To measure cultural values, we adopted Hofstede's cultural dimensions as they were suggested in literature as useful and valid in exploring cultural influence on individual's technology acceptance (e.g., Tarhini et al. 2017; Huang et al. 2019a, b, c; Teo and Huang 2019). Hofstede proposed six dimensions to meausrue cultural values: power distance, individualism versus collectivism, musculinity versus femininity, uncertainty avoidance, long-term versus short term orientation, indulgence versus restraint (definition were provided in the following section). The influence of these specific cultural variables, which affect the strength of the relationships among the constructs in the technology acceptance models (McCoy et al. 2007), may have contributed to the inconsistencies found on the literature on the adoption process across different cultures (Huang et al. 2019a, b, c; Tarhini et al. 2017).

Accordingly, if we ignore the elements related to these cultural values, we risk introducing significant research biases that may compromise the applicability of the adoption models to different cultural contexts (McCoy et al. 2007). However, few studies have focused on the influences of cultural values on technology acceptance among higher education teachers (see Huang et al. 2019a, b, c as an exception), a collective with characteristics that distinguish them from K-12 school teachers in aspects such as the interaction between their researcher identity and the teacher identity or the teacher training received (Postareff et al. 2007; McNaughton and Billot 2016).

Moreover, few studies have compared the technology acceptance of teachers in countries in the Latin-European cluster and those in countries in the Confucian-Asian cluster (Gupta, Hanges and Dorfman 2002; Huang et al. 2019a, b, c), two groups with different cultural values but with some similarities (Gupta et al. 2002). The comparison between

these two countries may offer relevant information about the influence of culture on the technology adoption process, especially of the values related with collectivism, power distribution, and life uncertainty.

Spain, as a representative country of the Latin-European cluster, is characterised by a paternalistic state, and as having some collectivistic features within an individualistic value system. Accordingly, the Spanish tend to deal well with uncertainty, but still feel the need to be part of a more structured organisation (Gupta et al. 2002). However, this desire contrasts with the rejection of the values of power distance, and Spanish citizens prefer a society in which power is distributed equally (Jesuino 2002).

In contrast, Chinese society is characterised by its strong institutional collectivism and family orientation (Huang and Teo 2020; Gupta et al. 2002). The organisations in Chinese society have highly structured hierarchies in which the members accept the power distance between themselves and their leaders, and expect their leaders to absorb the uncertainty in new situations (Gupta et al. 2004; Pillai et al. 2011).

In recent years, Spain and China have been making continuous efforts to integrate ICTs into their universities (Gil-Flores et al. 2017; Teo et al. 2008). Thus, these countries are ideal settings for analysing how cultural differences influence higher education teachers' adoption of ICTs, hypotheses on this topic will be provided later on the literature review section.

Therefore, this study aims on the one hand to develop a technology adoption model that can explain the factors that predict the intention to use ICTs in teaching practices in higher education institutions and, on the other hand, to analyse how certain cultural factors influence the ICT acceptance of Spanish and Chinese university teachers. We examine the following two research questions:

RQ1 Which factors predict the technology acceptance of university teachers in China and Spain?

RQ2 Are there any differences between China and Spain in the relationships between the factors that predict the acceptance of ICTs among university teachers?

To address these questions, we develop a model based on two of the most well-known theories used in the analysis of technology adoption and cultural values, namely, the technology acceptance model (TAM) (Davis 1989) and Hofstede's cultural values (Hofstede 2011).

Literature review

Technology acceptance model

The technology acceptance model (TAM) is arguably one of the most comprehensive tools for studying the factors that condition the use of a given technology by an individual (King and He 2006). The model explains the adoption process based on four main dimensions: perceived usefulness (PU), perceived ease of use (PEU), attitude towards use (AU) and behavioural intention (BI) (Fig. 1) (Davis 1989).

PU measures the user's perception of the utilitarian properties of a technology and is defined by Davis as 'the prospective users' subjective perception of the probability that using a specific application system will increase his or her job performance within an

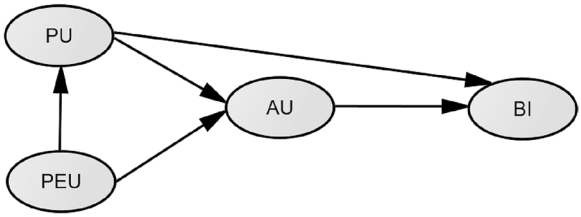

Fig. 1 Technology acceptance model (Davis 1989). *PU* perceived usefulness, *PEU* perceived ease of use, *AU* attitude towards use, *BI* behavioral intention

organizational context' (Davis et al. 1989, p. 985). PEU refers to the effort required to incorporate a new tool within the working practice of the potential user. In TAM, PEU is defined as 'the degree to which the prospective user expects the target system to be free of effort' (Davis et al. 1989, p. 985).

The two remaining constructs were developed by Davis based on the theory of planned behaviour (TPB) (Ajzen 1991). Firstly, AU assesses whether an individual has a favourable or unfavourable attitude towards using a new ICT. Secondly, BI measures the strength of the user's intention to incorporate the technology into their working practice and is the direct antecedent of the actual use of a technology.

TAM has evolved over the years, and has frequently been adapted to new fields of knowledge or extended with new constructs to increase the percentage of variance explained. In addition, two new versions of the model, TAM 2 (Venkatesh and Davis 2000) and TAM 3 (Venkatesh and Bala 2008), integrate some of the new constructs used by researchers. Namely, TAM 2 introduced subjective norm as an antecedent on BI and PU and, at the same time, image, job relevance, output quality and results demonstrability as antecedents of PU. Additionally, TAM3 incorporated another 6 constructs affecting PEU: computer self-efficacy, perception of external control, computer anxiety, computer playfulness, perceived enjoyment and objective usability.

In education, TAM has been used as the framework to measure the acceptance of ICTs, such as computers and learning management systems (Agudo-Peregrina et al. 2014). TAM has also been used as the basis for developing new theories and studies on the factors that condition the acceptance of ICTs among both in-service (Huang and Teo 2020) and pre-service teachers (Sánchez-Prieto et al. 2017).

