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ABSTRACT

Understanding the usage of the geographic information system (GIS) among geography teachers is a crucial step in evaluating the current dissemination of GIS knowledge and skills in Taiwan's educational system. The primary contribution of this research is to further our understanding of the factors that affect teachers' GIS usage. The structural equation model was employed to analyze the data collected from 725 senior high school geography teachers. This was done using a survey questionnaire inspired by the Technology Acceptance Model (TAM), which postulates the importance of how teachers perceived the usefulness and ease of use of GIS. Further, this study investigates the direct effect of GIS workshop attendance on actual GIS usage and assesses whether GIS workshop attendance mediates the relationship between perceived ease of use, perceived usefulness, and actual usage. Structural equation modeling results suggest that the perceived usefulness of adopting GIS is vital as it directly affects teachers' attendance at GIS training, and can further prompt their application of GIS in lectures. The perceived ease of GIS use does not influence actual usage directly, but does affect teachers' GIS usage in teaching through perceived usefulness and workshop attendance. Finally, workshop attendance can increase teachers' usage of GIS and mediate the association between perceived usefulness and actual usage.

Keywords: geographic information system, perceived usefulness, perceived ease of use, actual usage, workshop attendance

1. Introduction

The rapid evolution of information technology (IT) is transforming various aspects of our lives, making the operation of our societies more effective and competitive.

GIS usage is one facet of this societal trend, and there have been efforts in various countries to integrate the geographic information system (GIS) into geography classes. Both teaching with GIS and teaching about GIS are vital elements for integrating GIS into geography education.

This research explores the usage of GIS by senior high school geography teachers in Taiwan. Taiwan's senior high school system is approximately equivalent to grade 10 through 12 in the American system. Geography is a core course in Taiwan's senior high school education; all grade 10 and 11 students must take geography courses. For grade 12 students, only those majoring in social sciences and humanities must take geography.

GIS was first included in the senior high school geography curriculum in 1995 as an elective course for grade 12 students, primarily students wishing to major in humanities and social sciences after completing high school. This began to change in the 2006 and 2010 curricula when the course hours of GIS started to increase and the introduction of GIS concepts moved from being only a grade 12 elective course to an obligatory course in grade 10 (Chen, 2012).

In response to the increased inclusion of GIS in the senior high school curriculum, Taiwan's Ministry of Education (MOE) sponsors a number of in-service training opportunities through the Department of Geography at the National Taiwan University (NTU), at which teachers may refresh and consolidate their GIS knowledge and skills. Approximately 30 high schools, referred to as "seed schools," have joined this promotional mission. NTU started by cultivating teachers in these seed schools and is gradually expanding its coverage to include more teachers in non-seed schools in Taiwan. Lay, Chen, and Chi's (in press) study finds that school support and teacher's perceived usefulness of GIS will determine how often geography teachers attend GIS in-service training.

To advance the work of Lay et al. (in press), we ask whether GIS workshop attendance can in fact motivate teachers to apply GIS in their teaching. To this end, we use a structural equation analysis of data gleaned from a census of Taiwan's senior high school geography teachers. In the following section, we will elaborate on how TAM can contribute to our hypothesis formulation of GIS usage among high school geography teachers in Taiwan.

2. Teachers' GIS usage

Theoretical models for explaining the adoption of various kinds of technology have been rigorously tested and refined (Cheung, Chang, & Lai, 2000; Davis, 1989; Fulk, Steinfield, Schmitz, & Power, 1987; Kelman, 1958; Lee, Cho, Gay, Davidson, & Ingraffea, 2003; Malhotra & Galletta, 1999; Song, Parry, & Kawakami, 2009). TAM is a well-known model that indicates the importance of perceived usefulness (PU) and perceived ease of use (PEOU) in technology adoption. PU refers to the extent to which a person believes that the technology can benefit his or her job performance (Davis, 1989), while PEOU looks at the extent to which the user believes that the technology is "free of effort" (Davis, 1989).

