

THE RELATIONSHIP BETWEEN TEACHER'S TECHNOLOGY INTEGRATION ABILITY AND USAGE*

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ABSTRACT

Despite a steady supply of equipment and continuous training, teachers' use of computers for instruction seems to be limited. Whether the problem is due to teachers' ability or usage of computers for instruction is not well understood. In order to better understand the role of ability and usage in technology integration, teachers' proficiency of technology integration was evaluated by separate ability and usage scales. Based on performance indicators from the International Society for Technology in Education (ISTE), two scales were developed that measured teachers' self-perceived ability and their frequency of usage of technology integration. The survey was administered to grade 1-9 teachers in Taiwan ($n = 3729$). The results showed a positive correlation between teachers' technology integration ability and usage (Pearson $r = .56$). Further examination using Structural Equation Modeling (SEM) confirmed the structure of the scales and revealed a higher correlation between the two scales after adjusting for measurement error.

INTRODUCTION

Teachers' integration of technology has been investigated for a long time. Research has shown, however, there has not been much progress in teachers' integration of computers in their lessons over the last 20 years (Culp, Honey, & Mandinach, 2003). The reasons for teachers' limited use of computers have sparked the interest of many researchers (Baylor & Ritchie, 2002; Levin &

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Wadmany, 2008). Various measures to evaluate teachers' level of technology integration have been developed and factors that influence teachers' technology integration have been scrutinized (Hermans, Tondeur, van Braak, & Valcke, 2008; Mueller, Wood, Willoughby, Ross, & Specht, 2008). A fundamental question seldom asked is this: Is it teachers' usage or teachers' ability that we are trying to increase in technology integration?

In order to discuss the issue of teachers' usage and ability in technology integration, three issues need to be clarified. First, technology integration proficiency is different from computer proficiency, with the former including more complicated aspects such as pedagogical considerations. Second, ability and usage are different entities, although they could be influenced by similar factors such as beliefs and attitudes. Third, teachers who have the ability to integrate technology into teaching may not be able to do so in their classes because of barriers such as the lack of functional equipment, appropriate software, students' ability, and school curriculum. Due to these three issues, it is necessary to measure teachers' technology integration ability and usage separately and examine the relationship between these two constructs.

Technology Integration Proficiency is Different from Teachers' Computer Proficiency

Technology integration is not as well understood as computer usage. Recently, researchers have suggested that using technology for instructional integration requires knowledge and skills which are different from simply using computers (Angeli & Valanides, 2009). Teachers need specific knowledge and skills that utilize technology for education. Integrating technology into teaching means considering the needs of the students, the curriculum, and available technology, as well as the lesson planning and media design issues, and somehow combining them into a practice that will enhance student learning (Hennessy, Ruthven, & Brindley, 2005).

Ability and Usage are Different Entities and Should be Examined Separately

Ability and usage are similar constructs. It was not obvious to the researchers in the early days that it was necessary to separate ability and usage when examining teachers' proficiency of technology integration. Frequency of usage was often employed as the indicator of teachers' capability to integrate computers. In a large-scale survey by Becker (1999), teachers' frequency of computer or Internet use was the key indicator for their measure of technology integration proficiency. Teachers were asked to specify frequency in terms of "do not use," "occasionally," "weekly," and "more often" on technology use items such as using information from Internet in lessons, using electronic mail to communicate with teachers in other schools, and posting information to the Word Wide Web. In another

large-scale study, Moersch (1999) proposed a similar framework for teachers' level of technology integration based on frequency. In their questionnaire, items measuring frequency of usage such as "I use prepackaged curriculum units" were used to assess teachers' technology integration proficiency. Both studies used teachers' frequency of usage as indicators of teachers' level of proficiency. Many later studies also follow the same tradition (e.g., Hermans et al., 2008; Mueller et al., 2008), measuring teachers' technology integration proficiency with frequency of usage. With this framework, teachers who are not using technology are usually assumed to lack competency or proficiency. Usage, therefore, has been a proxy for teachers' ability.