However, the original formulation of TAM has some limitations, mainly due to its excessive simplicity, which does not include the measurement of external variables that may affect the acceptance process (Davis et al. 1989; Legris et al. 2003). This simplicity can also cause problems in the level of variance explained when applying TAM in exploratory studies (Legris et al. 2003). In addition, TAM has been criticised for being culturally biased for not measuring any of the cultural variables that affect the relationships between the constructs of the model (Tarhini et al. 2017) which is especially important when applied to non-Western cultures (McCoy et al. 2007). For these reasons, we decided to design and develop a modified TAM that is applicable to the context and objectives of this study. Our modified model is based on the original TAM proposal by Davis (1989), and retains the constructs of PU, PEU and BI.

Although attitude was included in the first version of TAM, in the following years Davis and Venkatesh (2000) and Venkatesh and Bala (2008) removed this dimension in TAM 2 and TAM 3 because the construct only partially moderates the effects of PU and PEU on BI. Thus, its removal allows for a better understanding of the effects of the constructs on the fundamental dependent variable of interest, BI (Venkatesh 2000). In the educational field, attitude is also frequently removed to achieve more compelling models that are

adapted to the educational context (e.g., Hu et al. 2003; Park 2009; Tan et al. 2014). We propose the following hypotheses for the abovementioned constructs adapted from TAM 2 and TAM 3:

H1 PU positively predicts higher education teachers' BI to use ICTs in their teaching practice.

H2 PEU positively predicts higher education teachers' BI to use ICTs in their teaching practice.

H3 PEU positively predicts higher education teachers' perception of the usefulness of ICTs.

In the educational context, teachers' behaviours and decisions are influenced by their beliefs on how the teaching process (Teo 2009). Teaching beliefs can be classified in two groups, traditional teaching beliefs and constructivist teaching beliefs (CTB) (Judson 2006; Teo et al. 2008).

This way, teachers with constructivist beliefs would commonly conceive that the students' knowledge is built through their own experiences which require the involvement of the individuals in meaningful teaching–learning activities adapted to their own interests and experiences (Higgens and Moseley 2001; Judson 2006). Consequently, constructivist teachers would feel inclined towards the use of student-centred classes where the teacher does not control the whole learning process (Jacobsen et al. 2009).

However, this does not imply that a teacher under a constructivist paradigm should necessarily adopt a passive role, on the contrary, it has been established that pure discovery on itself may be ineffective and teachers should adopt the role of guide of the cognitive learning process of their students by deciding how much and what kind of guidance to provide depending on the situation (Mayer 2004).

Accordingly, the adoption of ICTs among teachers is also conditioned by their teaching beliefs (Kiraz and Ozdemir 2006), influencing both their intention of using the devices and the type of activities (Judson 2006). This construct has been used in previous studies on technology acceptance in education showing that teachers who hold CTBs use technology more frequently (Overbay et al. 2010). In consequence, we propose the following hypotheses based on the works of Teo et al (2008) and Karahanna et al. (2006).

H4 Constructivist teaching beliefs positively predict higher education teachers' BI to use ICTs in their teaching practice.

H5 Constructivist teaching beliefs positively predict higher education teachers' perception of the usefulness of ICTs.

As previously mentioned, TAM is partially based on TPB, which proposes that the behaviour of an individual is conditioned by three factors: the individual's beliefs, environmental pressure and the individual's ability to control his or her behaviour. To measure the environmental pressure placed on an individual to perform a given task, Ajzen (1991) proposed the subjective norms (SN) variable. This construct is frequently used in TAM-based studies within the educational field (Kreijns et al. 2013; Ma et al. 2005; Park 2009) to measure the factors related to the effects of social pressure on teachers and students'

intentions to use ICTs. The SN variable is also included in TAM 2 and TAM 3. In this context, following Venkatesh and Davis (2000) and Venkatesh and Bala (2008), we hypothesise that SN affects both PU and the BI to use ICTs:

H6 SN positively predicts higher education teachers' BI to use ICTs in their teaching practice.

H7 SN positively predicts higher education teachers' perception of the usefulness of ICTs.

SN, as formulated in TAM 2 and TAM 3, measures the sources of subjective norms in a generic manner, as the relevance of the opinions of the people important to the user. However, Taylor and Todd (1995) proposed analysing the effects of each of these sources and how they condition SN.

A possible source of SN in the educational context is the influence of the teacher's perceived expectations of the students. Student influence (STI) is a relatively new construct that examines how the perceived pressure of students influences the behaviour of the teachers (Mejia and Phelan 2013).

Although the exploration of this construct is still in its initial stages, it has been used in studies on teachers suggesting its effect on perceived usefulness when SN is not included in the model (Mejia and Phelan 2013) and a strong influence on SN when it is incorporated (Sadaf et al. 2016). This research takes an approach closer to the proposal by Taylor and Todd (1995) and Sadaf et al. (2016) including the construct of SN with STI as its antecedent, proposing the following hypothesis:

H8 STI positively predicts higher education teachers' perception of the social pressure to use ICTs.

As previously mentioned, TPB also proposes that an individual's perceived control over his or her behaviour is a direct antecedent of BI (Ajzen 1991). From this perspective, higher education teachers' perception of their control over the use of ICTs in educational contexts is likely to condition their intention to use the technology (Taylor and Todd 1995). The elements that constrain higher education teachers' use of ICTs may be related to the availability of the resources, knowledge or skills needed to use the technology.

The construct of perceived behavioural control (PBC), adapted from TPB, has been successfully used to study technology acceptance in educational settings evidencing its influence on BI (Liu 2010; Pynoo et al. 2012). For this study, we formulate the following hypothesis based on the work of Taylor and Todd (1995), thus completing the research model (Fig. 2):

H9 PBC positively predicts primary teachers' BI to use mobile devices.

Moderating effects of cultural variables

Culture can be defined as the shared system of meanings followed by members of the same community, and acquired through a learning process that may differ across groups and individuals (Arenas-Gaitán et al. 2011; Hoecklin 1995). The effects that these shared systems of values have on the behaviour of individuals is a growing topic of interest among researchers (Tarhini et al. 2017).

