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Research Article

The role of school socioeconomic status in school-wide technology integration in the U.S.

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ABSTRACT

This study aimed to examine the relations between first-order and second-order barriers and ICT (information and communications technology) integration across schools with different SES (socioeconomic status) levels in the US. This study was based on a nationally representative sample of public elementary and secondary schools included in the fast response survey system (FRSS)–educational technology in the US public schools. Multiple-group path modeling was employed as the main analytic method. The results showed that in advantaged schools, first-order and second-order barriers demonstrated additive effects on ICT integration. However, in disadvantaged schools, first-order and second-order barriers showed multiplicative effects on ICT integration. This study suggests that in advantaged schools, eradicating second-order barriers can compensate for the constraints on ICT integration imposed by first-order barriers. However, in disadvantaged schools, removing second-order barriers will not be effective if first-order barriers are not addressed first. This study contributes to the literature by highlighting the role of school SES in planning school-wide ICT integration. Also, a contextualized model is proposed to capture the differential relations between barriers and ICT integration in specific school contexts.

Keywords: technology integration, first-order barriers, second-order barriers, school SES, equity

INTRODUCTION

Information and communication technology (ICT) has increasingly become an integral part of classrooms. The federal government of the US, which has invested huge amounts of resources in technology infrastructure and teacher preparation, is behind the efforts to create a ubiquitous and connected learning experience (Bearden, 2017). With infrastructure in place, teachers should feel motivated to use ICT more often in classrooms. However, it has been found that suffusing schools with technology does not automatically translate into the active use of ICT in classrooms (Baker & Gowda, 2018). Teachers' ICT integration is an extremely complex process and is not hampered simply by a lack of infrastructure. The complexities associated with ICT integration call for theoretical frameworks that can shed light on the causes of the underuse of technology at schools.

Technology integration barriers represent one of the earliest conceptual frameworks that attempt to explain the reasons for the underuse of ICT at schools (Vongkulluksn et al., 2018). It has been suggested that ICT implementation is limited by two major factors: first-order (environmental determinants) and second-order (personal determinants) barriers (Bowman et al., 2020). Several studies have been conducted to identify the significant dimensions of the first-order and second-order barriers and to clarify the relations between these dimensions and ICT integration within the barrier-to-technology integration model (Dinc, 2019; Scott,

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2020). These studies provided empirical evidence to support the theoretical underpinnings of this model (henceforth the barrier model). However, past research based on the barrier model tended to focus on the overall relations between barriers and ICT integration by aggregating data across school sites, thereby assuming that these relations would not differ by school characteristics (Hamutoglu & Basarmak, 2020; Ifinedo et al., 2020). Without testing this assumption, it is not certain if stakeholders can directly apply the existing findings based on aggregated data to their unique school contexts.

Although there were studies that examined barriers to ICT according to school type, the emphasis was on the mean differences in technology integration barriers and ICT integration (Dogan et al., 2021; Mané, 2019). This area of research identifies types of schools that would face greater barriers and have lower levels of ICT integration than others but does not consider the relations between barriers and ICT integration. On the other hand, studies investigating technology integration barriers at a specific school level were conducted at different geographic locations and normally included different sets of first-order and second-order barriers (Schmitz et al., 2022; Spencer, 2019). These shortcomings make it difficult to gauge whether the relations between barriers and ICT integration differ by schools. Therefore, it is not clear if a specific factor that is important for technology integration in certain schools will carry the same weight in different school settings. Among school characteristics, school socioeconomic status has been demonstrated to be a critical factor in relation to schoolwide technology integration (Kim et al., 2021). However, thus far, few studies have considered how the relations between barriers and ICT integration may vary by school socioeconomic status.

The goals of the current study were to address the aforementioned gaps in the literature by examining whether the relations between barriers and ICT integration varied by school socioeconomic status based on a nationally representative dataset to ensure the findings can be generalized to all the public schools in the US. This line of inquiry will add critical contributions to the theoretical underpinnings of the barrier model and practice of ICT integration. First, the external validity of the barrier model can be directly assessed, and the extent to which the findings about the hypothesized relations can be generalized to different school contexts can be understood. Second, this research direction is able to uncover findings that are contextualized and, thus, will be relevant and useful for stakeholders' decision-making. The design of the current study was guided by the following questions:

1. **RQ1:** What are the overall relations between first-order barriers, second-order barriers, and ICT integration?
2. **RQ2:** Do the relations between first-order barriers, second-order barriers, and ICT vary by schools with different levels of SES?

LITERATURE REVIEW

The Barrier to Technology Integration Model

The barrier model describes how environmental factors and personal factors impact ICT integration in classrooms. Environmental factors, that is, first-order barriers, are obstacles that are external to teachers' technology use in classrooms, such as technological resources, technical support, time, and training (Vongkulluksn et al., 2018). Personal factors, that is, second-order barriers, are obstacles intrinsic to teachers that impede the meaningful use of technology, such as teachers' beliefs about instructional technology (Bowman et al., 2020; Cheng et al., 2020a, 2020b). The relations between first-order barriers, second-order barriers, and ICT integration are complex and not simple.