Ability and usage, however, are different entities. Ability refers to how capable or competent a person is when doing something. Ability includes, or is related to, knowledge and skills (Compeau & Higgins, 1995), and is influenced by many factors such as attitudes (Shapka & Ferrari, 2003), beliefs (Yang & Huang, 2008), self-efficacy (Anderson & Maninger, 2007), and morale (Baylor & Ritchie, 2002). Usage, on the other hand, is how much or how often a person is doing something. Usage can also be described as behavior or performance. These two constructs need to be studied separately.

Several studies have attempted to assess teachers' technology integration and the relationship between ability and usage. For example, Smarkola (2008) examined teachers' intention to use computers for instruction by using the self-efficacy model developed by Bandura (1977), investigating how perceived ability influences one's intention of behavior. Using path analysis, Smarkola showed that teachers' intentions to use computers for instruction can be predicted by belief-based measures pertaining to attitudes (e.g., usefulness and compatibility), subjective norms (e.g., peer influence and superior's influence), and perceived behavioral control (e.g., self-efficacy, technology and resource constraints/support). In Smarkola's study, teachers' perception of their capability predicts their intention to use computers for instruction.

Barriers that Prevent Teachers from Realizing Their Ability in Technology Integration

Previous studies have come close to suggesting that teachers' usage or intended usage is associated with their ability or perceived capability of technology integration. Analyses of outcomes of training programs and workshops, however, have encouraged researchers to speculate that the barriers can be divided into ability and usage (Bichelmeyer & Molenda, 2006; Cuban, Kirkpatrick, & Peck, 2001). While it is possible that training programs are not effective, and therefore teachers did not get the necessary competencies to enable them to integrate technology, it is equally possible that teachers obtained the knowledge and skills, but did not want to utilize them in class. In studying inhibitors of teachers' use of computers, Mumtaz (2000) concluded that out of seven barriers there was

only one related to teachers' ability; the barrier was the lack of teaching experience with ICT. Most of Mumtaz's factors were outside of the teacher's control, which created usage problems. Those barriers included the lack of computer availability, ICT specialist teachers, on-site support, supervision of children when using computers, financial support, and time required to successfully integrate technology into the curriculum. Likewise, Shiue (2007) used path analysis to study factors that influenced teachers' use of technology among 242 secondary Taiwanese teachers. Shiue found that teachers' use of technology and their inclination toward its use were largely determined by teacher-technology interface factors, which included ease-of-use, computer self-efficacy, and perceived usefulness. The teacher-technology interface, furthermore, was influenced by objective technological environment factors, which included technical support, computer access, and professional development opportunities. Given these results, it seems possible that even after teachers obtained necessary competence in technology integration, they may still not be able or willing to integrate technology in their teaching.

Perceived vs. Actual Ability and Usage

Using teacher-reported data has a potential problem of teachers inaccurately estimating of their own ability and usage. In order to overcome such problems, Bunz, Curry, and Voon (2007) developed a perceived Computer-email-web (CEW) fluency scale for subjects' perceived CEW fluency, and used the subjects' score on the applied skills in CEW related tasks as their actual fluency. Their study found a significant correlation between subject's perceived and actual fluency. In a study by Dunning, Johnson, Ehrlinger, and Kruger (2003), subjects with poor performance tended to over-estimate their expected performance. High performers tended to slightly under-estimate their expected performance. The under-estimates of high performers, however, were still higher than the over-estimates of low performers. It is therefore reasonable to use perceived ability and perceived usage when examining their correlations.

PURPOSE

The purpose of this study is to find the relationship between teachers' technology integration ability and usage. This study used direct translation of ISTE NETS-T performance standards as teachers' perceived ability scale. Another scale of teachers' technology integration developed from the ISTE NETS-T (Hsu, 2010) was used to measure teachers' perceived usage. A group of teachers in grades 1-9 completed both instruments during one administration of the survey. Confirmatory factor analysis (CFA) of the ability scale was performed to confirm the structure in the scale, and the relationship of both ability and usage scales were examined using correlations and structural equation modeling (SEM).