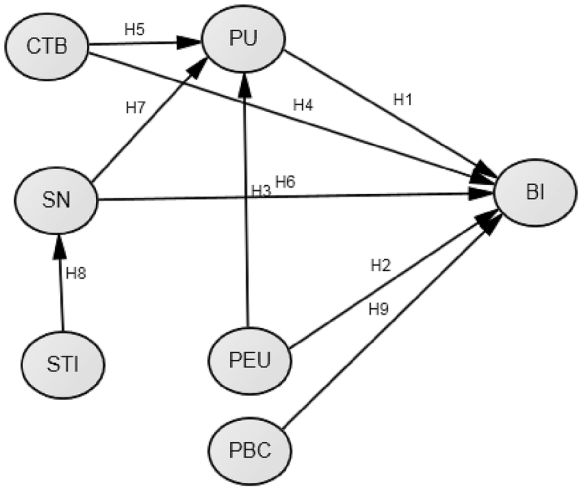

Fig. 2 Research model. *PU* perceived usefulness, *PEU* perceived ease of use, *BI* behavioral intention, *SN* subjective norms, *CTB* constructivist teaching belief, *PBC* perceived behavioral control, *STI* student influence

Hofstede's (1980) cultural values framework is one of the most cited theories in the applied study of culture. The framework stems from a series of studies on national cultures based on a sample of nearly 120.000 workers from IBM in 40 different countries. Initially, Hofstede (1980) distinguished four universal dimensions of culture: power distance, individualism/collectivism, uncertainty avoidance and masculinity/femininity. Over the years, Hofstede's framework has been extended to include new dimensions, such as short-term/long-term focus and indulgence (Hofstede et al. 2010). This theoretical framework is widely used by researchers in cross-cultural studies to measure the cultural values of the participants in samples from different countries.

In recent years, Hofstede's cultural dimensions have also been incorporated in technology acceptance research in e-commerce (Smith et al. 2013) and education (Huang et al. 2019a, b, c; Sánchez-Franco et al. 2009). The research in these fields suggests that Hofstede's cultural values may affect the strength of some of the relationships within the TAMs (Tarhini et al. 2017).

Based on the analysis of Chinese and Spanish samples by Hofstede et al. (2010) and Hofstede Insights (2018), we selected three dimensions that were found to differentiate two countries the most, namely, power distance (PD) (China = 80, Spain = 57), individualism/collectivism (IC) (China = 20, Spain = 51) and uncertainty avoidance (UA) (China = 30, Spain = 86) (Hofstede Insights 2018).

PD is defined as the extent to which the members of institutions and organisations within particular societies expect and accept inequalities in the distribution of power (Hofstede 2001). Some authors (e.g., Dinev et al. 2009; Tarhini et al. 2017) have suggested that PD moderates the relationship between SN and BI, such that a higher PD leads to SN having a greater effect on BI, and thus increases the effect of the opinions of others on an individual's BI to use ICTs. In addition, we have established how SN affects PU; therefore, we posit that this influence will also be stronger in societies with higher levels of PD.

Within the educational field, there is also a power relationship between teachers and students. Consequently, in societies with higher PD, teachers are placed in the centre of the teaching–learning process, and thus have complete control over the communication process (Hofstede 2001). As a result, we expect that the opinions of the students will have less influence on the teachers' perceptions of the social pressure to use ICTs.

Furthermore, research suggests that users from low PD countries may feel more empowered to decide whether to use a technology based on their own judgement of its usefulness (Tarhini et al. 2017). Hence, we expect to find a stronger relationship between PU and BI among higher education teachers from countries with lower PD than those from countries with high PD.

Following the line of reasoning of Tarhini et al. (2017), we also expect that the teachers' beliefs about the teaching methodology will have less influence on their intention to use ICTs in countries with higher PD given that this value influences the feeling of empowerment to make decisions based on personal beliefs and considerations. Therefore, we propose the following research hypotheses for this variable:

H10A PD positively moderates the predictive relationship between SN and BI.

H10B PD positively moderates the predictive relationship between SN and PU.

H10C PD negatively moderates the predictive relationship between STI and SN.

H10D PD negatively moderates the predictive relationship between constructivist teaching beliefs and BI.

The second dimension included in this study is individualism-collectivism (IC), which focuses on the relationship between the individual and the collective (Hofstede 2001). In Hofstede's work, individualism signifies loose social ties and is predominant in societies where individuals are expected to look after themselves and their immediate family only. In contrast, collectivism is predominant in societies in which individuals are integrated into cohesive groups from birth. The strong loyalty bonds within these groups protect the members throughout their lifetime.

The moderating effects of IC have also been explored in the technology acceptance research. Researchers have hypothesised that IC conditions both the effect of PU on BI and the influence of SN on BI.

This way, in collectivist societies the effect of SN on BI is stronger given that the group preferences are more important than the individual (Tarhini et al. 2017; Srite 2006). In consequence, the relationship between PU and BI in these groups is weaker, given that PU refers to individual preferences (Sánchez-Franco et al. 2009; Tarhini et al. 2017).

Additionally, in collectivist societies, the organisational relationships are closer to those established among family members and are predicated on mutual obligations to protect in exchange for loyalty (Hofstede 2001). This way, it is expected that the organizational bond between teachers and students would be stronger in collectivistic societies, as it happens with the relationships between the members of organizations in other professional fields (Hofstede 2001) increasing the effect of STI on SN.

Finally, IC may also affect the influence of the control over BI. In collectivistic societies, individuals place more trust in collective decisions and thus have less control over their work and working conditions. This situation may weaken the influence of PBC on BI. To summarise, we propose the following hypotheses for the moderating effect of IC:

H11A Collectivism positively moderates the predictive relationship between SN and BI.

H11B Collectivism positively moderates the predictive relationship between SN and PU.

H11C Collectivism positively moderates the predictive relationship between STI and SN.

H11D Collectivism negatively moderates the predictive relationship between PU and BI.

H11E Collectivism negatively moderates the predictive relationship between constructivist teaching beliefs and BI.

Finally, the third cultural dimension examined in this study is uncertainty avoidance (UA). This construct measures how individuals in a particular society cope with uncertainty. In cultures with a low tolerance for uncertainty, individuals tend to rely more on specific rules and regulations to guide their behaviour.

In the context of technology acceptance, UA can affect some of the relationships between the constructs proposed in the research model. Firstly, in societies with high levels of UA, individuals rely more on their superiors, both in educational institutions and in the workplace, thus increasing their loyalty. In these situations, individuals place more trust in the good judgment of their leaders or the group than on their own decisions (Hofstede 2001). In consequence, we expect that there will be stronger relationships between SN and both BI and PU and also weaker relationships between STI and SN and PU and BI among university teachers with high levels of UA. The dependence on rules and regulations among individuals with high levels of UA also limits their freedom to control their behaviour and make decisions on their own. Thus, we expect that PBC will have less influence on the intention to use ICTs among teachers with high UA.