There are two main hypotheses associated with the barrier model: additive and multiplicative effect hypothesis (Ertmer, 1999). The additive effect hypothesis stipulates that first-order and second-order barriers contribute independently and uniquely to explain ICT integration. That is, both first-order barriers and second-order barriers have a direct influence on teachers' ICT integration practices. In addition, these barriers do not interact with one another. Therefore, a lack of access to computers will immediately hinder teachers' efforts to use them for the purpose of instruction. By the same token, if teachers do not believe computers are valuable for students learning, they are less likely to use them in classrooms. On the other hand, the multiplicative effect hypothesis stipulates that first-order and second-order barriers interact with one another to exert effects on ICT integration. That is, the effects of second-order barriers on ICT integration are

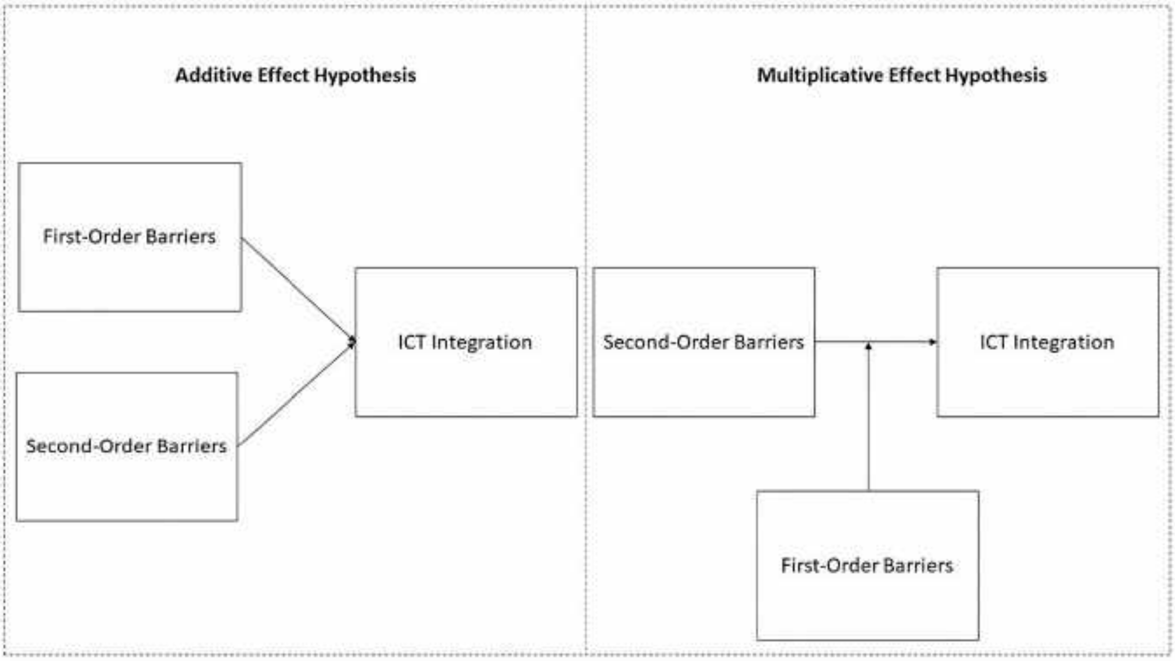

Figure 1. Additive and multiplicative effect hypothesis (Source: Authors)

moderated by and dependent on the magnitude of first-order barriers. If first-order barriers are high, the translation of teacher beliefs into practices could be undermined.

Figure 1 presents the additive and multiplicative effect hypothesis. In the next sections, empirical findings are presented to establish the significance of first-order barriers and second-order barriers in relation to ICT integration. The gaps in the existing literature will then be discussed.

Empirical Findings on the Direct Effects of First-Order Barriers on ICT Integration

The significant role of first-order barriers in relation to ICT integration as pointed out in the barrier model is supported by several empirical studies. Regarding the relations between first-order barriers and ICT integration, six salient dimensions have been identified in systematic review studies: shared vision, professional development, technology availability and accessibility, technical support, funding, and time (Tosuntas et al., 2019). Having shared visions and goals that stress the role of ICT in relation to teaching and learning provides teachers with clear expectations and facilitates technology integration (Dexter & Richardson, 2020). Apart from setting ICT integration as a priority in school districts, the development of people is also an indispensable component in a school's comprehensive ICT policy to support ICT integration (Thannimalai & Raman, 2018). A lack of training is often considered one of the major first-order barriers and is directly related to ICT integration in classrooms (Bowman et al., 2020; Lai et al., 2022; Picton, 2019).

Although receiving training for ICT integration is crucial, teachers also need technological resources to implement what they learn in professional development programs (Dinc, 2019). The issue of limited technological resources encompasses two aspects: technology availability and technology accessibility. Technology availability refers to the sheer number of instructional computers and mobile technologies in schools (Alghasab et al., 2020), while the issue of technology accessibility can happen when the computers are outdated (Shemshack, 2021) and the location of instructional computers are not easily accessible (Mwanda, 2017).

Apart from easy access to technological resources, successful ICT integration also requires access to adequate human infrastructure (Samatova, 2019). When using ICT in classrooms, teachers are likely to encounter technical difficulties and need timely assistance with troubleshooting and problem-solving (Francom, 2020). Quality human and technological infrastructures require adequate financial investment and support from school leaders. The allocation of schools' funding to buy ICT equipment is considered one of the core ICT leadership practices for developing the organization and removing barriers to ICT (Dinc, 2019). Integrating new technology in classrooms is a time-consuming process. Teachers need sufficient time to learn how to use technological tools, plan technology lessons, devise backup lesson plans, and carefully monitor students' learning activities in class (Tosuntas et al., 2019). However, a three-year-time-series study on teachers in K-12 public schools in the US also showed that a lack of time for ICT integration was reported as the most stable and persistent first-order barrier (Francom, 2020).

Empirical Findings on the Direct Effects of Second-Order Barriers on ICT Integration

Apart from first-order barriers, second-order barriers, such as teacher beliefs, also play significant roles in hindering teachers' implementation efforts (Vongkulluksn et al., 2018). Teacher beliefs are defined as "tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught" (Kagan, 1992, p. 65). Teacher beliefs serve as "an intuitive screen" (Goodman, 1988, p. 130) through which new information and events are filtered and, hence, affect teachers' decisions to use technology in classrooms (Chand et al., 2020). Research has suggested that teachers' beliefs about effective ways to teach and learn and their capabilities of using technology were closely related to ICT practices in classrooms (Cheng et al., 2020a, 2022; Teo et al., 2018). For instance, Teo et al. (2018) found that beliefs about student-centered learning significantly and positively predicted teachers' intention to use technology in classrooms. A study by Gurer and Akkaya (2022) also showed that beliefs about student-centered learning were significantly and positively correlated with teachers' intention to use technology in classrooms. Cheng et al. (2020a, 2022) consistently showed teachers' beliefs about their capabilities to use technology significantly and positively predict their intention to integrate technology into classrooms.

