Yeh, C. R., & Tao, Y.-H. (2013). How Benefits and Challenges of Personal Response System Impact Students' Continuance Intention? A Taiwanese Context. *Educational Technology & Society*, *16* (2), 257–270.

How Benefits and Challenges of Personal Response System Impact Students' Continuance Intention? A Taiwanese Context

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(Submitted September 19, 2011; Revised April 21, 2012; Accepted June 14, 2012)

ABSTRACT

To address four issues observed from the latest Personal Response System (PRS) review by Kay and LeSage (2009), this paper investigates, through a systematic research, how the derived benefits and challenges of PRS affect the satisfaction and continuance intention of college students in Taiwan. The empirical study samples representative college students enrolled in three universities from each of the Northern, Central, Southern, and Eastern geographical regions in Taiwan. The results based on 406 valid returned questionnaires and partial least square analysis confirm that classroom environment and learning benefits have positive effects, whereas technology- and student-based challenges have negative effects on student satisfaction, thus influencing their intention to continue using PRS. In contrast, assessment benefits and teacher-based challenges do not have significant influences on student satisfaction. The present research contributes to literature by empirically testing PRS benefits and challenges derived from previous works, validating only the aspects that influence student satisfaction and, consequently, their behavioral intention to continue using PRS. The implications and suggestions derived from this rigorous research are highly relevant in practice. The findings enable a set of general design strategies for successful PRS implementations, providing the empirical basis for conducting future in-depth PRS research.

Keywords

Personal response system, Expectation confirmation theory, Satisfaction, Benefits, Challenges

Introduction

The Personal Response System (PRS) (Griff, & Matter, 2008), also known as the audience response system (Bunz, 2005) or student response system (Bunce, VandenPlas, & Havanki, 2006), is a voting system (Draper, & Brown, 2004) that allows teachers to initiate a multiple-choice question exam using a computer and then displaying it on screen for the class; the students, in turn, anonymously respond to the questions through clickers. PRS allows the teacher to collect and summarize the answers in a statistical format on screen. This allows teachers to quickly assess student feedback and immediately make the necessary teaching adjustments to achieve better student learning effects. PRS has been studied extensively since a new generation of infrared PRS became available in 1999 and subsequently used after 2003 (Abrahamson, 2006).

The latest PRS review published by Kay and LeSage (2009) covers research studies from 2000 to 2007, including several earlier review papers by Judson and Sawada (2002), Fies and Marshall (2006), Simpson and Oliver (2007), and Caldwell (2007). These PRS review papers have provided rich meta-analyses of PRS literature derived through a qualitative approach, facilitating the further understanding and development of current practices of PRS in schools. Although a quantitative meta-analysis review remains the ideal method, this is not a feasible option due to the lack of empirical PRS studies in literature. Nevertheless, the abovementioned qualitative review papers agree on the considerable benefits and potential challenges of using PRS as well as its future research opportunities. Based on these, an empirical research that can validate the findings of previous studies is feasible and advantageous.

Four related PRS issues are included in the review conducted by Kay and LeSage (2009). First, specific benefits and challenges are good factors derived from the qualitative literature analysis, but these may need empirical studies to confirm the impact of the use of PRS. Second, while Kay and LeSage (2009) identify technology-based challenges in their research, few PRS studies actually involve technology-related theories in discussing ways by which to establish PRS usage in classrooms. The quantitative technology acceptance model (TAM) meta-analysis presented by King

and He (2006) revealed that technology is a potential moderating factor that can influence several model relationships. TAM is a popular technology-related theory, which proposes perceived usefulness and perceived ease of use as the two core influences of the actual use of a technology through the mediating effect of intention to use. Bhattacherjee (2001) tested the expectation confirmation theory (ECT), another technology-based theory used to predict usage. ECT compares the users' experiences and expectations and examines the effect of confirmation/disconfirmation on continuance usage. Third, Kay and LeSage (2009) suggested the expansion of PRS use in social science subjects and K-12 classrooms. For the interest of the current research, it is more favorable to obtain generalized research results by expanding the samples from a small class or single university to a larger regional or country-wide scope. Finally, Kay and LeSage (2009) studied listed systematic research with reliability and validity analyses as the first direction in relation to further studies in this research area. A rigorous research method for empirical studies is needed to achieve the goal of a systematic research with quantitative reliability and validity analyses.

To address the four issues, a path model on PRS usage is formulated, after which a rigorous empirical study is conducted, with practical relevance on PRS perceptions using college students in Taiwan as representative sample. The comprehensive procedure of structural equation modeling (SEM) for validating the measurement model and the model fitting (Gefen et al., 2000) helps achieve the objective of a systematic research with reliability and validity analyses that most PRS studies lacked. Moreover, Section 2 also presents a critical literature analysis of the review of Kay and LeSage (2009), four earlier PRS review articles, and a brief but critical review of technology-related theories. These reviews provide the context in formulating the proposed research model and in designing the empirical test as discussed in Section 3. Detailed data analysis and discussion are presented in Sections 4 and 5, respectively, followed by the presentation of conclusions in Section 6.