However, the effect of UA on the relationships between the variables in TAM remains unclear because the results of the existing studies are contradictory (Tarhini et al. 2017). We aim to contribute to the exploration of this construct by examining the following hypotheses:

H12A UA positively moderates the predictive relationship between SN and BI.

H12B UA positively moderates the predictive relationship between SN and PU.

H12C UA positively moderates the predictive relationship between STI and SN.

H12D UA negatively moderates the predictive relationship between PU and BI.

H12E UA negatively moderates the predictive relationship between PBC and BI.

Figure 3 shows the moderating effects examined in this research.

Method

Instrument

The survey instrument used in this study was divided into two sections. The first section gathered the demographic data of the participants, including country, gender, age, and teaching experience. The second section comprised 38 Likert-type items ranging from 1 to 7 (1 = completely disagree, 7 = completely agree), which were used to measure

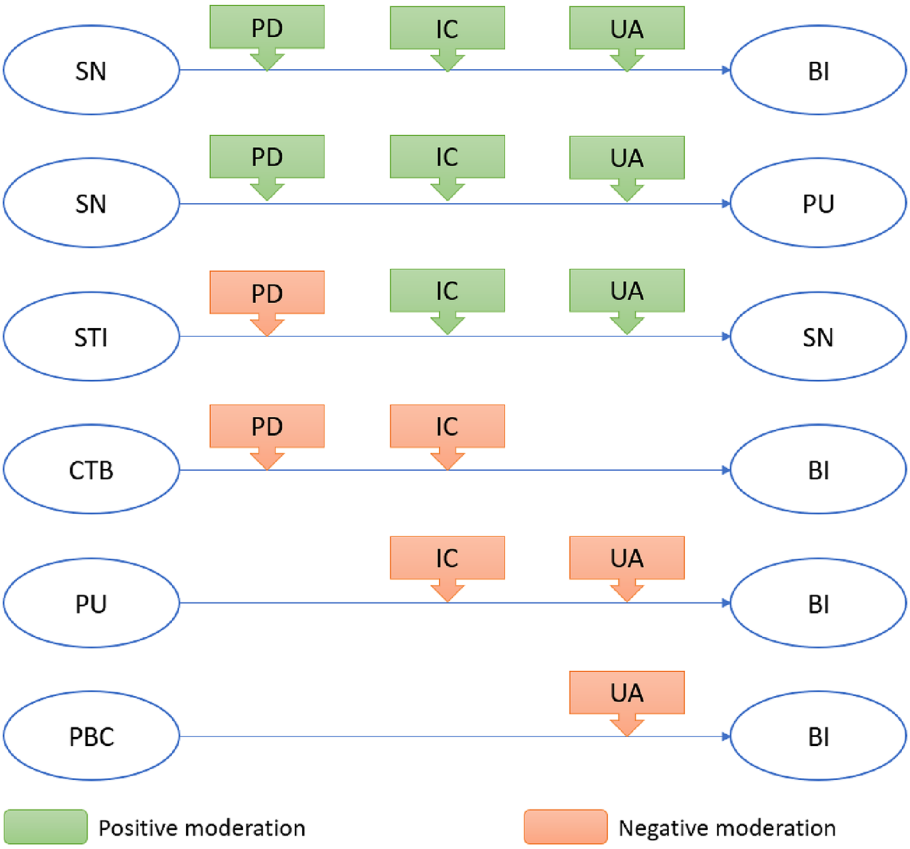

Fig. 3 Moderating effects. *PU* perceived usefulness, *BI* behavioral intention, *SN* subjective norms, *CTB* constructivist teaching belief, *PBC* perceived behavioral control, *STI* student influence, *PD* power distance, *IC* collectivism, *UA* uncertainty avoidance

the dimensions of the model. The items for these dimensions were developed based on the literature and adapted to the context and technologies under study (Table 9 in Appendix).

The items used to measure PU (4 items), PEU (4 items) and BI (4 items) were adapted from Davis (1989), and those for SN (4 items) and PBC (4 items) were adapted from Fishbein and Ajzen (1975) and Taylor and Todd (1995). The items used to measure STI (4 items) were adapted from Mejia and Phelan (2013), and those for CTB (7 items) were based on Teo et al (2008). Lastly, to assess the cultural values of the participants, we adapted the items proposed by Hofstede (Hofstede 2011): IC (5 items), PD (4 items) and UA (5 items).

The final version of the survey instrument was translated into Chinese and Spanish separately in a collaborative manner by teams of researchers at the University of Macau and the University of Salamanca. To ensure the sematic equivalence of the items, the translations were back-translated from Chinese and Spanish, respectively, into English (Renda and Okazaki 2016).

Population and sample

The sample for this study comprised 806 university teachers from Spain (385) and China (425). The participants were selected using convenience sampling and participated in the study voluntarily. The data gathering process was performed using a snowballing procedure, namely, the Spanish university teachers were contacted through an email that included a link to an online questionnaire developed and hosted in Google Drive while the Chinese university teachers were approached through WeChat. Both media tools allowed the access to teachers from different universities, in total there were participants from 93 and 41 different universities from China and Spain respectively.

In the overall sample, 52.6% of the respondents were men and 47.4% were women, although the percentages varied in the subsamples of the two countries. In the Spanish sample, 62.9% of the participants were men and 37.1% women, while in the Chinese sample the majority of the participants were female (56.8%). The average age of the participants was 43.6 years (S.D. 9.5), and the average teaching experience was 12.31 years (S.D. 7.8). The Chinese sample had an average age of 38.51 years (S.D. 8.455) and average teaching experience of 8.97 years. In the Spanish sample, the average age was higher, at 46.99 years (S.D 8.7), and the participants also had higher average teaching experience of 16.03 years (S.D. 7.9).