METHOD

The Ability Scale

The items in the ability scale were developed by ISTE and translated into Chinese. The items in the National Educational Technology Standards for Teachers (NETS-T) were used as measures of teachers' proficiency of technology integration.¹ The six constructs in the ability scale were: (a) technology operations and concepts; (b) planning and designing learning environments and experiences; (c) teaching, learning, and the curriculum; (d) assessment and evaluation; (e) productivity and professional practice; and (f) social, ethical, legal, and human issues (ISTE, 2000). There were 23 performance indicators in the six areas of NETS-T (see Appendix A for sample items). The 23 performance indicators were translated by five English teachers in secondary schools in Taiwan. The translation was evaluated for readability by four secondary school teachers in other disciplinary areas. Subjects rated their ability from 1 to 4, corresponding to four competence levels: "no idea at all," "need a lot of help from others," "can do it myself most of the time," and "familiar and proficient."

The Usage Scale

The items in the usage scale were also based on NETS-T standards. The six constructs in the usage scale were: (a) information collection and preparation; (b) material production and trouble-shooting; (c) communication and sharing; (d) planning, teaching and evaluation; (e) professional development and self-study; and (f) ethical, health, and safety issues. There were six constructs and 40 items in the usage scale (see Appendix B for sample items). The details of scale development were reported in Hsu (2010). An expert teacher panel interpreted the NETS-T standards and developed new items based on their teaching experience. Each item may be related to more than one NETS-T indicator, and there is no one-to-one correspondence to NETS-T items. Subjects rated their usage during the last semester from 1 to 4, corresponding to "never use," "once in a while," "sometimes," and "very often." Table 1 lists the number of items, the internal consistency coefficient (Cronbach's alpha), sample items, and the means and standard deviations of each subscale in both ability and usage scales.

¹ This study was conducted at the end of 2006 and the beginning of 2007 before NETS-T 2008 (ISTE, 2008) was released. Both NETS-T 2000 and NETS-T 2008 include similar categories and could function as general guidelines.

Table 1. Mean and *SD* for Ability and Usage Subscale

Scale/subscale	Items	Alpha	Mean	<i>SD</i>
Ability	23	.92	2.73	.46
A1	2	.85	2.84	.53
A2	5	.91	2.70	.55
A3	4	.91	2.60	.59
A4	3	.87	2.66	.59
A5	4	.86	2.83	.50
A6	5	.90	2.81	.51
Usage	40	.82	2.72	.50
U1	2	.72	3.44	.57
U2	5	.84	2.61	.66
U3	3	.70	2.21	.75
U4	18	.96	2.31	.68
U5	3	.82	2.82	.66
U6	9	.95	2.89	.76

Note: $n = 3759$. Alpha = Cronbach's alpha. Information of the usage scale is also reported in Hsu (2010).

Survey Procedure

Grades 1 to 9 teachers from all 23 cities and counties in Taiwan were sampled by using a probability proportional to size (PPS) method. A total of 334 schools were sampled and 15 teachers from each school were asked by the head of academic affairs at their schools to participate in the survey. A total of 4911 teachers were sampled and 3729 (76%) valid surveys were returned. Eighty-four percent of the returned questionnaires were submitted online and 16% were returned by postal mail. The sample was representative of the population based on several measures such as gender and district economic development (Hsu, Kuan, & Yang, 2008).

Data Analysis

Four steps were taken to confirm the ability and usage scales and the relationship between them. First, CFA was performed for the ability scale to confirm the structure of the NETS-T performance standards. Second, the correlations between the ability and usage subscales were calculated to examine the similarity between the structures for ability scale and usage scale. Third, the scatter plot of the mean scores from both scales was produced, and the correlation of average scores of both scales was analyzed to explore the relationship between them. Fourth, a SEM

model of both scales was constructed and the correlation between the two scales without measurement error was further examined (see Figure 1).