Background information

PRS reviews in literature

Recent studies provide adequate evidence on the positive perception of students on the use of PRS in higher education. Judson and Sawada (2002) provided the earliest summary of PRS use with 33 references from 1960 to 2000, and concluded that the pedagogical practices of the instructor, and not the technology itself, which affects student comprehension when using PRS. In contrast, Fies and Marshall (2006) reviewed the methods employed to assess PRS, including pedagogical constructs in the traditional and modern PRS systems with 21 references from 1996 to 2005. They concluded the need for concerted research efforts that can rigorously explore conditions of use across diverse settings and pedagogies. From a rigorous research perspective, Kay and LeSage (2009) commented that their selected peer-reviewed references are somewhat lacking and dated because the majority of their references included works published after 2003, prior to the established use of PRS.

Simpson and Oliver (2007) provided a summary of the pedagogical and organizational implications of PRS adoption, with corresponding perceptions of staff and students. In particular, they compared the PRS practice before and after 2000 and up to 2006 with 39 references. They concluded that both the practice and the research on PRS have matured, with a focus on the development of models seeking abstract and sharing practices. Meanwhile, Caldwell (2007) reviewed 25 peer-reviewed articles that identified the primary users of PRS, articulated the rationale for using PRS, as well as explored and questioned the strategies used by PRS. She concluded that PRS is a valuable tool for introducing and monitoring peer learning methods in the large lecture classroom. She also summarized the best practices for teachers adopting the system in terms of planning, attendance, communication with students, peer learning, grades and anxiety, preventing wasted time and frustration, writing effective questions, and other survival tips. However, Caldwell (2007) and Simpson and Oliver (2007) did not address sufficiently the impact of PRS on student learning (Kay & LeSage, 2009).

Therefore, Kay and LeSage (2009) argued that a more comprehensive review of PRS literature is needed in order to present a more current and representative summary of benefits, challenges, key problems, and future directions of PRS use. Their review is based on a very comprehensive review process of 67 papers. However, a statistical meta-analysis is not feasible because only 10 studies provided formal statistics.

The benefits of PRS are grouped into three categories: classroom environment, learning, and assessment benefits. Classroom environment benefits include attendance, attention, anonymity, participation, and engagement. Learning benefits include interaction, discussion, contingent teaching, learning performance, and quality of learning. Assessment benefits include feedback, and formative and comparative assessments.

The challenges of PRS are grouped into three categories: technology-, teacher-, and student-based challenges. Technology-based challenges include non-functional remote control devices and PRS. Student feedback, coverage, and question formulation are examples of teacher-based challenges. Student-based challenges include acceptability of new methods, discussion, effort, summative assessment, attendance for grades, identification of students, and negative feedback.

Key problems encountered by the current PRS research include the lack of systematic research methodology, bias toward using the anecdotal, qualitative data, excessive focus on attitudes as opposed to learning and cognitive processes, and inconclusive samples derived from limited education settings. The four research directions identified for future PRS research include (1) the need to determine why specific benefits and challenges influence the use of PRS; (2) the need for an in-depth research that analyzes the impact of specific types of questions on the creation of a student-centered learning experience; (3) the need for knowledge-rich learning that builds a classroom community that, in turn, facilitates the expansion of PRS to include social sciences subject areas and K-12 classrooms; and (4) the need for more research on the individual differences in the use of PRS, focusing on gender, year level, age, and learning style.

There are more research studies published after 2009 than those uncovered by Kay and LeSage. However, none of these new studies presented either a review or a meta-analysis of PRS. The majority focused on the teaching effects (Bradford, 2010) in domains such as science (Hoyt et al., 2011) and medicine (Stoddard & Piquette, 2011). Thus, the above summarized review results are still relevant and should be subjected to further evaluation.

Related technology-based theories and models

In technology-related theories, usage is typically the ultimate dependent variable, despite the various terms used to refer to it. For example, this is manifested as “adoption” in TAM-related theories and the unified theory of acceptance and use of technology (Venkatesh et al., 2003), “continuance usage” in ECT, and “success” which generally implies adoption or infusion in diffusion of innovation theory (Rogers, 1995). These information system (IS) theories are all applied in research at the individual level analysis. Usage can also be manifested at the organizational level analysis, such as “adoption” in technology, organization, and environment framework (Tornatzky & Fleischer, 1990).

In ECT, the ultimate goal is to determine the impact on usage continuance intention as mediated by satisfaction. In contrast, the IS success model (DeLone & McLean, 2003) identifies the parallel relationship between satisfaction and usage with regards their common antecedents. Therefore, satisfaction is closely related to usage as either an influencing or a mutually influencing factor.

The antecedent of satisfaction in technology-based theories may include confirmation/disconfirmation between expectation and actual perceptions of the targeted technology in ECT; it can also be quality of system, information, and service in IS success model (DeLone, & McLean, 2003). In addition, Wixom and Toad (2005) proposed a theoretical integration of user satisfaction and technology acceptance by linking the beliefs and attitudes from the object-based perspective of IS success model and the behavioral perspective of TAM.

Research methods

Based on the research questions and knowledge obtained from the review of previous literature, a description of the research model and hypotheses are provided in Section 3.1. This is followed by Section 3.2, which presents the description of the design of the empirical study.

Model and hypothesis development

Satisfaction is used to measure technology-based applications in education research. For example, So and Brush (2008) found high collaborative learning affects satisfaction, whereas Wu et al. (2010) concluded that performance expectation and learning climate affects satisfaction in blended e-learning systems. DeBourgh's (2003) research on an e-Learning nursing course found good pedagogy to be an influential factor affecting students' perceived satisfaction, whereas Tao et al. (2009) found that learning performance and playfulness affect user satisfaction in business simulation games. For PRS, Carnaghan and Webb (2007) empirically investigated the casual effect of PRS on learning outcome and satisfaction in accounting education; in comparison, nearly all PRS studies were descriptive and reported high levels of student satisfaction (Judson, & Sawada, 2002).