To explore the cultural values of the participants, we performed a descriptive analysis of the items for Hofstede's' dimensions (Table 1). The results show higher levels of collectivism, UA and PD in the Chinese sample, with the average values being above 5 for the majority of the items. In contrast, the values for all of the cultural dimensions are lower in the Spanish sample, with the values being under 5 for almost all of the items. We conducted a Student's t-test to test the statistical differences in the mean scores of the samples

Table 1 Averages of the cultural dimension items and t-test results

	Complete sample	Chinese sample	Spanish sample	95% CI for mean difference		t	df
				Lower	Upper		
IC_01	4.82	4.98	4.67	−0.53	−0.07	−2.58***	817
IC_02	4.93	5.22	4.62	−0.80	−0.38	−5.53*	818
IC_03	5.09	5.37	4.81	−0.77	−0.34	−5.21*	818
IC_04	5.11	5.22	4.99	−0.43	−0.01	−2.04***	819
IC_05	4.35	5.20	3.45	−1.97	−1.53	−15.58*	816
PD_01	4.08	4.74	3.35	−1.61	−1.16	−12.11*	820
PD_02	5.08	5.33	4.81	−0.73	−0.32	−5.07*	819
PD_03	3.40	3.81	2.99	−1.07	−0.57	−6.54*	818
PD_04	3.65	4.17	3.08	−1.31	−0.86	−9.40*	816
UA_01	5.02	5.21	4.82	−0.58	−0.19	−3.91*	823
UA_02	5.17	5.30	5.03	−0.46	−0.09	−2.94**	818
UA_03	5.27	5.44	5.07	−0.55	−0.19	−4.05*	821
UA_04	5.36	5.37	5.36	−0.19	0.17	−0.08	821
UA_05	4.66	5.21	4.07	1.33	−1.33	−10.97*	817

IC individualism-collectivism, *PD* power distance, *UA* uncertainty avoidance

*$p < .001$, **$p < .01$, ***$p < .05$

of the two countries. The results confirmed that the differences observed between the two samples were significant in all of the indicators except UA_04.

Data analysis

The model analysis and hypothesis testing were performed using a partial least squares structural equation modelling (PLS-SEM) approach. This approach to multivariate data analysis goes beyond the ordinary least squares (OLS) approach and allows the inclusion of more flexible assumptions and more precise examination of the relationships between the variables, thus reducing random measurement errors and misspecification (Garson 2015, 2016).

Due to the predictive nature of the study and the exploratory nature of the research on the effects of cultural values on the technology acceptance process, we decided to use PLS-SEM instead of the more traditional covariance based structural equation modelling (CB-SEM) (Hair et al. 2017; Nitzl 2016). By using PLS-SEM, we followed the example of previous cross-cultural studies on technology acceptance that integrated TAM and Hofstede's cultural values (e.g., Arenas-Gaitán et al. 2011; Sánchez-Franco et al. 2009).

The model analysis in PLS-SEM is a two-stage approach in which the first step involves examining the quality of the measurement model to confirm the validity and reliability of the dimensions. Once the validity and reliability are stablished, the second step focuses on evaluating the relationships in the structural model by testing the significance of the relationships and the variance of the endogenous variables predicted by the model (Hair et al. 2017). The analysis was conducted using the software SmartPLS 3.2.7 (Ringle et al. 2015). We applied the consistent PLS algorithm, which is more appropriate in PLS models where all of the variables are modelled as reflective.

Results

Model assessment

We assessed the model using the guidelines suggested by Hair et al. (2017). In the first stage of this procedure, we assessed the goodness of fit of the global model using the standardised root mean square residual (SRMR) index. According to this index, both the saturated and estimated model should have scores lower than 0.08. As we can see in Table 2, this condition is fulfilled in the complete sample and the subsamples of the two countries participating in the study with scores well under the threshold value. The Chinese sample has a slightly better goodness of fit than the Spanish sample in the saturated model, while the fit of the estimated model is better in the Spanish sample.

Table 2 Global model assessment

	Complete sample	Chinese sample	Spanish sample
Saturated model	0.024	0.025	0.039
Estimated model	0.059	0.064	0.059

Table 3 Convergent validity and reliability

	Complete sample		Chinese sample		Spanish sample	
	CRI	AVE	CRI	AVE	CRI	AVE
BI	.952	.832	.955	.842	.939	.795
CTB	.797	.568	.821	.607	.761	.515
PBC	.959	.854	.966	.875	.949	.823
PEU	.903	.757	.927	.809	.865	.682
PU	.876	.702	.866	.683	.903	.757
SN	.897	.684	.906	.706	.882	.653
STI	.942	.803	.938	.791	.948	.820

BI behavioural intention, *CTB* constructivist teaching beliefs, *PEU* perceived ease of use, *PU* perceived usefulness, *SN* subjective norm, *STI* student influence, *PBC* perceived behavioural control, *CR* composite reliability index, *AVE* average variance extracted

Table 4 Variance explained and the Stone–Geisser test

	R2			Q2		
	Complete Sample	Chinese Sample	Spanish Sample	Complete Sample	Chinese Sample	Spanish Sample
BI	.643	.724	.542	.456	.549	.375
PU	.506	.551	.442	.280	.343	.251
SN	.464	.608	.325	.283	.436	.238

BI behavioral intention, *PU* perceived usefulness, *SN* subjective norms

In the second stage of the model assessment, we analysed the construct reliability and validity of the measurement model for the three data groups. We tested the reliability of the indicators by checking that the loadings of all of the indicators were around 0.7 or higher (Hair et al. 2017). This process indicated the need to eliminate some items, namely, PEU_01, CTB_01, CTB_03, CTB_05 and CTB_06. In addition, the values for the composite reliability index (CRI) and average variance extracted (AVE) of the constructs were above .6 and .5, respectively, thus confirming the convergent validity and reliability of the dimensions included in the model (Hair et al. 2017) (Table 3).

The analysis of the measurement model concluded with the estimation of the discriminant validity. In PLS, the discriminant validity is usually verified using two methods, namely the Fornell–Larker criterion (Fornell and Larcker 1981) and the heterotrait-monotrait ratio (HTMT) (Henseler et al. 2015). All of the variables in the model satisfied the conditions of both methods, with the square root of the AVE being higher than the inter-construct correlations and HTMT scores under 0.085 for all of the constructs.