RESULTS

CFA of Ability Scale

Confirmatory analysis was used to build the ability model based on the NETS-T indicators. Six factors were tested for the ability model. The number of items and subscales was the same as the number of items and subscales in the NETS-T performance indicators. The results showed a large Chi-square, but the goodness of fit indicators showed that the model is acceptable (Chi-square = 600.05, $df = 216$, p -value < .001, RMSEA = .02, NFI = 1.00, NNFI = 1.00, CFI = 1.00). The large Chi-square could have been influenced by a large sample size. An

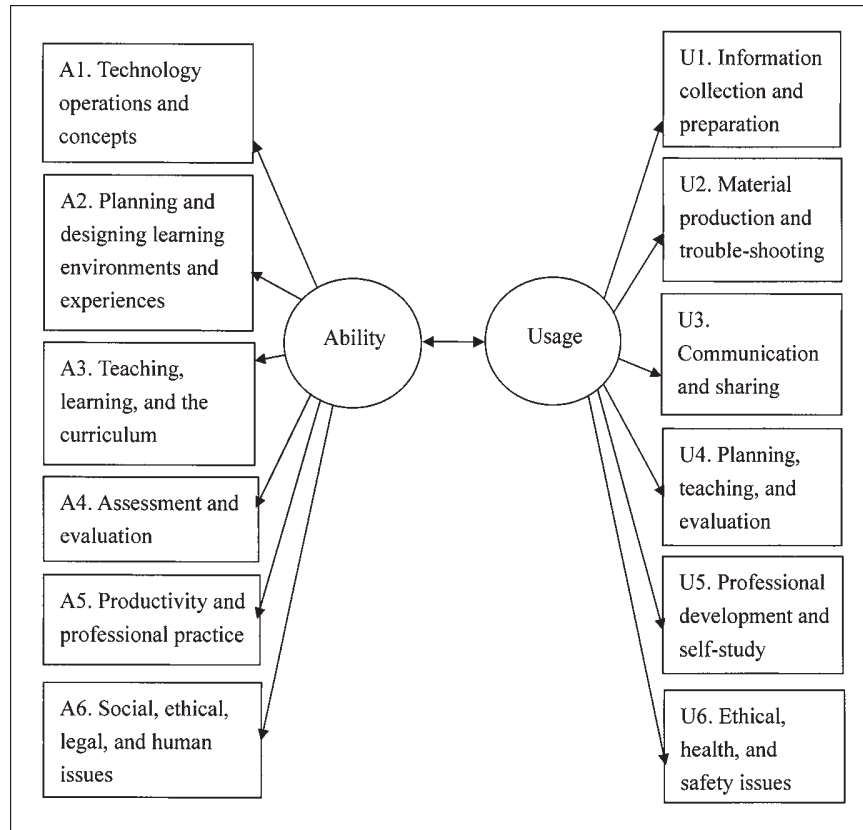


Figure 1. The SEM model of ability and usage.

RMSEA that is smaller than 0.05 is considered a good fit, and so does a NNFI or CFI that is close or equal to 1. Therefore, the model was accepted.

Correlation between Ability and Usage Subscales

The results of the correlations between the ability and usage subscales found that those two scales were quite different in terms of their structure (see Table 2). Although both scales were based on NETS-T performance indicators, and both of them had six subscales, they were actually two different scales. The six subscales in ability scale did not correspond to the six subscales in the usage scale. Although the last two subscales in both ability and usage scale were similar in terms of their meanings, there were only moderate correlations between those subscales, with Pearson correlation coefficient $r(A5B5) = .46$ and $r(A6B6) = .43$. Some subscales had very low correlations (e.g., $r(A1B3) = .20$). The second usage subscale “material production and trouble-shooting,” however, seemed to have higher correlations with all six ability subscales ($r = .41$ to $.52$). It was concluded that the ability and the usage scales did not measure the same factors.

Correlation between Total Average Scores for Ability and Usage

The correlation between the overall ability and usage scores was calculated to find the relationship between teachers’ ability and usage of technology integration. The mean scores for both ability (mean = 2.73, $SD = .46$) and usage (mean = 2.72, $SD = .50$) were obtained by averaging all the items in the scales, and then the correlation between the mean scores for ability and usage was calculated. The results showed that there was a positive correlation between teachers’ ability and behavior, with a Pearson correlation r of $.56$ ($p < .001$).