In addition to beliefs about teaching and learning and capabilities, teachers' beliefs about the values of using ICT in classrooms are also critical for their implementation effort. How and how often ICT is used in the classroom is related to the extent to which teachers believe that ICT integration is interesting, important, useful, or effortful for instruction and students' learning (Cheng et al., 2020b). Karakis (2022) found that teachers' beliefs about how interesting it was to use technology in instruction significantly predicted teachers' intention to use educational technologies. A study by Nelson and Voithofer (2022) noted that beliefs about how important technology was for instruction were significantly and positively correlated with how often teachers engaged in teaching lessons that combined content knowledge, technologies, and teaching approaches. Several studies have consistently shown that teachers' beliefs about the usefulness of ICT for improving their instructional performance and productivity significantly predicted their intention to adopt technology in classrooms (Teo et al., 2018). A study by Cheng et al. (2020a) indicated that teachers' beliefs about the effort and time required for ICT integration were significantly and negatively correlated with their intention to use technology in classrooms. Compared to first-order barriers, teacher beliefs are considered more difficult to address in that beliefs are latent, unobservable, and established over a long period of time (Ertmer, 2005).

Multiplicative Effect Hypothesis and the Role of School SES

As presented above, a majority of studies in the existing literature have focused on examining the additive effect hypothesis, that is, the direct and unique effects of first-order and second-order barriers on ICT integration. However, the multiplicative effect hypothesis remains understudied. Only a handful of studies have been conducted so far. For instance, Ertmer et al. (2012) described a case where a fourth-grade teacher's (Buller) espoused beliefs could not be translated into enacted practices of ICT integration owing to first-order barriers (e.g., limited access to technological resources). Based on a large sample of participants across middle and high schools in Texas and Mexico, Velázquez (2006) found that the relations between first-order barriers, second-order barriers, and ICT integration differed by cultural settings. First-order barriers were the strongest predictors of ICT integration for schools in Mexico but not for schools in Texas. Velázquez (2006) concluded that for schools facing high first-order barriers like those in Mexico, the role of second-order barriers, such as teacher beliefs, in relation to ICT integration would be minimal if first-order barriers were not removed first. These findings suggest that the relations between barriers and ICT integration are more complicated than what is proposed by the additive effect hypothesis. However, since both findings are tied to their own contexts (i.e., purposeful sampling), whether the multiplicative effect hypothesis is true in the population and where the interdependent relation is likely to present remains unclear. As reported in large-scale studies, first-order barriers, such as a lack of technological resources, presented a greater challenge to low SES schools than to high SES schools (Kim et al., 2021). Therefore, it is plausible that relations between barriers and ICT integration may vary by school SES, and multiplicative relations are more likely to occur in settings where first-order barriers are high such as low SES schools.

Gaps in the Existing Literature

Although a lot of research has been conducted to understand barriers and ICT integration, there are some notable shortcomings in the existing literature. First, there are studies considering the role of SES in ICT integration. However, the focus has been on the mean differences in barriers or ICT integration (Mané, 2019; Ritzhaupt et al., 2020). These studies contribute to the literature by revealing that school SES plays a significant role in promoting schoolwide ICT integration. However, the relations between barriers and ICT are not examined. Second, previous large-scale studies tended to combine school data from different SES levels and assumed that the observed relations would be the same among subpopulations (Hamutoglu & Basarmak, 2020; Ifinedo et al., 2020). These studies contribute to the literature by identifying significant dimensions of barriers in relation to ICT integration as general. However, this approach could be problematic in that relations that only appear in subgroups could disappear when data are combined as shown in Velázquez's (2006) study. Therefore, the assumption that similar barrier factors will carry equal weight in relation to ICT integration in different school settings could be incorrect. Hence, implications drawn from the findings based on the aggregated data may not be applicable to different school contexts, either. Third, there is research focusing on how barriers relate to ICT integration among specific teacher groups (Schmitz et al., 2022; Spencer, 2019). These studies contribute to the literature by identifying barrier factors that are significantly associated with ICT integration at each school level. However, these studies were conducted at different geographic locations and normally included different sets of first-order and second-order barriers, which makes it difficult to gauge whether the relations between barriers and ICT integration differ by school SES levels.

In sum, the existing literature remains limited in answering whether the relations between barriers and ICT integration vary by school SES (i.e., the multiplicative effect hypothesis). The aforementioned shortcomings point out a need to consider the role of school SES in examining the relations between barriers and ICT integration. This line of inquiry will reveal if a specific barrier factor that is important for technology integration in certain schools will carry the same weight in different school settings and, hence, provide stakeholders with implications that are specific to their school socioeconomic status. The goals of the current study were to address these gaps in the existing literature by examining whether the relations between barriers and ICT integration varied by school socioeconomic status based on a nationally representative dataset to ensure the findings can be generalized to all the public schools in the US.

METHOD

Research Design

The goal of the current study was to examine the relations between first-order and second-order barriers and ICT integration across schools with different levels of SES. To this aim, the current study followed a quantitative and descriptive research design without treatments involved (Babbie, 2021). The current study was based upon a cross-sectional and nationally representative survey dataset. Participants were only surveyed once.

Study Population and Sampling

The sampling frame of the national dataset initially consisted of 2,005 public elementary and secondary schools in the 50 states and the District of Columbia in the US. The survey data was based on complex sample designs, and stratified sampling was implemented to improve the representativeness of the sample. Weightings were designed to adjust for unequal probabilities of selection and differential response rates so that response data could be generalized to all regular public elementary and secondary schools in the US. Of the 2,005 schools, 1,949 were considered eligible cases, and 1,519 responses were recorded, which was estimated to represent 81,700 schools in the US.