In the third and final stage of the model analysis, we examined the structural model by analysing the amount of variance predicted by the model and testing the predictive hypotheses. As we can see in Table 4, the proposed model predicts a large percentage of the variance of BI in the three data groups, although the percentages of variance predicted for the three endogenous variables in the Chinese sample are higher than in the

Spanish sample. Table 4 also shows the results of the Stone–Geisser test, which yielded a Q^2 above 0 for all of the constructs, thus confirming the predictive capability of the model.

For the predictive hypotheses, the path analysis results in Table 5 provide support for all of the hypotheses proposed in the model except for H2 and H8. These results are consistent across the Spanish, the Chinese and the complete sample of teachers. We can also observe in the table that the Chinese sample has higher path coefficients than the Spanish sample in all of the relationships except PU → BI and SN → PU.

Moderating effects

We used a two-stage methodology (Hair et al. 2017) to test the hypotheses regarding the moderating effects of cultural values. We first tested the validity and reliability of the moderator variables, and then created the interaction term measuring the moderating effect. Finally, we conducted a bootstrapping analysis to test the significance of the moderation (Table 6).

The results in Table 6 show that there are differences in the moderating effects among the three samples. Firstly, in the complete sample, IC negatively moderates the PBC → BI and PU → BI relationships, and positively moderates the SN → BI relationship. However, this cultural dimension only moderates two relationships (CTB → BI and PBC → BI) in the Spanish sample, while in the Chinese sample it only negatively moderates the PU → BI relationship. Second, PD moderates the PU → BI and SN → BI relationships in the complete sample and the Chinese sample. However, in the Spanish sample, this variable only moderates the PU → BI relationship. Finally, UA also negatively moderates PU → BI in the Chinese sample and the complete sample. This dimension has a different effect in the Spanish sample, in that it negatively moderates PBC → BI instead of PU → BI.

Table 5 Path analysis

Path	Path coeff			T values		
	Comp	China	Spain	Comp	China	Spain
CTB → BI	.039+	.068+	.016+	1.948	1.798	0.301
CTB → PU	.234*	.171**	.242*	5.193	3.117	4.869
PBC → BI	.362*	.273*	.259**	5.570	3.569	3.242
PEU → BI	−.059+	.008+	.012+	0.207	0.127	0.205
PEU → PU	.345*	.352*	.245*	7.528	5.064	4.986
PU → BI	.429*	.331*	.424*	8.365	5.198	7.559
SN → BI	.182*	.306*	.160**	4.923	4.498	3.299
SN → PU	.336*	.327*	.376*	7.604	4.013	7.670
STI → SN	.682*	.743*	.543*	20.085	18.129	10.905

CTB constructivist teaching belief, *BI* behavioural intention, *PU* perceived usefulness, *PEU* perceived ease of use, *SN* subjective norms, *STI* student influence

*$p < .001$, **$p < .01$, + not supported

Table 6 Moderating effects

Path	Path coeff			T values		
	Comp	China	Spain	Comp	China	Spain
IC × CTB → BI	.028+	− .007+	.081***	0.998	0.167	1.863
IC × PBC → BI	− .082**	− .037+	− .149**	2.464	0.798	2.574
IC × PU → BI	− .101***	− .138***	.007+	2.338	2.320	0.107
IC × SN → BI	.079***	.116+	− .020+	1.845	1.455	0.391
IC × STI → SN	.009+	.018+	− .023+	0.272	0.444	0.447
PD × CTB → BI	− .020+	− .057+	.005+	0.690	1.186	0.107
PD × PU → BI	− .184*	− .197*	− .122***	4.879	3.973	1.961
PD × SN → BI	.127*	.148**	.014+	3.617	2.843	0.301
PD ×× STI → SN	− .024+	− .026+	− .050+	0.757	0.593	1.149
UA × PBC → BI	.013+	.056+	− .135***	0.249	0.685	1.864
UA × PEU → BI	− .041+	− .055+	.041+	0.954	0.894	0.700
UA × PU → BI	− .135**	− .191**	− .076+	2.869	2.680	1.020
UA × SN → BI	.051+	.117+	− .003+	1.081	1.366	0.050
UA × STI → SN	.028+	.023+	.027+	0.974	0.580	0.568

IC individualism-collectivism, *CTB* constructivist teaching belief, *BI* behavioural intention, *PBC* perceived behavioural control, *SN* subjective norms, *PD* power distance, *PU* perceived usefulness, *STI* student influence, *UA* uncertainty avoidance, *PEU* perceived ease of use

*$p < .001$, **$p < .01$, $p < .05$, + not supported

Multigroup analysis

Although there were some differences in the path coefficients and the R^2 of the Chinese and Spanish samples, we needed to conduct a PLS multigroup analysis (PLS-MGA) to determine whether these differences found at the structural level between the samples were statistically significant.

To test the measurement invariance between the two groups necessary for the PLS-MGA, we conducted a measurement of invariance of composite models (MICOM) test (Henseler et al. 2016), which is a three-step process. The first step tests the configural invariance to ensure that the two groups have identical indicators and are analysed using the same procedure. This step is necessary for the second step, which tests the compositional invariance to assess whether the dimensions are equally formed across the groups. To do so, the MICOM procedure examines the weights of the indicators in the different groups and applies a statistical test to ensure that the weights do not significantly differ across the groups.

Finally, if the results of step 2 confirm the compositional invariance of the indicators, then the third and final step can be completed. This step tests the scalar invariance by analysing the equality of the mean values and variances of the dimensions. If the results of this step show the existence of scalar invariance, then there is full measurement invariance. Alternatively, if there is no scalar invariance, then there is partial measurement invariance across the data groups. PLS-MGA requires the existence of at least partial measurement invariance (Henseler et al. 2016).

Table 7 MGA of the path coefficients

Path	Path coeff dif	p value
CTB → BI	.053	.800
CTB → PU	.070	.172
PBC → BI	.200	.575
PEU → BI	.021	.480
PEU → PU	.004	.894
PU → BI	.106	.128
SN → BI	.097	.049
SN → PU	.141	.302
STI → SN	.049	.001

CTB constructivist teaching belief, *BI* behavioural intention, *PBC* perceived behavioural control, *PEU* perceived ease of use, *PU* perceived usefulness, *SN* subjective norms, *STI* student influence

Table 8 MGA of the variance explained

	Spanish sample	Chinese sample	p value
BI	.542	.724	.002
PU	.442	.551	.196
SN	.325	.608	.002

BI behavioral intention, *PU* perceived usefulness, *SN* subjective norms

Our results showed that the model had both configural and compositional invariance, although there was no scalar invariance. Therefore, the model had partial measurement invariance, which was sufficient to conduct the MGA to compare the path coefficients of the country samples.