In the conclusions on benefits and challenges made by Kay and LeSage (2009), they inferred that benefits should have positive influences, whereas the challenges should have negative influences on student satisfaction. Thus, the current study presents its hypotheses on the influence of the benefits and challenges of PRS on user satisfaction below.
H_1 PRS benefits have positive effects on satisfaction.
H_{1-1}. Classroom environment benefits have positive effects on satisfaction.
H_{1-2}. Learning benefits have positive effects on satisfaction.
H_{1-3}. Assessment environment benefits have positive effects on student satisfaction.
H_2 PRS challenges have negative effects on satisfaction.
H_{2-1}. Technology-based challenges have negative effects on satisfaction.
H_{2-2}. Teacher-based challenges have negative effects on satisfaction.
H_{2-3}. Student-based challenges have negative effects on satisfaction.

DeLone and McLean (1992) reviewed the existing definitions of IS success and their corresponding measures, and classified them into six major categories, in which user satisfaction and use are mutually influenced. In their revised IS success model (2003), the relationship between user satisfaction and use has been refined into the following: User satisfaction influences intention to use, while use influences user satisfaction. Therefore, satisfaction is deemed closely related to usage as either an influencing or a mutually influencing factor.

Extending the use to continuance usage, Bhattacherjee (2001) provided evidence for extending ECT in IS domain, such that satisfaction significantly influences intention to continuance usage. The application of ECT can also be found in educational settings, such as business simulation games (Tao et al., 2009) and e-learning systems (Hernandez et al., 2011). Hence, the hypothesis below is proposed.
H_3. Student satisfaction has positive effects on the intention to continue usage.

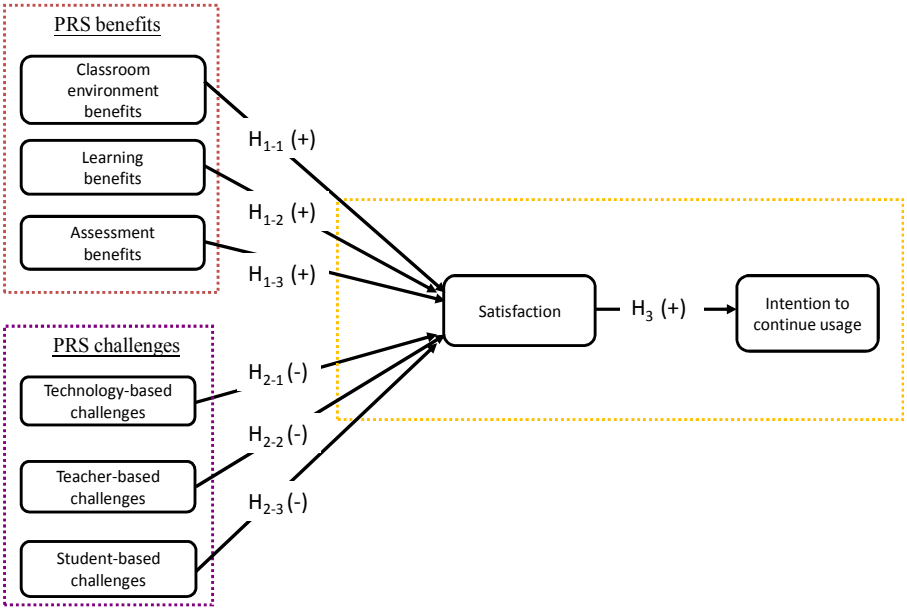

Figure 1. The proposed integrated model

The integrated research model shown in Figure 1 is formulated to explore a general and simple IS model format for the investigation of the impact of PRS benefits and challenges on usage continuance intention, which is mediated by satisfaction.

Research design

Section 3.1 addresses the first two issues and this section addresses the remaining two issues. Regarding the third issue, the objective of this study is to obtain results that are representative of the 164 higher educational institutions of Taiwan. Therefore, the target population comprises college students who have used PRS systems in their classes. The Taiwan research population loci are divided into the Northern, Central, and Southern regions. Several studies added the Eastern geographical regions as well. To ensure that all of the Taiwanese regions are well represented, the sample populations were selected from three universities in each of the four regions. The sampling approach was employed to identify the teachers in each university who were willing to assist in the distribution of the questionnaires to students in PRS classes.

The student questionnaire had four sections. The first section consisted of items that collected data to measure PRS benefits. The second section collected data on PRS challenges. Both sections were based on the 13 benefits and 12 challenges summarized by Kay and LeSage (2009). However, there were only two items on the technology-based challenges. Moreover, one of the items on "bringing" the remote control devices, was not applicable to most situations in Taiwan. For this reason, alternative items were added to replace the inapplicable question. New items were also created to complete the total number of questions in this variable to three. The third section collected data on satisfaction and the intention to continue usage based on Bhattacherjee (2001), with minor modifications to reflect the targeted PRS technology and the specific setting for future PRS classes addressed in the current study. Four questions on satisfaction and four questions on the intention to continue usage were included. The last section collected data on four personal profile items, including sex (male vs. female), school location (Northern, Central, Southern, or Eastern), and class performance (top 25 %, top 50 %, top 75 %, or bottom 25 %). The Appendix provides the detailed listing of questionnaire items and corresponding sources. Students were asked to respond to each questionnaire item of the first three sections using a 7-point Likert scale, with 1 representing "extremely disagree" and 7 representing "extremely agree."