Data Collection

This current study leveraged the public-use data from fast response survey system (FRSS)–educational technology in the US public schools. The aim of this school-level survey was to provide national data on ICT access and use in public elementary and secondary schools in the US. The survey was designed and conducted by National Center for Education Statistics based on a technology study sponsored by Office of Educational Technology in the US Department of Education. This dataset was selected for the following reasons. First, findings based on a nationally representative sample can be generalized to the population, and, hence, the validity of a theoretical model can be directly tested. This goal is hardly attainable for a convincing sample owing to possible selection biases as commonly seen in the existing literature. Second, nationally representative datasets often contain large sample sizes, which increase statistical power to detect a true effect and reduce the likelihood that a type II error occurs. Third, at the time of analysis, the dataset is still the most recent nationally representative data that contains variables related to first-order barriers, second-order barriers, and ICT integration in the United States released by the Fast Response Survey System. Fourth, this dataset is collected at the school level, and the implications drawn from the current study can also be directly applied to school policy without committing the atomistic fallacy (Hox et al., 2018). Fifth, for any valid theoretical model or hypothesis, true relations between variables are less likely to be altered in spite of the age of the data. For instance, the association between teachers' competence beliefs and ICT integration is likely to be statistically significant and consistently positive regardless of when the data is collected (Cheng et al., 2020a, 2022; Vongkulluksn et al., 2018). Therefore, the true relations between barriers and ICT integration should not be substantially affected by the age of the data, either.

Validity and Reliability of Survey Instruments

The construct validity of survey instruments was assessed using exploratory factor analysis (Brown, 2015). Nomological validity was assessed based on Pearson product-moment correlations to examine if correlational patterns aligned with the hypothesized associations in theory (Lee, 2019). The reliability (i.e., internal consistency) of survey instruments was inspected based on Cronbach's alpha coefficients (Field, 2018).

Instruments

For the current study, five variables were selected to represent first-order barriers, one to represent second-order barriers, and one to represent ICT integration at schools.

First-order barriers

Vision and funding (α=.71) were assessed by three 4-point Likert scale items (1=strongly disagree to 4=strongly agree). This construct represents the extent to which technology was a priority of the district administration and the extent to which funding for educational technology was adequate and appropriately used for instructional programs in the school. Professional development (α=.89) was assessed by two 4-point Likert scale items (1=strongly disagree to 4=strongly agree). This construct represents the extent to which teachers in the schools were sufficiently trained to use technology and integrated it into classroom instruction. Technology accessibility (α=.77) was assessed by four binary items (1=yes to 2=no). This construct indicates whether the school used its district network or Internet access to provide teachers with online student assessments, standardized assessment results and data to individualize instruction, data to inform instructional planning, and high-quality digital content for teaching and learning. Technical support (α=.68) was assessed by three 5-point Likert scale items (1=less than one hour to 5=a month or more). This construct represents how long it usually took at the school to obtain help for technical problems associated with computers, software, and networks. Time was assessed by one 4-point Likert scale item (1=strongly disagree to 4=strongly agree). This construct represents the extent to which using ICT in the school was adversely affected by competing priorities in the classrooms.

Second-order barriers

Second-order barriers were assessed by one 4-point Likert scale item (1=strongly disagree to 4=strongly agree) to represent the extent to which teachers at a school were interested in using ICT in classroom instruction.

ICT integration

ICT integration was assessed by one 4-point Likert scale item (1=strongly disagree to 4=strongly agree) to measure the extent to which teachers at a school constructed lessons in which students used a range of ICT.

School SES levels

School SES was determined by the percentage of students eligible for free or reduced-price lunch and comprised four categories: less than 35% (extremely high SES; n=599); 35-49% (high SES; n=260); 50%-74% (low SES; n=378); 75% or more (extremely low SES; n=282).

Data Analysis

Since the factor structure of first-order barriers is not always consistent in the existing literature (e.g., Bowman et al., 2020; Vongkulluksn et al., 2018) there is a need to validate the dimensionality of first-order barriers. As such, exploratory factor analysis (EFA) was employed using Mplus 8.3. For EFA, the GEOMIN oblique rotation was selected, given that first-order barriers are correlated, as evidenced in previous studies (Scott, 2020). The weighted least square mean and variance adjusted (WLSMV) estimator was used considering that the indicators were a combination of dichotomous and interval scales (Flora & Curran, 2004). Based on Hu and Bentler's (1999) criteria, a four-factor solution yielded a satisfactory fit: $\chi^2_{(32)}$=48.44, p=.03, comparative fit index (CFI)=.99, the Tucker–Lewis index (TLI)=.98, root mean square error of approximation (RMSEA)=.02, and the standardized root mean square residual (SRMR)=.02. Since the factor loadings for the survey item representing time for ICT integration were small (<.30, Brown, 2015), this item was treated as a separate variable in the subsequent analysis.

Multiple-group path modeling was employed to examine **RQ1** and **RQ2**. For **RQ1**, a dataset in which data points were aggregated over schools with different SES levels was used to examine the overall relations between barriers and ICT integration. In the first step, ICT integration was regressed on first-order and second-order barriers (additive effect hypothesis). In the second step, the interaction between first-order and second-order barriers were tested (multiplicative effect hypothesis). For **RQ2**, the aggregated dataset was then separated by school SES levels. In the first step, a regression model where the direct effects of barriers on ICT integration were specified (additive effect hypothesis) was built for each school SES level. In the second step, the interaction between first-order and second-order barriers were tested (multiplicative effect hypothesis) across school SES levels. Given that variables of interest were scaled differently and to facilitate the interpretation of interaction terms, constructs were standardized prior to all analyses. To ensure that the current findings were generalizable to all the public schools in the US, full sample weighting (AWT) was applied to all the statistical analyses in the current study. Replicate weights (AWT1-AWT50) using the jackknife replication method (JK1) were included in all the regression models to obtain accurate estimates of standard errors as recommended by the user's manual (Gray et al., 2010). Missing data were imputed using a hot-deck approach (Gray et al., 2010).