TAM has been applied to the study of technology acceptance in educational settings, such as the adoption of e-learning systems and distance learning modules (Lee, Hsieh, & Hsu, 2011; Sahin & Shelley, 2008; Tselios, Daskalakis, & Papadopoulou, 2011). It has, however, rarely been applied to the analysis of GIS adoption (Lay et al., in press). We believe that TAM accurately summarizes the various incentives for GIS dissemination in education that have been noted by Kerski (2003); Yap, Tan, Zhu, and Wettasinghe (2008); Baker, Palmer, and Kerski (2009); and others. Hence, we intend to use this model to explore GIS adoption by geography teachers in Taiwan. One can thus initially postulate that both PEOU and PU have a positive relationship with GIS usage.

It is worth noting, however, that some studies have found PEOU to be highly associated with PU. In addition, as previously stated, in-service training plays an important role for geography teachers in regard to refreshing and consolidating their GIS knowledge and skills. Hence, we also intend to examine whether attending GIS in-service training will affect teachers' actual GIS usage. The conceptual model of our study is composed of seven hypotheses that are closely related to TAM (Table 1).

Table 1

Hypotheses.

Hypotheses	Path	Description
H1A	PEOU→AU	PEOU has a positive effect on actual GIS usage.
H1B	PEOU→WA→AU	PEOU indirectly has a positive effect on actual GIS usage through WA.

H1C	PEOU→PU→AU	PEOU indirectly has a positive effect on actual GIS usage through PU.
H1D	PEOU→PU→WA→AU	PEOU indirectly has a positive effect on actual GIS usage through PU and WA.
H2A	PU→AU	PU has a positive effect on actual GIS usage.
H2B	PU→WA→AU	PU indirectly has a positive effect on actual GIS usage through WA.
H3	WA→AU	WA has a positive effect on actual GIS usage.

Note: PEOU = perceived ease of use; PU = perceived usefulness; AU = actual usage; WA = workshop attendance.

3. Method and data

3.1 Questionnaire design

The questionnaire begins with some standard questions that investigate the respondents' demographic characteristics (e.g., gender, level of education) and experience with GIS. The questionnaire then goes on to elicit more important information on variables related to our hypotheses of interest.

Inspired by the studies of Baker, Palmer, and Kerski (2009); Igbaria, Pavri, and Huff (1989); Igbaria (1992); and Kerski (2003), we use three manifest indicators to measure actual GIS usage: (1) the frequency of GIS usage in class during the previous semester, using a six-point scale (i.e., never, 1–5 times, 6–10 times, 11–15 times, 16–20 times, and more than 20 times; AU1) (Baker, Palmer, & Kerski, 2009) ; (2) the number of GIS software packages used in teaching (AU2) (Igbaria, Pavri, & Huff, 1989; Igbaria, 1992); and (3) the number of lecture themes in which GIS was employed (AU3) (Baker, Palmer, & Kerski, 2009; Kerski, 2003).

Workshop attendance (WA) is a manifest variable. We ask respondents to indicate the numbers of times they attended GIS in-service training during the previous five years.

Davis's (1989) six-item measurement of PEOU is extensively used for the study of technology adoption, and our measurement is primarily based on Davis's design. These items investigate teachers' views on the following aspects: "learning to operate GIS would be easy" (PEOU1), "finding it easy to get GIS to do what I want GIS to do" (PEOU2), "interaction with GIS would be clear and understandable" (PEOU3), “finding GIS to be flexible to interact with” (PEOU4), “it would be easy to become skillful at using GIS” (PEOU5), and “finding GIS easy to use” (PEOU6). We simplify Davis’s original seven-point scale and use a five-point scale (i.e., strongly disagree, disagree, neutral, agree, and strongly agree) (Malhotra & Galletta, 1999).

Likewise, the measurement for PU is adopted from Davis’s (1989) six-item measurement. The items are as follows: “accelerating teaching” (PU1), “improving teaching performance” (PU2), “increasing teaching productivity” (PU3), “enhancing teaching effectiveness” (PU4), “making teaching easier” (PU5), and “usefulness in teaching” (PU6).