To address the last issue, a systematic research with reliability and validity analyses was conducted. The analytical method used for the descriptive statistics was SPSS. Partial least square (PLS)-based SEM was used on the path model to assess the impacts of PRS benefits or challenges on satisfaction and continuance intention.

Analysis

Sample profile

A total of 406 valid questionnaires were returned. The descriptive statistics for the five profile variables are shown in Table 1. Female students account for twice the percentage of male students, which may be attributed to the classes selected for data collection. Except for the schools located in the South, which account for almost 50% of the samples, students from the three other locations have a fairly even gender distribution. The main reason for the greater number of responses from the Southern region is the more enthusiastic response we received from volunteer teachers from this area in terms of monitoring and collecting the questionnaires from their students, compared with those of teachers from the three other regions. Given that the teachers were recruited through a consistent approach, it is reasonable to retain the full data for the following analyses.

Approximately 5% of the students considered themselves to be at the bottom 25% of the overall class performance, whereas the majority evaluated themselves as part of the upper 25% to 50%. The participation of college students was representative of the range from freshman to senior, with greater than 10% participation from each year level. Only a small percentage (3.2%) of graduate students participated in this investigation.

Table 1. Student profile

Gender:	Male	131(32.3%)	Female	263(64.8%)
Location:	North	56 (13.8%)	Central	80 (19.7%)
	South	201 (49.5%)	East	59 (14.5%)
Expected class	Top 25%	72 (17.7%)	Top 50%	223 (54.9)
performance:	Top 75%	77 (19%)	Bottom 25%	20 (4.9%)
Year level:	Freshman	87 (21.4%)	Sophomore	155 (38.2%)
	Junior	86 (21.2%)	Senior	48 (11.8%)
	Graduate	13 (3.2%)		

Measurement model validation

Descriptive statistics was used to derive the means and standard deviation (S.D.) of the eight variables in the proposed integrated model. The Smart PLS software for PLS-SEM developed by Ringle et al. (2005) was utilized to analyze the path model. The second column in Table 2 displays the descriptive means and S. D. of all the variables after data screening for the qualified factor loading, composite reliability, and average variance extracted (AVE) values, as a measure of the shared or common variance in a latent variable. In general, the mean scores of the three benefits that exceed 5 on a 7-point Likert scale indicate a relatively positive perception of PRS benefits. Meanwhile, teacher- and student-based challenges that are rated slightly below 4 are expressions of neutral to moderately lower perceptions of PRS challenges. Technology-based challenges that are rated slightly above 4 indicate neutral to moderately higher perceptions of this challenge. Regarding the two outcome variables, namely, satisfaction and continuance usage, both are rated positively because their mean scores are closer to the positive value of 5.0.

The SEM path model analysis includes the measurement model and model fitting. The PLS measurement model includes item reliability (factor loading), composite reliability, and AVE and its square root. After excluding items with factor loadings below 0.7, a minimum hurdle suggested by Fornell and Larcker (1981), the new factor loadings all exceed the value 0.7, as shown in the fourth column. One exception is the IBC3, under the teacher-based challenges, which has a value slightly lower than 0.7; however, this has been retained for evaluating the IBC construct with at least two measurement items in the model. The convergent validity is further examined to determine whether or not the AVE is greater than 0.5 (Fornell, & Larcker, 1981). The sixth column shows that all AVE values are greater than 0.5, thereby indicating good convergent validity.

Table 2. Descriptive statistics and reliability

Variables	Mean/S.D.	Items	Factor loading (>0.7)	Composite reliability (>0.7)	Average variance extracted (AVE) (>0.5)
Technology-based challenges (TBC)	4.13/1.42	TBC1	0.83	0.90	0.75
		TBC2	0.89		
		TBC3	0.88		
Teacher-based challenges (IBC)	3.78/1.08	IBC1	deleted	0.77	0.64
		IBC2	0.95		
		IBC3	0.60		
Student-based challenges (SBC)	3.50/1.37	SBC1	0.74	0.91	0.71
		SBC2	0.75		
		SBC 3	0.80		
		SBC 4	0.82		
		SBC 5	deleted		
		SBC 6	deleted		
		SBC 7	deleted		
Classroom environment benefits (CEB)	5.09/1.03	CEB1	deleted	0.87	0.68
		CEB 2	0.83		
		CEB 3	deleted		
		CEB 4	0.79		
		CEB 5	0.87		
Learning benefits (LB)	5.06/1.02	LB1	0.74	0.89	0.63

		LB2	0.75		
		LB3	0.80		
		LB4	0.82		
		LB5	0.84		
Assessment benefits (AB)	5.33/1.00	AB1	0.89	0.88	0.71
		AB2	0.87		
		AB3	0.76		
Satisfaction (SAT)	4.94/1.20	SQ1	0.94	0.97	0.88
		SQ2	0.95		
		SQ3	0.94		
		SQ4	0.92		
Intention to continue usage (USE)	4.78/1.23	USE1	0.95	0.93	0.88
		USE2	0.93		
		USE3	deleted		

Discriminant validity can be determined by the square root of AVE, which is higher than the correlations with other constructs. In Table 3, the square roots of AVE in the diagonal column are all higher than the construct-pair correlations, indicating adequate discriminant validity in all variables. The evidence suggests that the overall reliability and validity of the data set with seven items deleted are adequate. Table 3 also shows the negative correlations between the three challenge constructs (TBC, IBC, and SBC) and all other constructs, providing initial evidence that those challenges do have negative impacts on satisfaction.