RESULTS

Descriptive Profiles of Barriers and ICT Integration

Figure 2 presents the descriptive profiles of barriers and ICT integration for the aggregated and subgroup data. Overall, professional development and technical support were the major first-order barriers for public schools in the United States. ICT integration was moderately low. Schools with extremely high SES faced the fewest first-order barriers, demonstrated the highest interest in using ICT for instruction, and integrated technology the most. Technology accessibility was the major first-order barrier for these schools. Schools with high SES faced such first-order barriers as vision and funding, professional development, and technical support. Interest in using ICT for instruction and ICT integration was moderately low. Schools with low SES faced such first-order barriers as technical support and time. Interest in using ICT for instruction was moderately high. However, ICT integration was lower than in schools with high SES. Schools with extremely low SES faced the greatest first-order barriers, demonstrated the lowest interest in ICT for instruction, and

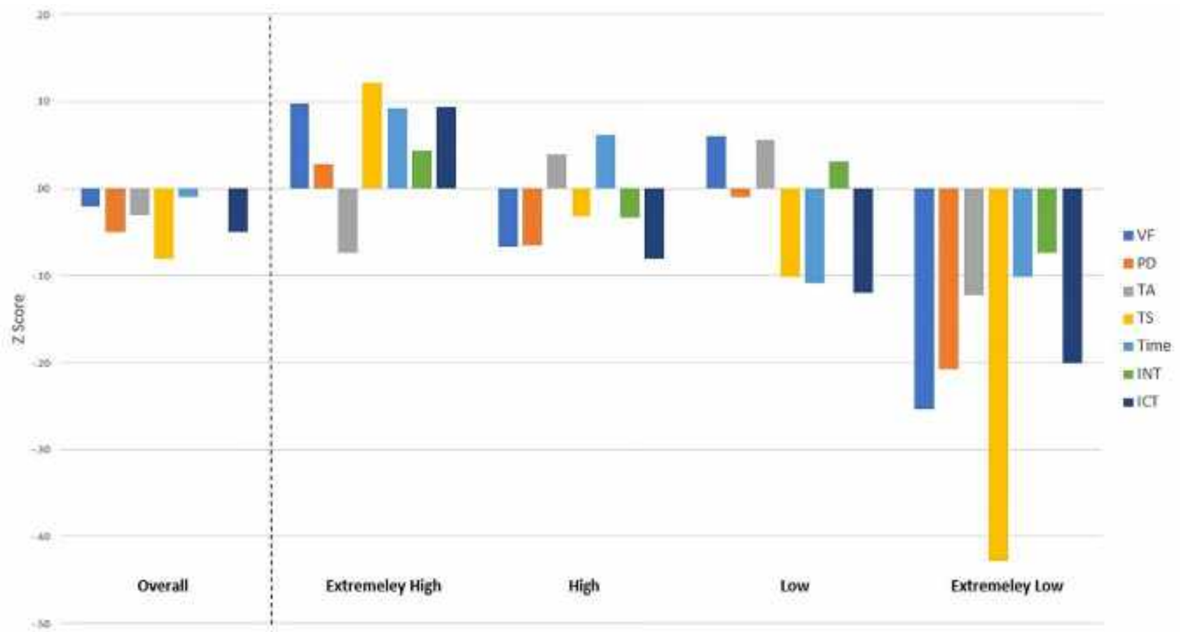

Figure 2. Barriers and ICT integration by school SES levels (Source: Authors)

integrated technology the fewest. Vision and funding and technical support were the major first-order barriers for these schools. All the variables were not severally non-normal given the values of skewness and kurtosis.

Relations between Barriers and ICT Integration

The results of multiple-group path modeling based on the additive effect hypothesis showed that overall, vision and funding (β=.14), professional development (β=.40), time (β=.05), and interest (β=.27) significantly and positively predicted ICT integration. When school SES was taken into consideration, different relational patterns were observed. For schools with extremely high and high SES, vision and funding (β=.13 & .23), professional development (β=.37 & .33), and interest (β=.30 & .18) were the only significant and positive predictors. For schools with low SES, professional development (β=.45), technology accessibility (β=.10), technical support (β=.11), time (β=.08), and interest (β=.29) significantly, and positively predicted ICT integration. For schools with extremely low SES, professional development (β=.43) and interest (β=.24) was the only significant and positive predictors.

Following additive effect models, the multiplicative effect hypothesis was tested. The results showed that there was no interaction between first-order barriers and second-order barriers when school data were aggregated. No interaction was found in schools with extremely high and high SES, either. On the contrary, a significant interaction between first-order and second-order barriers was found for schools with low and extremely low SES. Specifically, for schools with low SES, the effect of interest on ICT integration depended on the level of vision and funding (β=.11). For schools with extremely low SES, the effect of interest on ICT integration depended on the level of technical support (β=.12). To probe the interaction, the Johnson-Neyman technique was implemented to identify regions of significance (Hayes, 2022). **Figure 3** and **Figure 4** present the extent to which the relations between interest and ICT integration varied by levels of vision and funding and technical support.

As **Figure 3** shows, when vision and funding were low (<-0.2 SD; grey area), the relation between interest and ICT integration was not significant. On the contrary, when vision and funding were high (>-0.2 SD; white area), the relation between interest and ICT integration was significant and positive. This magnitude increased as the levels of vision and funding became higher.

As **Figure 4** shows, when technical support was low (<-1.3 SD; grey area), the relation between interest and ICT integration was not significant. On the contrary, when technical support was high (>-1.3 SD; white area), the relation between interest and ICT integration was significant and positive. This magnitude increased as the levels of technical support became higher.