Age, gender, level of education, and school type are controlled. In terms of age, we measure whether a geography teacher’s age (younger or older than 40) will affect his/her participation in GIS training and actual GIS usage in teaching. With regard to level of education, respondents are divided into those with a bachelor’s degree and those with a master’s degree or above. Finally, we differentiate between respondents from public and private schools.

3.2 Data collection

There are approximately 1,530 senior high school geography teachers in Taiwan. In June 2011, we mailed the questionnaire to all of them with a cover letter indicating the purpose and significance of the study. Both the letter and the questionnaire were written in Chinese as this is the primary language in Taiwan. Data collection ended in December 2011, yielding 727 returned questionnaires with a response rate of 47.52%. Of these, eight were invalid and thus discarded. In the end, we were able to analyze data garnered from 719 respondents.

The respondent profile is summarized in Table 2. There were more female teachers (473 respondents, 65.8%) than male. The substantial number of the respondents (315, 43.8%) were aged between 30 and 39. A large number of respondents (401, 55.8%) held master’s degrees. Of the remainder, 305 teachers (42.4%) had completed bachelor’s degrees and 13 (1.8%) possessed doctoral degrees. The majority of the respondents (516, 71.8%) taught in public schools, while 203 teachers (28.2%) worked in private schools.

Table 2

Demographic profile of respondents.

Characteristic	Number	Percentage
Gender		
Female	473	65.8
Male	246	34.2
Age Group		
≦29	95	13.2
30~39	315	43.8
40~49	245	34.1
≧50	64	8.9
Level of Education		
Bachelor’s	305	42.4
Master’s	401	55.8
PhD	13	1.8
School Type		
Public	516	71.8
Private	203	28.2

3.3 Data analysis

Since the key variables of this study are latent constructs (e.g., PEOU) and our research hypotheses include indirect effects as well as direct effects (e.g., H1B), structural equation modeling (SEM) procedures were carried out for data analysis. SEM can be divided into two components: a measurement model and a structural model. The measurement model depicts the links between latent constructs (unobserved variables) and their manifest indicators (observed variables). In the measurement model, measurement errors are accounted for explicitly, which allows the parameters to be precisely estimated. The structural model specifies the causal relationships between endogenous and exogenous variables. A series of causal relationships could be estimated simultaneously, by which the direct and indirect effects can be obtained (Byrne, 2012; Hair, Black, Babin, & Anderson, 2009). To facilitate comparison of the effects of variables that differ in unit scaling, we use the standardized coefficient. The standardized coefficient reflects the change of y in standard deviation for a one standard deviation change in x. To minimize the effects of any non-normally distributed variables, we use maximum likelihood estimation with robust standard errors (MLR) in Mplus Version 6.11 as the method of estimation. The statistical significance is set to 0.05.

4. Results

Our analysis begins with a validation of our measuring instrument. Construct reliability is assessed by composite reliability, average variance extracted, and Cronbach's alpha (see Table 3). Most—albeit not all—standardized loadings for scale items exceed the minimum loading criterion of 0.7. The composite reliabilities of all factors exceed the recommended 0.7 level. Moreover, the average variance-extracted values are all above the threshold value of 0.5. Finally, the Cronbach's alpha of PEOU and PU meet the 0.8 criterion, while the Cronbach's alpha of AU is slightly below the threshold.

Table 3

Construct reliability.

Factors	Indicators	Standardized Loadings	Composite Reliability	Average Variance Extracted	Cronbach's Alpha
Perceived Ease of Use (PEOU)	PEOU1	0.698	0.893	0.582	0.905
	PEOU2	0.748			
	PEOU3	0.859			
	PEOU4	0.733			
	PEOU5	0.756			
	PEOU6	0.775			
Perceived Usefulness (PU)	PU1	0.766	0.862	0.514	0.868
	PU2	0.690			
	PU3	0.642			
	PU4	0.837			
	PU5	0.756			
	PU6	0.582			
Actual Usage (AU)	AU1	0.756	0.822	0.607	0.787
	AU2	0.720			
	AU3	0.855			

Discriminant validity is obtained by comparing the correlation shared between factors with the square root of the average variance extracted from the individual factors (Fornell & Larcker, 1981). Table 4 shows that the square root of the average variance extracted for the individual factors exceeds the factor correlations. Discriminant validity is thus assured.