Table 2. Correlations between Ability and Usage Subscales

		Usage scale					
		U1	U2	U3	U4	U5	U6
Ability scale	A1	0.28	0.43	0.20	0.32	0.38	0.27
	A2	0.26	0.52	0.22	0.41	0.41	0.32
	A3	0.22	0.51	0.26	0.45	0.40	0.35
	A4	0.23	0.46	0.24	0.42	0.39	0.34
	A5	0.33	0.46	0.24	0.35	0.46	0.32
	A6	0.25	0.41	0.24	0.38	0.40	0.43

Figure 2 shows the scatter plot of the participants' mean scores for ability and usage. Visual inspection of the plot in Figure 2 shows definite groups of low ability and high ability teachers, though naturally most teachers were in the middle of the range. Although variables with nonlinear relationships could still produce a positive correlation coefficient, the scatter plot suggested that there is a linear relationship between ability and usage (Anscombe, 1973).

SEM Analysis of a Causal Relationship

A SEM model was developed that hypothesized a mutual correlation relationship between teachers' ability and behavior in technology integration. The SEM of ability and usage showed an acceptable fit (Chi-square = 13305.15, $df = 1163$, $p < .001$, NNFI = .97, NFI = .97, CFI = .97, RMSEA = .053) (see Figure 3). This result confirmed the SEM model that ability and usage correlated with each other. In addition, the SEM model, which removed the measurement error, demonstrated a higher correlation between teachers' ability and teachers' usage in technology integration ($r = .66$).

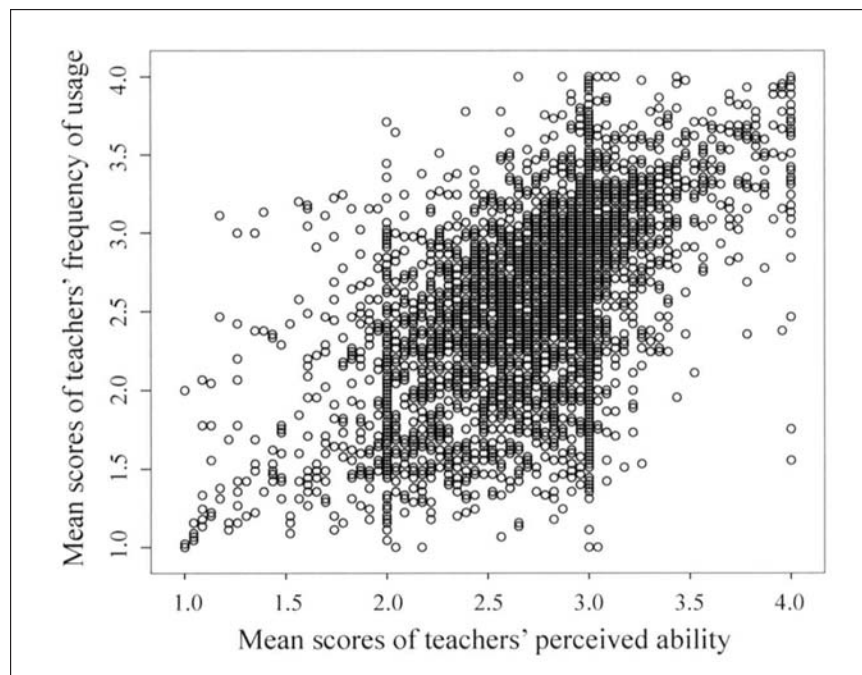


Figure 2. Scatter plot of teachers' ability and usage in technology integration.