Table 3. Discriminant validity analysis

Constructs	AVE	Correlation of Constructs							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TBC(1)	.75	.87[a]							
IBC(2)	.64	.40	.80						
SBC(3)	.71	.40	.61	.84					
CEB(4)	.68	-.12	-.08	-.28	.82				
AB(5)	.71	-.15	-.18	-.34	.60	.84			
LB(6)	.63	-.14	-.17	-.34	.71	.74	.79		
SAT(7)	.88	-.28	-.18	-.41	.55	.50	.59	.94	
USE(8)	.88	-.21	-.10	-.37	.50	.44	.52	.81	.94

Note. [a] Each of the diagonal $\sqrt{AVE}$ value is required to exceed the construct AVE value, and other related coefficients of the non-diagonal construct values.

Hypothesis testing results

The results of the hypotheses tests are shown in Table 4. As can be seen, classroom environment and learning benefits are positively related to student satisfaction at 0.01 and 0.001 levels, respectively, whereas the assessment benefits are not. Similarly, from among the three challenges, only technology- and student-based challenges are negatively related to satisfaction at 0.01 level; teacher-based challenges are not significant at all. Satisfaction is positively related to continuance usage intention at 0.001 level. Accordingly, both H_1 and H_2 are partially but strongly supported. Meanwhile, H_3 is fully supported by data that are similar to those reported in numerous ECT research studies.

Table 4. Integrated research model and results

Research hypothesis		t value	Results
H_1	$H_{1\text{-}1}$. Classroom environment benefits have positive effects on satisfaction.	2.70**[a]	Supported
	H1-2. Learning benefits have positive effects on satisfaction.	4.60***[b]	Supported
	$H_{1\text{-}3}$. Assessment benefits have positive effects on student satisfaction.	0.72	Not supported
H_2	$H_{2\text{-}1}$. Technology-based challenges have negative effects on satisfaction.	3.06**	Supported
	$H_{2\text{-}2}$. Teacher-based challenges have negative effects on satisfaction.	1.55	Not supported
	$H_{2\text{-}3}$. Student-based challenges have negative effects on satisfaction.	2.72**	Supported

H_3	Student satisfaction has positive effects on the intention to continue usage.	27.30***	Supported

Note. [a] *** Significant at 0.001. [b] ** Significant at 0.01.

The final path model is presented in Figure 2. The R square values are 0.45 and 0.66 for satisfaction and intention to continue usage, respectively. These are high levels according to Cohen (1977), thus indicating a superior explanation power of the research model.

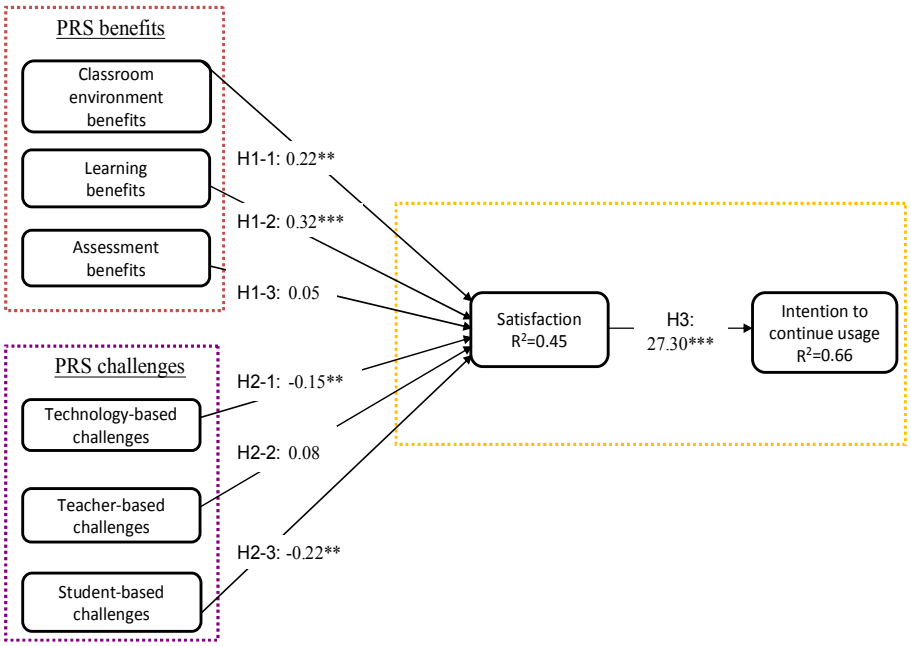

Figure 2. Integrated research model and results

Discussion and implications

Four implications may be derived along with the discussion of the outcomes obtained in Section 4, followed by a suggestion for the higher education institutes in Taiwan facing PRS implementation.