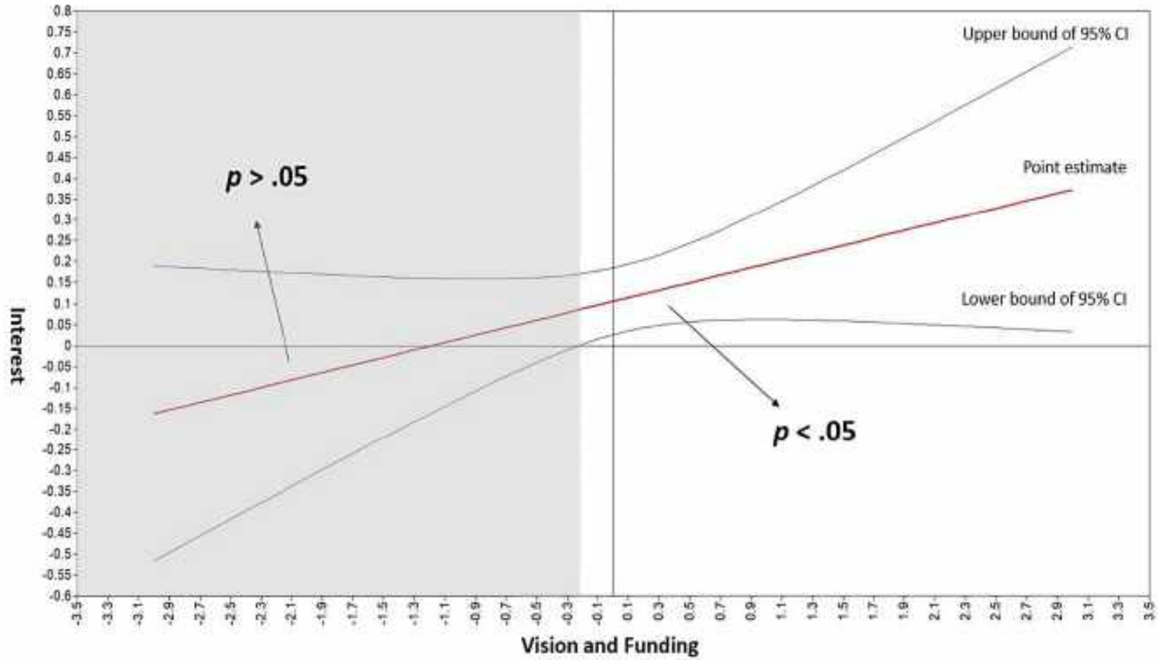

Figure 3. Probing interaction for schools with low SES (Source: Authors)

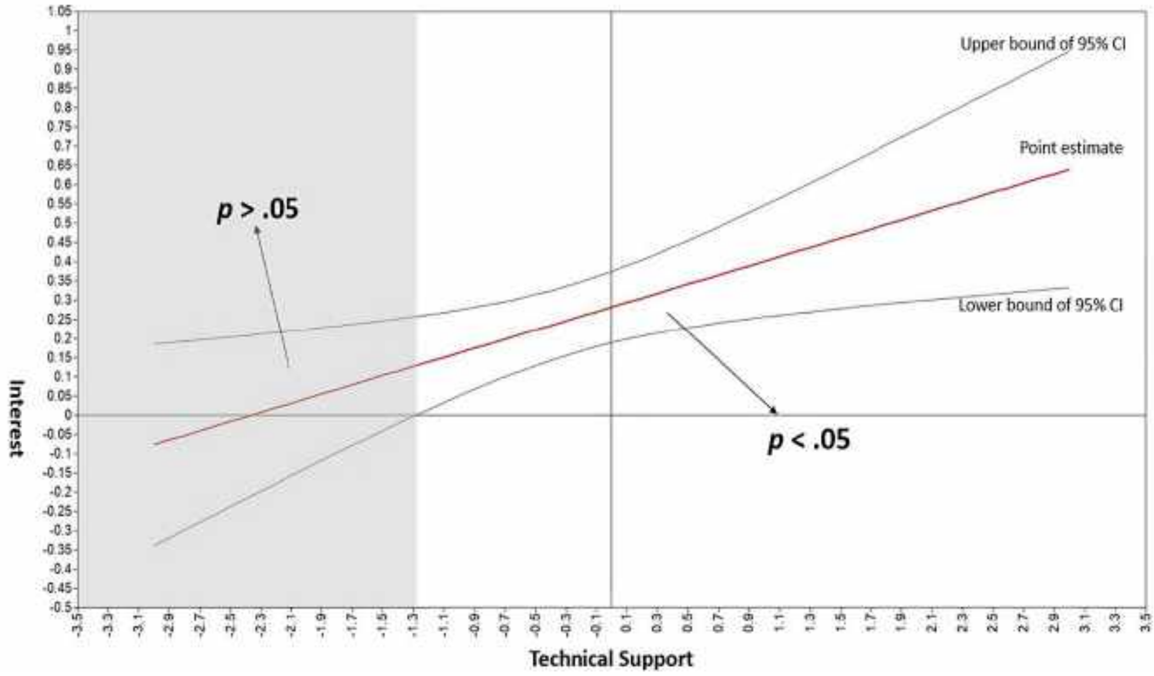

Figure 4. Probing interaction for schools with extremely low SES (Source: Authors)

Given that schools with extremely high and high SES shared similar additive effect models, the magnitude of regression coefficients between these models could be directly compared. The results of the Wald test showed that there was no significant difference in the magnitude of regression coefficients between schools with extremely high and high SES. That is, identical relational patterns were found between schools with these two types of schools. Lastly, the goodness-of-fit indexes showed an excellent fit for the data with a contextualized barrier model (**Table 1**), where additive relations between barriers and ICT integration were specified for schools with extremely high and high SES and multiplicative relations between barriers and ICT integration were specified for schools with low and extremely low SES ($\chi^2_{(12)}$=14.42, p=.28; CFI=1.00; TLI=.99; RMSEA=.02; SRMR=.03).