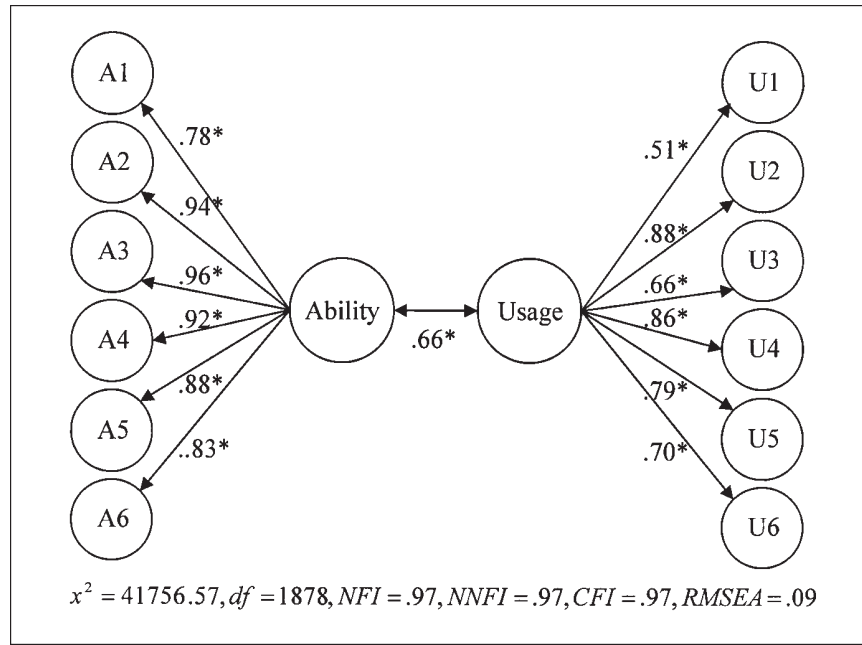


Figure 3. Standardized estimates of the structural model of ability and usage.

DISCUSSION

This large scale survey of 3729 Taiwanese teachers addresses the relationship between teachers' ability and usage in technology integration. Two scales were created using the ISTE NETS-T 2000 performance indicators, and models of the relationship were tested. This study verifies the structure of the ability scale, which contains the same six subscales and 23 performance items as in the NETS-T 2000 model. The usage scale was based on the NETS-T model, but it underwent some changes when being translated and interpreted for usage (Hsu, 2010). With these changes, the correlations of the subscales showed that the ability and usage scales were sufficiently different. Two major findings are discussed.

Positive Correlation between Ability and Usage of Technology Integration

The study shows that there is a moderate positive correlation ($r = .56$) between ability and usage. This Pearson correlation indicates a medium-size correlation between the ability and usage, but other correlations besides a linear relationship could still be possible among the variables (Anscombe, 1973). The linear

relationship between ability and usage is further confirmed by the inspection of the scatter plot of the two variables (see Figure 2). The results suggest that teachers with high ability in technology integration generally have higher usage of technology integration in the classroom.

While many researchers have studied psychological factors for possible barriers to technology integration, it may be worthwhile to ask a basic question: Have those teachers gained the ability to implement technology integrated lessons? This study found that those teachers who had higher ability do integrate technology more often, and therefore have higher frequency of usage. Unlike Shiue (2007), this study suggests that ability, not self-efficacy or perceived usefulness, determines the amount of use, at least for teachers in Taiwan.

The findings in this study should be comforting for researchers who have utilized usage, not ability, to indicate teachers' proficiency in technology integration (e.g., Becker, 1999; Cuban, Kirkpatrick, & Peck, 2001; Moersch, 1999). At the time, it may have been used without the consideration of the differences between ability and usage. The finding that ability correlates positively with usage supports those studies in their hidden assumption that teachers who use more are generally better at integrating technology into classroom.

SEM Analysis of Ability and Usage Relationship

There are many potential relationships between teachers' ability and usage in technology integration. The Pearson correlation of the mean scores of both ability and usage scales show that there is a positive correlation between the two variables. In the SEM model, furthermore, the covariance between ability and usage is equal to the correlation between the two variables ($r = .66$). This correlation coefficient is higher than the one in the Pearson correlation calculation ($r = .56$) because the SEM controls for measurement errors that are often included by Pearson correlations (Seber & Lee, 2003). Thus, the correlation between ability and usage is even greater than the Pearson correlation coefficient suggests, after the measurement errors are removed.