The first implication is that the teachers and school administrators must prioritize their efforts to better manage their PRS implementation by promoting higher student awareness on classroom environment benefits and learning benefits to increase student satisfaction. They can also achieve this by addressing critical issues related to technology- and student-based challenges, thus reducing student dissatisfaction. This implication is based on the hypothesis testing result of the present empirical study, which found that classroom environment benefits (H_{1-1}) and learning benefits (H_{1-2}) have positive influences, whereas technology-based challenges (H_{2-2}) and student-based challenges (H_{2-3}) have negative influences on student satisfaction (see Table 4). These efforts can eventually help enhance the behavioral intention of students in Taiwan to continue to using PRS. Furthermore, classroom environment benefits and learning benefits also received more favorable ratings from the students, with positive mean scores of 5.09 and 5.06 (see Table 2), respectively; this should be emphasized when promoting PRS usage. Table 2 shows that student-based challenges have a mean score of 3.50, indicating fairly low student perceptions on these factors as challenges. Thus, teachers and school administrators may find it easier to overcome such challenges. However, students perceive technology-based challenges to be neutral or moderate with a mean score of 4.13, indicating the need for further investments on the procurement and maintenance of PRS technology.

T**he second implication** is that more research and development efforts on deployment strategies may be needed by the teachers and school administrators of Taiwan to effectively implement PRS assessment that, in turn, fulfills its promises of generating positive benefits to influence student satisfaction toward continuance usage. The rationale behind this implication lies in the two rejected hypotheses related to assessment benefits (H_{1-3}) and teacher-based

challenges (H_{2-2}), as shown in Table 4. The descriptive analysis in Table 2 indicates a lower level of student agreement on teacher-based challenges (3.78) and a higher level of agreement on assessment benefits (5.33). The unexpected results deserve more attention and discussion than the supported hypotheses. For the assessment benefits (H_{1-3}), the descriptive statistics provided by Tao and Yeh (2009) suggest that the teachers in Taiwan have failed to facilitate PRS at a level that would have allowed the effective use of student feedback. Moreover, the teachers failed to a) utilize the PRS assessment to detect the occasions when students have certain misconceptions and b) initiate appropriate discussions to promote student comprehension. The reason why teachers do not use PRS assessment may be attributed to the fact that students resent PRS quizzes or simulation tests, because these are associated with attendance monitoring and the requirement to accumulate points as evidence of their participation (D'Arcy et al., 2007; Tao & Yeh, 2009). This is also evident from the descriptive statistics obtained, in which Taiwanese students felt strongly about questionnaire items on student-based challenges, such as summative assessment (SBC4) and attendance for grades (SBC5). Hancock (2010) concluded that although synergy exists when formative and summative tests using PRS are combined, the students are sensitive as to how the assessments have been designed by the instructors.

Meanwhile, the insignificant negative influence of the teacher-based challenges (H_{2-2}) may be attributed to the inability of students to experience or understand the challenges from the teacher's perspective in relation to the task of responding to student feedback (IBC1) and the process by which the questions have been developed (IBC3). The insignificant negative influence may also be attributed to the fact that the teachers may have failed to make their complaints known or reveal any challenges they experienced in class, such as the issue of limited academic coverage (IBC2). In fact, these challenges have been observed by Tao and Yeh (2009) and d'Inverno et al. (2003). In contrast, it is also reasonable to believe that these challenges may have more impacts on the teachers than on the students. Therefore, student perceptions on this category of challenges may not be as significant compared with their perception in the two other categories.

The third implication lies in the finding that actually presents a good opportunity for teachers and school administrators in Taiwan: the potentially negative impact of teacher-based challenges is not significant from the students' perspective (H_{2-2}). Although it would have been better to assess the teacher-based challenges from the teachers' perspective, the students' perceptions present valuable feedback to the teachers, encouraging them to continue implementing PRS in the classroom even if the course content may not be fully covered (IBC2) and PRS questions are too few or not always well designed (IBC3). This is particularly encouraging because the mean score of teacher-based challenges in Table 2 is 3.78, indicating a moderately lower to neutral student perceptions on these teacher-related factors as challenges. Therefore, teachers should not let those teacher-based challenges hinder their use of PRS.

T**he fourth implication** is that more in-depth studies may be needed to explore the differences between Taiwan and Western countries, such as the United States, in teacher-student dynamics in the context of using PRS. This approach may help explain the gap between Western literature and the results of the present study on assessment benefits (H_{1-3}) and teacher-based challenges (H_{2-2}). The rationale for this implication is that the benefits and challenges derived from literature should all have significant impacts on satisfaction. However, the present empirical study could not prove the assessment benefits and teacher-based challenges, which have been derived from Western studies. The higher mean score of assessment benefits (5.33) among the three benefit variables, and a moderately lower mean score of teacher-based challenges (3.78) further support the need for an investigation that can determine why these are not related to student satisfaction in Taiwanese context.

One feasible and general approach for sustaining the positive benefits and minimizing the impacts of negative challenges is to enhance the PRS service capability of the teachers' resource centers, which can be easily found in the higher education institutes in Taiwan and other colleges worldwide. Currently, very few schools in Taiwan have undertaken full-scale implementations of PRS, and most of these do not provide adequate PRS-related support to their faculty, if they do provide it at all. Regardless of the scale of such implementations, one quick solution, for example, to bridge the assessment benefits-satisfaction gap is to provide teachers with better training and consultation sessions as well as promote PRS benefits through planned student activities. Teachers' resource centers are in the best position to organize these support activities, taking into consideration extant PRS research outcomes and the distribution of this knowledge to individual teachers before PRS is formally used in course delivery.