Table 1. Predicting ICT integration

Predictors	Contextualized Barrier Model			
	β	SE	95% CI	
SES: Extremely high				
Vision and funding	.16*	.03	.09	.22
Professional development	.37*	.05	.27	.46
Technology accessibility	.05	.04	-.02	.12
Technical support	.00	.03	-.06	.07
Time	.03	.03	-.03	.08
Interest	.27*	.03	.22	.33
R^2		.44		
SES: High				
Vision and funding	.16*	.03	.09	.22
Professional development	.37*	.05	.27	.46
Technology accessibility	.05	.04	-.02	.12
Technical support	.00	.03	-.06	.07
Time	.03	.03	-.03	.08
Interest	.27*	.03	.22	.33
R^2		.38		
SES: Low				
Vision and funding	.09	.06	-.02	.20
Professional development	.44*	.06	.33	.56
Technology accessibility	.09†	.05	.00	.18
Technical support	.12*	.05	.02	.21
Time	.07*	.03	.01	.13
Interest	.31*	.04	.24	.38
Vision and funding × interest	.11*	.04	.03	.19
R^2		.51		
SES: Extremely low				
Vision and funding	.14*	.07	.00	.28
Professional development	.41*	.07	.28	.54
Technology accessibility	.06	.07	-.08	.20
Technical support	-.02	.06	-.12	.09
Time	.05	.08	-.09	.20
Interest	.28*	.05	.19	.38
Technical support x interest	.12*	.05	.03	.21
R^2		.41		

Note. *p<.05 & †=.051

DISCUSSION

The findings of the current study demonstrated the complexities of the relations between barriers and ICT integration and highlighted the need to tailor the barrier model to school SES levels. As shown in descriptive profiles, different patterns were observed between aggregated and subgroup data. For instance, the aggregated data showed that overall, schools faced moderate first-order barriers, demonstrated moderate interest in using technology, and showed moderately low ICT integration. However, this result is hardly applicable to schools with extremely high and extremely low SES. Schools with high and low SES also faced patterns of barriers that were specific to their school contexts. Therefore, this piece of evidence suggests that aggregating data across school SES levels is likely to commit the atomistic fallacy (Hox et al., 2018) and leads to implications that may not be applicable to different school settings.

In terms of predictive relations, based on the aggregated data, vision and funding, professional development, technology accessibility, time, and interest were significant predictors of ICT integration, which aligns with the prior findings reported in Kuwait, Turkey, and the US (Alghasab et al., 2020; Bowman et al., 2020; Dexter & Richardson, 2020; Karakis, 2022; Tosuntas et al., 2019). However, the standardized regression coefficients of technology accessibility and time were relatively small, which aligns with the findings in Turkey and the US as reported by Karaca et al. (2013) and Scott (2020) that compared to other first-order barriers, technology accessibility and time had weaker correlations with classroom technology integration. Of these predictors, professional development played the most important role followed by interest and then vision and funding, which aligns with what has been found in China as reported by Lai et al. (2022) that professional development had a stronger association with technology integration than other first-order barriers and teacher beliefs. In addition, the current study did not find an interaction between first-order barriers and second-order barriers based on the aggregated data. This pattern was fairly similar to that among schools with extremely high and high SES. Although technology accessibility and time were not significant predictors among these schools, the standardized regression coefficients of these predictors were small as well. In addition, professional development had the strongest relation to ICT integration, followed by interest and then vision and funding (**Table 1**).

These findings suggest that although both first-order and second-order barriers play a role in relation to ICT integration, the enactment of interest into ICT integration would not be hindered by first-order barriers in schools with extremely high and high SES. Consider a scenario where two teachers are from schools with extremely high SES. Teacher A is situated in a school where vision and funding and professional development are one standard deviation below the national mean levels. However, his/her interest is two standard deviations above the national mean. Teacher B is situated in a school where vision and funding and professional development are at the national mean levels. However, his/her interest is two standard deviations below the national mean.

The predicted ICT integration for teacher A would be .01 standard deviations above the national mean, while the predicted ICT integration for teacher B would be .54 standard deviations below the national mean[1]. Therefore, in schools with extremely high and high SES, interest can compensate for the constraints on ICT integration imposed by first-order barriers. When facing environmental constraints in such schools, teachers with high interest can still find a way to integrate technology into classrooms. This scenario is reported by previous studies in the US in which teachers in the same school who held adaptive beliefs about ICT integration were able to re-organize their classrooms to implement technology-enhanced lessons even with limited access to technology resources (Ertmer et al., 1999, 2001). This additive effect hypothesis has also been the part of the barrier model that has been widely examined in the prior studies situated in China, Turkey, and the U.S. (Bowman et al., 2020; Lai et al., 2022; Scott, 2020; Uslu & Usluel, 2019). It should be noted that the current findings do not dismiss first-order barriers as unimportant in these schools. Rather, they indicate that ICT integration in schools with extremely high and high SES would not be completely deterred when first-order barriers are present.

A completely different picture was found among schools with low and extremely low SES. In such schools, first-order barriers and second-order barriers did not contribute uniquely and independently to explaining ICT integration. Rather, the translation of interest into practices was conditional on the levels of first-order barriers. In schools with low SES, teachers' interest had stronger effects when vision and funding increased. On the contrary, when vision and funding decreased, teachers' interest would have little effect on ICT integration. That is, in such destitute conditions, interest did not matter at all. In schools with extremely low SES, interest had stronger effects when timely technical support increased. On the contrary, when such support was reduced to a low level, the enactment of teachers' interests would be severely undermined. The effect of interest on ICT integration became inconsequential regardless of how much interest teachers might have in using technology when technical support was absent. These findings echo what has been reported in Mexico and the US by Ertmer et al. (2012) and Velázquez (2006). The contribution of the current study is to reveal the context (i.e., school SES), where this phenomenon is likely to take place across the whole country.

In sum, the results of the current study suggest that the relations between first-order barriers, second-order barriers, and ICT integration vary by school SES levels. The additive relations are likely to be found among schools with extremely high and high SES, while the multiplicative relations are likely to happen among schools with low and extremely low SES. Based on these new findings, a contextualized barrier model is proposed to capture the role of school SES in the barrier model (**Figure 5**).