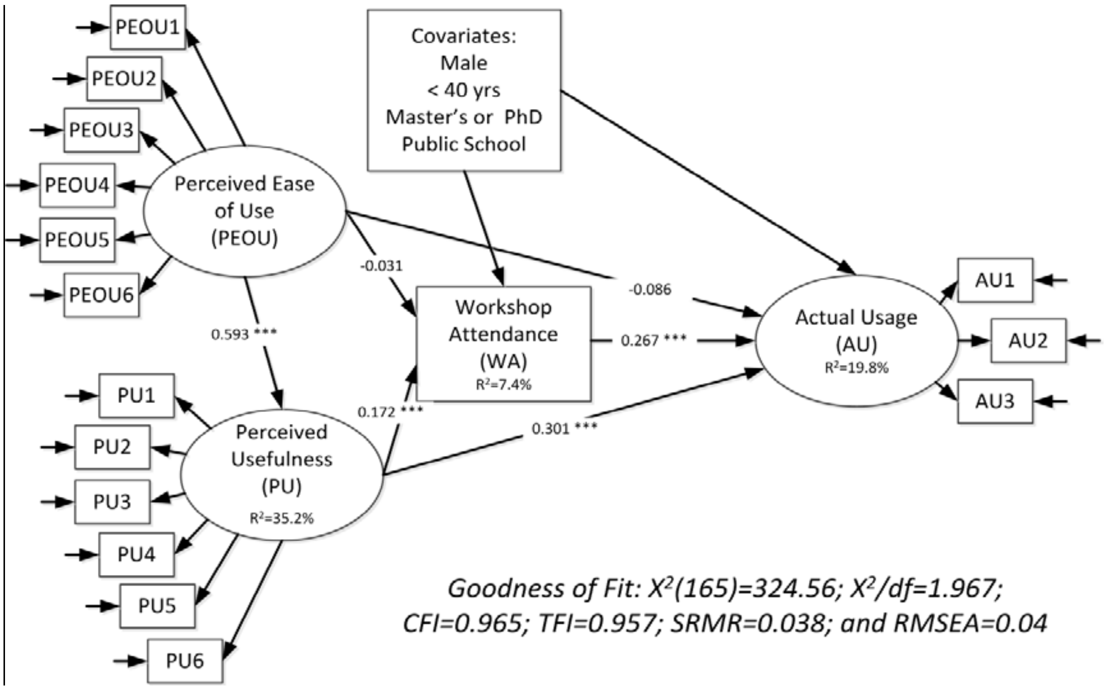
Table 4

Discriminant validity.

Factors	Perceived Ease of Use	Perceived Usefulness	Actual Usage
Perceived Ease of Use	**0.763**		
Perceived Usefulness	0.593	**0.617**	
Actual Usage	0.112	0.291	**0.779**

Note: Diagonal elements (in bold) represent the square root of the average variance extracted, and the other matrix entries are the factor correlation.

After validating our measurement instrument, we proceed to SEM. The first step in interpreting SEM results is to review the fit indices summarized in Figure 1. Comparing all fit indices with their recommended values suggests that the hypothesized model fits the empirical data.



Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$ (two-tailed test).

Fig. 1. The estimated structural equation model (standardized coefficient).

Figure 1 further reveals the resulting path coefficients of our research model. Overall, five out of seven hypotheses are supported by the data. Table 5 is a summary of the hypotheses testing results. The two unsupported hypotheses are H1A and H1B, indicating that PEOU does not affect actual GIS usage, either directly or indirectly through workshop attendance. However, PEOU indirectly affects actual usage through PU (H1C) as well as through PU and WA (H1D).

The importance of PU is further proved as it can directly or indirectly influence GIS usage (H2A and H2B). In-service training also directly influences GIS usage (H3).