Conclusions

Addressing four PRS issues observed from the recent review by Kay and LeSage (2009), an empirical study employing a systematic approach (issue 4) which conducted a survey of college students throughout Taiwan (issue 3), the current research validates the influence of the challenges and benefits (issue 1) classified by Kay and LeSage (2009) on PRS continuance usage as mediated by student satisfaction (issue 2). The resulting model (Figure 2) demonstrates that learning and classroom environment benefits have positive influences, whereas technology- and student-based challenges have negative influences on student satisfaction, thus strongly and positively influencing behavioral intention for PRS continuance usage, respectively. These PRS challenges and benefits obtained from the qualitative review of Kay and LeSage (2009) are only partially validated in the Taiwanese context.

The primary research contribution of this study is that it combines research rigor with relevance in practice (Robey & Marcus, 1998). It systematically tested issues on PRS implementations that have been presented by extant non-systematic, but practical research. Based on the empirical results, four implications have been derived, and one general solution is suggested for PRS research and practice. These serve as good references that can help both school administrators and teachers determine resource allocations on PRS implementation and better deploy effective strategies when adopting PRS in classroom teaching and learning, respectively.

Although this research is conducted in Taiwan, a set of universal guidelines can also be derived from the findings, which can be applied by teachers worldwide and help them adopt PRS more successfully in the classroom. First, teachers are advised to familiarize themselves with PRS implementation issues that have been discussed in reputable literature, such as Caldwell (2007) or the PRS book by Duncan (2005). These issues include planning, attendance, communication with and dynamics among students, grades, and other technical tips. Second, instead of a full-blown implementation, gradually scaling up the use of PRS in classroom activities is a better alternative, starting with light, and perhaps, fun activities to overcome student perceptions that PRS usage leads to more confusion and effort. Third, the teacher or the teaching assistant should come earlier before each class to ensure that the PRS and remote devices are functioning properly. Fourth, PRS must be used to check student comprehension of key learning points, while making it clear that the purpose is to clarify misconceptions and modify instructions when necessary, instead of testing the students. Fifth, PRS must be used in group activities to increase the levels of student engagement and peer discussion. Finally, students must be recognized and immediately rewarded when they demonstrate better performance in a learning activity using PRS. These design strategies create the appropriate learning environment as suggested by classroom environment benefits and learning benefits. Doing so can enhance the students' perceived satisfaction, while minimizing the hurdles of technology- and student-based challenges and avoiding negative perceptions of PRS usage at the same time.

Three future research directions can be suggested. First, the resulting model in this research can be made more comprehensive by supplementing the perceptions of the teacher counterparts in future research. Meanwhile, as suggested in the fourth implication above, further research into the differences of student perceptions and behaviors in classrooms between the West and Taiwan may be needed, because several perceptional differences toward PRS usage have been observed. Finally, other in-depth PRS research suggestions from five PRS review papers should also be validated empirically using existing theories.

References

Abrahamson, L. (2006). A brief history of networked classrooms: Effects, cases, pedagogy, and implications. In D. A. Banks (Ed.), *Audience Response Systems in Higher Education* (pp. 1–25). Hershey, PA: Information Science Publishing.

Bhattacherjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly, 25*(3), 351-370.

Bradford, B. J. (2010). Incorporation of a student response system into a large animal nutrition lecture course. *Journal of Dairy Science, 93*(5), 2308-2309.

Bunce, D. M., VandenPlas, J. R., & Havanki, K. L. (2006). Comparing the effectiveness on student achievement of a student response system versus online WebCT quizzes. *Journal of Chemical Education*, *83*(3), 488.

Bunz, U. (2005). Using scantron versus an audience response system for survey research: Does methodology matter when measuring computer-mediated communication competence? *Computers in Human Behavior*, *21*(2), 343-359.

Caldwell, J. E. (2007). Clickers in the large classroom: Current research and best-practice tips. *Life Science Education, 6*(1), 9-20.

Carnaghan, C. and Webb, A. (2007). Investigating the effects of group response systems on student satisfaction, learning, and engagement in accounting education. *Issues in Accounting Education, 22*(3), 391-409.

Cohen, J. (1977). *Statistical power analysis for the behavioral sciences* (Revised ed.). New York, NY: Academic Press.

D'Arcy, C. J., Eastburn, D. M., & Mullally, K. (2007). Effective use of a personal response system in a general education plant pathology class. *The Plant Health Instructor*. doi: 10.1094/PHI-T-2007-0315-07

Delone, W. H., & Maclean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, *3*(1), 60-95.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4), 9-30.

Duncan, D. (2005). *Clickers in the classroom: How to enhance science teaching using classroom response systems*. New York, NY: Addison Wesley and Benjamin Cummings.

d'Inverno, R., Davis, H., & White, S. (2003). Using a personal response system for promoting student interaction. *Teaching Mathematics and its applications, 22*(4), 163-169.

DeBourgh, G. A. (2003). Predictors of student satisfaction in distance-delivered graduate nursing courses: What matter most? *Journal of Professional Nursing, 19*(3), 149-163.

Draper, S. W., & Brown, M. I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning, 20*(2), 81–94.

Fies, C., & Marshall, J. (2006). Classroom response systems: A review of the literature. *Journal of Science Education and Technology, 15*(1), 101-109.

Gefen, D., Straub, D. W., & Boudreau, M-C. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the Association for Information Systems, 4*(7), 1-70.