First-order barriers will constitute a greater challenge for schools with low and extremely low SES since they directly inhibit the enactment of teachers' espoused beliefs. Interest only matters when environmental constraints are removed.

[1] $\hat{Y}_{teacher\ A} = -1 \times .16 - 1 \times .37 + 2 \times .27$; $\hat{Y}_{teacher\ B} = 0 \times .16 + 0 \times .37 - 2 \times .27$

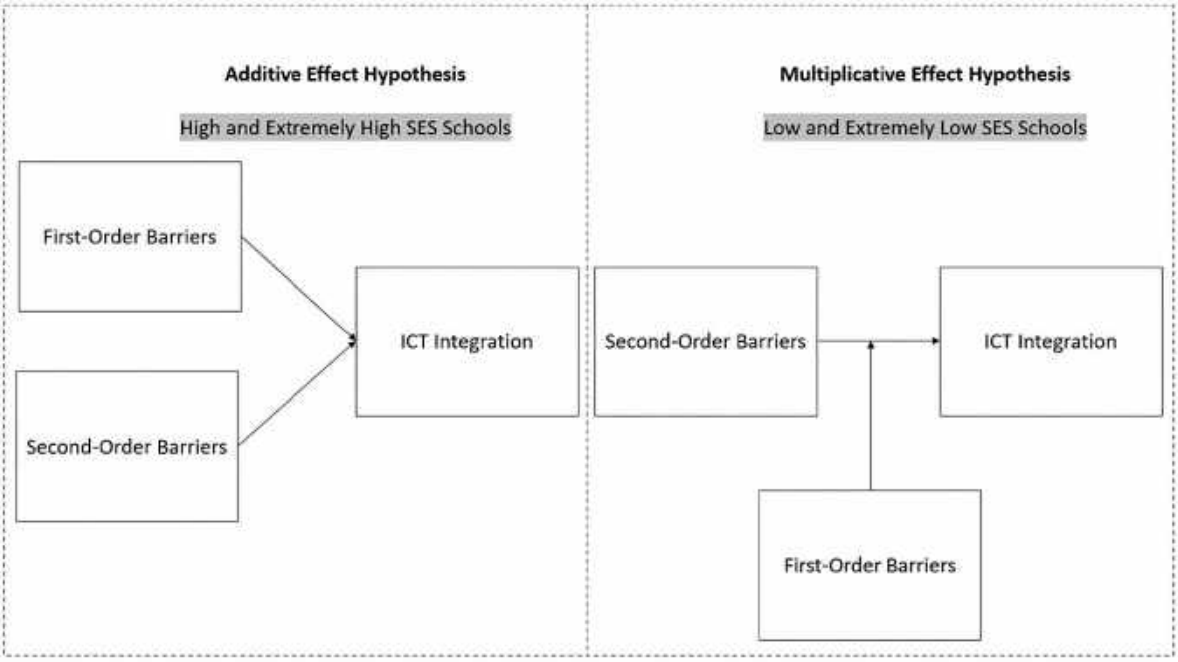

Figure 5. The contextualized barrier model (Source: Authors)

Implications for Research and Practice

Findings of the current study offered some important implications for research and practice in school-wide ICT integration. In terms of research, school characteristics such as SES need to be considered in the analysis of barriers and ICT integration. Nuances specific to a school context are likely to be overlooked when data are aggregated over schools with different SES levels. An analysis conducted at the subgroup level seems able to reveal more contextualized findings.

In terms of practice, the current study offers general and specific directions for stakeholders to promote school-wide ICT integration. Regardless of school SES levels, providing quality technology professional development is the key. School administrators should also consider involving teachers in formulating shared visions for ICT integration, establishing clear expectations, and determining the most appropriate ways of using funding for educational technology (Dexter & Richardson, 2020). This is particularly critical for schools with low SES given the interaction between vision and funding and interest. Involving teachers in reflecting on the relevance of ICT to their instruction is useful for developing interest in ICT integration (Kale & Akcaoglu, 2018). However, this is not sufficient for teachers in schools with low and extremely low SES. Providing timely technical support to teachers in schools with extremely low SES is also needed to facilitate the enactment of their interest in ICT integration. On the other hand, providing access to such assistance is expected to have a positive effect on ICT integration in schools with low SES.

Limitations and Future Directions

There are a number of limitations associated with this study. First, the current dataset was collected in the US. The findings reported here can only be generalized to US public schools. Research with more recent nationally representative datasets from other countries is needed to verify the findings. Second, the current study used cross-sectional data to examine the hypothesized relations in the barrier model. Therefore, any causal claims should be made with caution. Researchers should consider using longitudinal or experimental designs to establish strong evidence for the causal relations represented in the barrier model. Last, owing to the restriction of the dataset, there is only one item that can represent second-order barriers (i.e., interest) in the current study. Therefore, how first-order barriers may interact with other second-order barriers such as teachers' beliefs about teaching and learning and capabilities of using technology is unknown. This would be an important avenue for future studies using a national dataset that includes measures to assess different types of second-order barriers.

CONCLUSIONS

The current study leveraged a nationally representative dataset to examine the relations between first-order barriers, second-order barriers, and ICT integration across schools with different SES levels. The findings added important insights into the knowledge base on barriers and ICT integration and pointed out a need to contextualize the barrier model. As the current study shows, aggregating school data without taking school SES into consideration may overlook nuances that are specific to a school context. The conventional barrier model with a focus on the direct effects of first-order and second-order barriers does provide a valid account of ICT integration in schools with extremely high and high SES. However, this kind of barrier model is short of capturing the complexities of ICT integration in schools with low and extremely low SES. First-order barriers present a greater challenge for these schools in that first-order barriers can undermine the enactment of teachers' espoused beliefs about the interest in using technology. In cases where these environmental supports are extremely low, interest matters little for ICT integration. Researchers are encouraged to consider the role of school SES when examining school-wide ICT integration using the barrier model in their future studies. This line of inquiry will lead to findings and implications that can be tailored to specific school contexts.

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