The results of the MGA analysis shown in Table 7 reveal significant differences in two of the paths of the model, namely, SN → BI and STI → SN. In both cases, the path indexes for the Chinese university teachers are higher than those for the Spanish higher education teachers.

We also tested whether the differences found between the R^2 coefficients were also significant at a statistical level using the same PLS-MGA procedure. As we can see in Table 8, there are significant differences in the constructs BI and SN.

Discussion

This research fills a research gap in the literature related with the influence of culture on university teachers' technology adoption by proposing a cross-cultural comparison between instructors from China and Spain using an expanded TAM model. The results obtained in this study have confirmed the effect of the constructs included in the model on the technology adoption of university teachers supporting 7 of the 9 hypotheses formulated. In this sense, it is especially important the effect of PU and social pressure, this last one particularly in the Chinese sample.

Additionally, this investigation has also found significant differences in the path coefficients between the samples of Chinese and Spanish teachers and confirmed the impact of culture on the technology adoption of university teachers.

In the following sections we will discuss the implications of the outcomes of this study for the research on the technology acceptance of university teachers and the effect of culture.

Implications of the model assessment

The first research question was related to the factors that predict university teachers' intentions to use ICTs. To answer this question, we developed an extended TAM, as described in "Literature review". When examined separately, the model predicts 54% of the variance of the BI in the Spanish sample and the 72.4% in the Chinese sample, a percentage significantly higher than that of previous studies focused on technology acceptance among in-service higher education teachers (e.g. Dansarki et al. 2016; Tarcan et al. 2012). This, along with the support of 7 of the 9 hypotheses included in this study, confirms the relevance of the constructs added to the model.

Although the results for the hypotheses are consistent between the two samples, the variables display different behaviours. Firstly, PU, SN and PBC play key roles in the university teachers' technology acceptance in both countries, in line with previous studies on technological adoption (e.g. Chen and Tseng 2012; Huang et al. 2020; Lay et al. 2013). As expected, SN is especially important in the case of China. We further elaborate this finding later in this section.

In turn, PEU does not play a relevant role as a direct predictor of BI. The effect of PEU in the technology adoption of teachers constitutes a topic of interest among researchers given the inconsistencies found in the literature, especially regarding its relationship with BI, which is not always supported (Dansarki et al. 2016; Tarcan et al. 2012; Motaghian et al. 2013).

One possible explanation for these inconsistencies may lie in the role of experience. Davis et al. (1989) affirm that experience moderates the relationship between PEU and BI by weakening its effect, if we take this into consideration and the fact that the sample of this study is composed by experienced teachers who demonstrate features of digital natives (Huang et al. 2019a, b, c), we can suggest that teachers' experience may have had a moderating role on this relationship. However, more research is needed to clarify this issue and explore the possible differences between the effect of professional experience and experience using the technology (Huang et al. 2019a, b, c).

The results of the data analysis also support the relationship between STI and SN, which indicates that the students' opinions have a strong effect on the teachers' perceived social pressure to use ICTs. This result is consistent with prior studies (Sadaf et al. 2016) and highlights the importance of considering the different sources of SN separately (Mejia and Phelan 2013). This finding also suggests that university teachers have a high consideration of their students and close relationships with them.

Another alternative explanation for the support of H12 is the effect of the student evaluations to which university teachers are subjected. This way the desire to obtain positive evaluations may lead professors to change their teaching methods (Floden 2016). This phenomenon is more common in teachers with less experience and temporary positions, probably due to the feeling of pressure to obtain higher scores in order to advance in their careers (Grimard 2018).

Finally, constructivist teaching beliefs do not directly predict the participants' BI to use ICTs, which contradicts the results found in the literature (Teo et al. 2008). However, this variable does have a predictive direct effect on PU, thus confirming that the usefulness of ICTs is influenced by the methodology used by the teacher. This indicates that constructivist teaching beliefs do not directly determine the intention to use ICTs but they do condition their potential uses. Therefore, teachers with CTBs are more aware of the advantages that these tools possess to support constructivist learning activities.

We predicted that the effect of constructivist teaching beliefs on technology acceptance would be similar to the effect of the compatibility with the preferred work style proposed by Karahanna et al. (2006). However, the results indicate that constructivist teaching beliefs only condition the teachers' perception of the possible application of ICTs in their teaching. This explains why this construct works in a similar way to the job relevance construct included in TAM 3.

In this research, we have modelled BI following the proposal by Davis (1989), which measures general uses of the technologies. However, teachers with constructivist teaching beliefs may have intention of using ICTs for different purposes than those with traditional teaching beliefs (Liu et al. 2017; Jääskelä et al. 2017). This may explain the lack of relationship between CTB and BI found in this research and constitutes an interesting direction for future studies.

Ultimately, the results of the model imply the need to rethink some common assumptions on technology adoption among teachers. Firstly, there is a need to further delve into the study of the well-established constructs frequently included in technology acceptance models to explain teachers' technology adoption, namely BI, SN and PEU.

Secondly, in order to promote the intention to use technology among teachers, organizations should focus less on factors related with the ease of use of technologies and pay attention to some factors usually overlooked in technology adoption studies, such as the teachers' awareness of student opinions and their preferred teaching model, fostering and facilitating constructivist teaching practices.

Implications of the analysis of the effect of culture

To answer the second research question, we analysed the moderating effects of the cultural dimensions. Although the results show that the cultural variables have a moderating effect on some of the hypotheses, our analysis highlighted some differences between the two countries. These differences suggest that the moderating effects of the cultural variables on the adoption process also depend on the contextual and organisational factors.

Some of the results relating to the moderating effects are of interest. First, the cultural dimensions have more moderating effects in the complete sample than in the Chinese and Spanish samples, which can be explained by the greater heterogeneity of the scores in the overall sample. Second, none of the cultural variables have any effect on the relationship between STI and BI, which reflects the complex relationship between teachers and students in both countries. Third, all of the cultural dimensions negatively moderate the relationship between PU and BI, which indicates that the effect of this dimension on BI would be lower in China if PU was not also a moderator of the effect of SN on BI. This further indicates the important role that SN plays in the technology acceptance of Chinese higher education teachers.