Griff, E. R., & Matter, S. E. (2008). Early identification of at-risk student using a personal response system. *British Journal of Educational Technology, 39*(6), 1124-1130.

Hancock, T. M. (2010). Use of audience response systems for summative assessment in large classes. *Australasian Journal of Educational Technology, 26*(2), 226-237.

Hernandez, B., Montaner, T., Sese, F. J., & Urquizu, P. (2011). The role of social motivations in e-learning: How do they affect usage and success of ICT interactive tools? *Computers in Human Behavior, 27*(6), 2224-2232.

Hoyt, A., McNulty, J. A., Gruener, G., Chandrasekhar, A., Espiritu, B., Ensminger, D., Price, R., & Naheedy, R. (2011). An audience response system may influence student performance on Anatomy examination questions. *Anatomical Science Education, 3*(6), 295-299.

Judson. E., & Sawada, D. (2002). Learning from past and present: Electronic response systems in college lecture. *Journal of Computers in Mathematics and Science Teaching, 21*(2), 167-181.

Kay, R. H., & LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: A review of the literature. *Computers & Education, 53*(3), 819-827.

King, R. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management, 43*(6), 740-755.

Robey, D., & Markus, L. (1998). Beyond rigor and relevance: Producing consumable research about information systems. *Information Resources Management Journal*, *11*(1), 7-15.

Rogers, E. M. (1995). *Diffusion of Innovations* (4th ed). New York, NY: Free Press.

Ringle, C. M., Wende, S., & Will, A. (2005). *SmartPLS 2.0 (beta)*. Retrieved January, 25, 2012, from http://www.smartpls.de

Simpson, V., & Oliver, M. (2007). Electronic voting systems for lectures then and now: A comparison of research and practice. *Australasian Journal of Educational Technology, 23*(2), 187-208.

So, H.-J., & Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. *Computers & Education, 51*(1), 318-336.

Stoddard, H. A., & Piquette, C. A. (2011). A controlled study of improvements in student exam performance with the use of an Audience Response System during medical school lectures. *Academic Medicine, 85*(10), S37-S40.

Tao, Y.-H., Cheng, C.-J., & Sun, S.- Y. (2009). What influences college students to continue using business simulation games? The Taiwan experience. *Computers & Education, 53*(3), 929-939.

Tao, Y.-H., & Yeh, R. C. (2009, July). *Personal response system: A model-based case study in Taiwan.* Paper presented at the 14th Annual Meeting of Asia Pacific Region of Decision Sciences Institute, Shanghai, China.

Tornatzky, L.G., & Fleischer, M. (1990). *The processes of technological innovation*. Lexington, MA: Lexington Books.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.

Wixom, B. H., & Todd, P. A. (2005). A theoretical integration of user satisfaction and technology acceptance. *Information System Research, 16*(1), 85-102.

Wu, J.-H., Tennyson , R. D., & Hsia, T.-L. (2010). A study of student satisfaction in a blended e-learning system environment. *Computers & Education, 55*(1), 155-164.

Appendix: Questionnaire Items and Sources

CEB - Classroom environment benefits (Kay, & LeSage, 2009)	
	Using PRS enables students go to class more.
	Using PRS enables students to be more focused in class.
	Using PRS enables students to participate anonymously.
	Using PRS enables students to participate with peers more in class to solve problems.
	Using PRS enables students to be more engaged in class.
LB - Learning benefits (Kay, & LeSage, 2009)	
	Using PRS enables students to interact more with peers to discuss ideas.
	Using PRS enables students to actively discuss misconceptions to build knowledge.
	Using PRS enables the instruction to be modified based on feedback from students.
	Using PRS enables the learning performance to increase.
	Using PRS enables qualitative differences in learning.
AB - Assessment benefits (Kay, & LeSage, 2009)	
	Using PRS enables the students and teacher to get regular feedback on understanding..
	Using PRS enables the assessment to be done to improve student understanding and quality of teaching.
	Using PRS enables students to compare their own response to class response.
TBC - Technology-based challenges (Kay, & LeSage, 2009 or this research)	
	The remote or system setup was not ready on time and caused the class delay its progress onsite.
	Remote devices did not function properly.
	The overall system did not function properly.
IBC - Teacher-based challenges (Kay, & LeSage, 2009)	
	I think less experienced teachers cannot adjust to student feedback.
	I think the use of PRS often make the teachers short of time to cover the course content.
	I think designing good PRS questions will cost a lot of teacher's time.
SBC - Student-based challenges (Kay, & LeSage, 2009)	
	Students find it difficult to shift to a new way of learning.
	Discussion leads to confusion or wasting time.
	Too much effort is required by students when using ARSs.
	Using ARS for tests may not be popular with students.
	Students do not like ARS used for monitoring attendance.
	Students want to remain anonymous.
	Students feel bad when receiving negative feedback.
SAT - Satisfaction (Bhattacherjee, 2001)	
	My overall experience of PRS is very satisfied. ◦
	My overall experience of PRS is very pleased.
	My overall experience of PRS is very contented.

	My overall experience of PRS is absolutely delighted
USE - Intention to continuance usage (Bhattacherjee, 2001)	
	I want to continue using PRS in future classes rather than discontinue its use.
	My intentions are to continue using PRS rather than any alternative means in future classes.
	If I could, I would like to *dis*continue use of PRS in future classes.