Table 5

Hypotheses testing results.

Hypotheses	Path	Coefficients		Standard Error	Results
H1A	PEOU→AU	–0.086		0.055	Not supported
H1B	PEOU→WA→AU	–0.008		0.016	Not supported
H1C	PEOU→PU→AU	0.178	***	0.034	Supported
H1D	PEOU→PU→WA→AU	0.027	**	0.009	Supported
H2A	PU→AU	0.301	***	0.055	Supported
H2B	PU→WA→AU	0.046	**	0.015	Supported
H3	WA→AU	0.267	***	0.043	Supported

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$ (two-tailed tests). PEOU = perceived ease of use; PU = perceived usefulness; AU = actual usage; WA = workshop attendance.

Regarding control variables, their influence on GIS workshop attendance echoes the finding of Lay et al. (in press). Teachers with at least a postgraduate degree, as well as those working in public schools, are more active in attending training. As for actual GIS usage, teachers under 40 and those working in public schools are more active in integrating it into lectures. Gender and educational degree have no significant influence on actual GIS usage (data not shown).

In sum, actual GIS usage is found to be significantly influenced by four variables: perceived usefulness, workshop attendance, age, and school type. This results in an R^2 of 0.198, implying that the above variables account for nearly one-fifth of variance in GIS usage. Likewise, attendance in GIS workshops is significantly influenced by perceived usefulness, educational level, and school type, resulting in an R^2 of 0.074, meaning that these three variables explain 7.4% of variance in workshop attendance. Finally, perceived usefulness is significantly affected by perceived ease of use;

perceived ease of use alone explains 35.2% of variance in perceived usefulness. This high association of perceived usefulness and perceived ease of use is often observed in other TAM studies.

5. Discussion

The perceived usefulness of adopting GIS is vital as it directly affects teachers' attendance at GIS training, and it can further affect their actual GIS usage. The perceived ease of GIS use is less vital. A possible reason for this is that if teachers are more interested in learning GIS (after considering the benefits of GIS for teaching performance), they will naturally try the technology and will not hold back simply because the technology might be difficult to adopt.

In fact, Lay et al. (in press) have suggested the significance of perceived usefulness in encouraging teachers to participate in GIS training. The primary contribution of our SEM analysis is to further our understanding of the impact of GIS training on teachers' later adoption of GIS in education. Previously, we mentioned the top-down initiative from Taiwan's MOE to support NTU in undertaking senior high school teachers' GIS training. In addition to supporting the NTU, the MOE established a geography center at the National Taichung Girls' Senior High School in central Taiwan to offer in-service training and to assemble teaching modules for further improvement of the new curriculum. Our finding suggests that the MOE's support has paid off to a certain extent because geography teachers are beginning to apply GIS in lectures.

This study is groundbreaking in that it uses comprehensive nationwide census data to investigate the actual usage of GIS in geography lectures in Taiwan. SEM helps us to understand the relationship between various variables, clarifying how these factors affect teachers' actual GIS usage. A cross-sectional design, however, does not allow us to comprehend the causal relationships temporally. Panel studies and quasi-experiment research can redress this limit in future studies.

6. Conclusion

This study speaks to both the local and the wider international education community whose members are concerned about GIS promotion. The academic and practical value of this study warrants further exploration and, more specifically, policy debates. In terms of practical value, although in-service training does foster GIS usage, it is obvious that not all teachers want to utilize GIS in lectures after they obtain the relevant knowledge and skills. If we learn that perceived usefulness influences actual implementation, we can suggest to workshop organizers that they improve their syllabi, making it clearer how to apply the acquired knowledge and skills to the teachers' lectures. As mentioned, there have been modules written for teachers to adopt in their teaching. It is thus crucial to raise awareness during training of available resources and to demonstrate how these modules can actually be implemented in schools.

Academically, one might ponder what kind of relationship exists between teachers' GIS usage and that of their students. Future studies on this theme will lead us closer to grasping the full diffusion process of GIS in Taiwan's educational system.

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