Finally, the MGA conducted revealed significant differences at the structural level between the samples in two of the relationships that explain why R^2 is higher in the

Chinese sample. First, there is a significant difference in the relationship between SN and BI, which can be explained by the effect of PD in strengthening this relationship in the Chinese sample. Second, there is also a significant difference in the relationship between STI and SN. The explanation for this difference lies in the complex relationship between teachers and students. First, because PD has no moderating effect, we can conclude that there is no perceived PD that may weaken the relationship. However, because IC also has no moderating effect, this suggests that teachers do not perceive themselves as belonging to the same group as their students. The explanation for this difference may lie in the desire for harmony and conflict avoidance that characterises leadership in China (Hofstede 2001), which may generate teachers that value the opinions of their students more. Leadership in Latin-European countries is more focused on charismatic leadership than humane leadership (Jesuino 2002), which may explain why the Spanish university teachers are less concerned about their students' expectations.

The results of this research confirm that the technology adoption process is conditioned by the organizational culture in a very complex way that causes important discrepancies both between countries and previous investigations (e.g. Tarhini et al. 2017; Sánchez-Franco et al. 2009). Therefore, it is essential to continue with the research on the effect of these factors in order to attain the knowledge necessary to guide the intervention.

Limitations and future research work

This study has some limitations. First, due to the difficulties regarding the access to the population we used a convenience sampling process, which may affect the generalisability of the results to the whole population of university teachers from the two countries. Therefore, the result of this research should be restricted to the groups of participants. Future studies should address this issue by using a more systematic sampling procedure in order to increase the representability of the sample.

Another important limitation of this investigation is the use of self-reports to measure the constructs, which may introduce a social desirability bias that should be taken into consideration, especially in the relationship between BI and actual use.

The second issue is related to the construct selection to measure the effect of culture. Although there were implications derived from this study regarding the complexity of the relationship between organizational culture and higher education teachers' technology adoption, the results obtained indicate the need to rethink the modelling of cultural factors. One possible alternative for future studies lies in the use of a different cultural value theory such as Schwartz's culture model (Schwartz 1992) or Triandis' model of subjective culture and social behaviour (Triandis 1994), whose modelling of cultural values may have a more clear and consistent interaction with the constructs from the technology adoption theories.

Finally, as we have indicated earlier in the discussion, this research raised some questions that indicated the need to refine the modelling of BI, PEU and SN. The use of qualitative techniques to attain a better understanding of the meaning that these constructs have for teachers might constitute a useful tool to achieve this goal.

Conclusion

In this study, we presented an extended TAM, which we validated in two different national contexts. Our findings confirm that the proposed model constitutes an effective tool for predicting Spanish and Chinese higher education teachers' intentions to use ICTs, thus confirming the importance of PU, PEU, PBC, SN in the adoption process. Additionally, this investigation has also explored the effect of CTB and STI two constructs little explored in TAM-based models suggesting their effect on PU and SN respectively.

Our results also show that cultural values influence the technology adoption of higher education teachers. Accordingly, our findings suggest that there are significant differences in the acceptance processes of higher education teachers in the Latin-European and Confucian-Asian clusters that should be explored in future studies. Therefore, the results of this research contribute to the existing literature by providing empirical evidence of both the differences in the technology adoption process between Spanish and Chinese university teachers and the moderating effect of cultural values indicating that future studies should take the influence of culture in the technology adoption of higher education instructors.

Appendix

See Table 9.

Table 9 Questionnaire items

Construct	Number of Items	Items
Perceived usefulness	4	1: Using technologies enables me to efficiently use the limited class time 2: Using technologies enhances my teaching effectiveness 3: Using technologies improves my teaching performance 4: Using technologies is useful in my job
Perceived ease of use	4	1: My interaction with technologies is clear and understandable 2: I find it easy to get technologies to do what I want to do 3: I find computers easy to use 4: I find technologies easy to learn
Behavioral intention	3	1: I will use technologies in teaching in the future 2: I plan to use technologies in teaching often 3: I expect that I will use technologies in teaching in the future
Subjective norms	3	1: People whose opinion I value think that I should use technologies in teaching 2: People who are important to me think that I should use technologies in teaching 3: People who influence my behaviour think that I should use technologies in teaching
Perceived behavioral control	4	1: I have the ability to use technologies in teaching 2: I have sufficient knowledge to use technologies in teaching 3: I have the resources needed to make use of technologies in teaching 4: Using technologies in teaching is entirely under my control
Student influence	3	1: My students think I should use technologies in teaching 2: My students expect me to use technologies in teaching 3: My students think it is important for a teacher to apply technologies in teaching
Individualism-collectivism	5	1. Individuals should sacrifice their self-interest for the interests of the groups they belong to 2. Individuals should stick with the group even when faced with difficulties 3. Group interest/welfare is more important than individual interest 4. Group success is more important than individual success 5. Being accepted as a member of a group is more important than having autonomy and independence
Power distance	5	1: Teachers should make most of their decisions by consulting/discussing with administrators/superiors 2: Teachers should have social interactions with administrators/superiors 3: Administrators/superiors should use authority and power when dealing with teachers 4: Teachers should agree with administrators/superiors' decisions

Table 9 (continued)

Construct	Number of Items	Items
Uncertainty avoidance	5	1: Specific rules or regulations are important to me 2: Detailed requirements are important to me 3: Detailed instructions are important to me 4. Standardised operating procedures help me to follow suit 5: The best approach is to closely follow requirements, instructions and procedures
Constructivist teaching belief	7	1: Good teachers always encourage their students to think for answers themselves 2: The focus of teaching is to help students construct knowledge from their learning experience instead of knowledge delivery 3: Different objectives and expectations in learning should be applied to different students 4: Good teachers always make their students feel important 5: Instruction should be flexible enough to accommodate students' individual differences 6: It is important that a teacher understands the feelings of the students 7: Learning means students have ample opportunities to explore, discuss and express their ideas

Funding The funding was provided by Qingdao Philosophy and Social Sciences Planning and Management Office (CN) (QDSKL2001107).

Compliance with ethical standards

Conflict of interest All authors have approved the final article and there is no conflict of interest.

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