One question that may be asked is: Can causal relationships such as ability predicting usage, or usage predicting ability, be assumed? In this study, it is assumed that there is a correlation between these two scales. Statistically, the predictor and independent variable in an SEM model can be placed pointing in either way, and the covariance value would be the same. In other words, teacher's ability could be assumed to predict usage, or the other way around. To answer the question about the other direction of the causation, another set of assumptions should be made. These assumptions are probably best addressed by longitudinal studies that look at the impact of increased usage on teachers' ability in technology integration. Further analysis of the causal relationship is needed in order to understand more precise relationships between teacher's ability and usage in technology integration.

Limitations of the Study

Teacher's proficiency as measured in the current study does not differentiate teachers' and students' use of technology. In other words, this study does not discriminate between increasing use of technology for instructional preparation from student use of ICT during learning activities. The latter concept, regarding how teachers are actually helping students learn with technology, is the goal of many researchers and educators. A finer differentiation between the two concepts, teachers' use and students' use of technology, is an important step in fine tuning the search of understanding teacher's technology integration.

CONCLUSION

The results of this study present a positive correlation between teacher's ability and usage in technology integration, and suggest that well-trained teachers successfully integrate technology. Using the NETS-T performance indicators for teachers' technology integration, this study found that teachers who regard themselves as having high ability in technology integration generally do more technology integration than those who report they have lower skill levels. This study surveyed over 3000 teachers and demonstrated that this positive correlation exists for many different grade level and subject area teachers in Taiwan.

One implication from the results of this study is that the quality of training programs matters. Past studies have suggested that training programs help teachers improve, albeit slowly (Bichelmeyer & Molenda, 2006). Teachers do not immediately become technologically savvy, but they can make progress. There is a reason why the importance of professional training has been emphasized as one of the most important factors that improves teachers' computer integration (Culp et al., 2003), despite numerous failures. Technology integration is more than just using computers. Teachers need to understand how to use technology properly in their disciplinary content areas. National and international standards, such as NETS-T, seem to be valid and can be used as a guideline for professional development. Future training workshops and programs should be aligned to those standards. When teachers have better understanding and thus higher competence of integrating technology into teaching, their chance of having higher integration will be within reach.

Appendixes follow

APPENDIX A
Constructs and Selected Items in the Ability Scale

Subscale	Description	Sample item
A1	Technology operations and concepts	Demonstrate introductory knowledge, skills, and understanding of concepts related to technology.
A2	Planning and designing learning environments and experiences	Identify and locate technology resources and evaluate them for accuracy and suitability.
A3	Teaching, learning, and the curriculum	Facilitate technology-enhanced experiences that address content standards and student technology standards.
A4	Assessment and evaluation	Apply multiple methods of evaluation to determine students' appropriate use of technology resources for learning, communication, and productivity.
A5	Productivity and professional practice	Continually evaluated and reflected on professional practice to make informed decisions regarding the use of technology in support of student learning.
A6	Social, ethical, legal, and human issues	Apply technology resources to enable and empower learners with diverse backgrounds, characteristics, and abilities.

Note: For a complete list of items, please see ISTE (2000).

APPENDIX B
Constructs and Selected Items in the Usage Scale

Subscale	Description	Sample item
U1	Information collection and preparation	Used the Internet or other information technology to search for information to provide supplementary course material for students
U2	Material production and trouble-shooting	Used the computer to record, edit sound or music in my course material
U3	Communication and sharing	Used e-mail or MSN to communicate with students
U4	Planning, teaching, and evaluation	Tried new strategies to increase student's level of concentration during ICT-integration classes
U5	Professional development and self-study	Attended conferences or read journals to learn about ICT integration methods
U6	Ethical, health, and safety issues	Helped students evaluate the authenticity, relatedness, properness, and justness when students referred or quoted information from the Internet

Note: For a complete list of items, please see Hsu (2010).

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