Does ICT Use Matter between Socioeconomic Status and Academic Performance?

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Abstract—**The present study explored the mediating and moderating effect of information and communications technology (ICT) use on the relationship between students' socio-economic status (SES) and their academic performance. Using the PISA (Program for International Student Assessment) 2015 data of seven East Asian countries involving 42,634 students, we find that ICT use neither mediates nor moderates the relationship between SES and academic performance. The findings are contradictory to what we used to perceive of ICT in education, making us reconsider the application of ICT use in secondary education and how ICT could be better integrated into curriculum implementation to enhance students' academic performance.**

Keywords—*ICT use in education, PISA 2015, socio-economic status, academic performance, mediating effect, moderating effect*

I. INTRODUCTION

Information and communications technology (ICT) use in education has long been considered an effective way to enhance students' academic performance in all levels of education. A plethora of empirical studies in diverse education settings and review studies have arrived at reciprocally similar conclusions that ICT use for educational purpose has been associated with students' better performance in school in various subjects [1-3]. However, the Organization for Economic Co-operation and Development (OECD) published a thought-provoking report in 2015, claiming that ICT use has little to do with students' academic achievement, i.e. in mathematics, reading or science [4].

Moreover, socio-economic status (SES) has been taken as a contributor to students' gaps in academic performance worldwide, and researchers have noticed that SES had a medium to high impact on students' academic performance [5]. OECD also revealed that the relationship between SES and students' performance in school was strongly correlated in every subject assessed by PISA (Program for International Student Assessment) data [4].

For long, ICT use has been taken as an economical and effective way to reduce education inequity brought about by SES. However, using ICT could also increase the probability of widening the achievement gaps caused by variations in SES [6]. The contradictory research findings concerning ICT use in education triggered our second thought on the effectiveness of ICT use on students' academic performance at school. Therefore, to further evaluate ICT use in secondary education, the present study is targeted to examine the mediating as well as moderating effect of ICT use on the relationship between students' SES and their academic performance in East Asia.

II. REVIEW ON ICT USE IN SECONDARY EDUCATION

A. The Effect of ICT Use on Academic Performance

Large-scale survey (e.g. PISA) studies have found opposing results regarding the effect of ICT use in education [7-9]. Studies whose findings are in favor of ICT use in education reveal a positive effect on students' academic performance [1-2]. That is, ICT use for academic purposes both at home and in school settings tend to improve students' achievements. By contrast, due to different methodologies in defining and categorizing the observed variables regarding ICT use, some researchers uncovered no significant [10] or negative effect [11-12] of ICT use on students' academic performance. They even found that students' ICT use for academic purposes negatively correlated with their performance while ICT use for entertainment positively correlated with their performance [12]. Those contradictory results truly raise unstoppable debate over the use of ICT in school settings.

B. Increasing SES-Achievement Gap Worldwide

Ever since the publication of the Coleman report in 1966 [19], family SES has been deemed a factor that leads to an academic gap between individual students in school settings [14-15], and according to some synthesis studies, this gap has been increasingly widened in all aspects of SES overtime globally [16-18]. Moreover, SES may even enlarge the gap in primary and secondary education regardless of students' intelligence [19]. This gigantic effect of SES on students' academic performance has drawn much research attention in education and related fields and generated considerable interest and controversy. Even though studies have revealed that student family's SES and their academic achievement is positively associated [20-21], students from lower SES families somehow struggle more and more in learning due to the increasingly widened SES-achievement gap.

The SES-based gap oftentimes transits into a gap in education resources a household can afford in educating children. To some extent, ICT could bridge the resources gap and with easier and easier access to computers and the Internet, ICT use in education may narrow the SES-achievement gap and turn the status quo for the better.

To examine whether ICT use could play its role in the relationship between SES and students' academic

performance, the present study employed the PISA 2015 dataset and tested the following research hypotheses:

- H1: ICT use mediates between students' SES and their overall academic performance composed of their reading, mathematics and science test scores.

- H2: ICT use moderates the effect of students' SES on their overall academic performance composed of their reading, mathematics and science test scores.

III. METHODOLOGY

The present study utilized PISA 2015 data of seven countries in East Asia to investigate the mediating and moderating effect of ICT usage on students' SES and their academic achievement. Amos 24.0 and SPSS 25.0 are employed for model establishment and model evaluation as well as for testing the hypotheses.

A. Sample

Seven East Asian countries or economies were selected, namely Hong Kong, Japan, (South) Korea, Macao, Beijing-Shanghai-Jiangsu-Guangdong (mainland China), Singapore and Chinese Taipei. These areas are relatively developed economies and share a Confucian Heritage Culture (CHC). More importantly, the responses of the ICT questionnaire are applicable, unlike those in less developed areas in Asia where students' responses are not applicable. After removing missing values involved in the present study, the total sample size is 42,634, of which 20,885 (48.99%) are female.

B. Variables and Measures

1) Academic Performance: OECD assesses students' academic performance via three aspects, i.e. mathematics, reading and science, and PISA 2015 provides 10 plausible values for each student concerning these three subjects. Following OECD's suggestions [20], this present study re-coded these plausible values into proficiency levels defined by OECD and utilized the median as individual's academic performance for each subject.

2) SES: PISA estimates students' overall SES via the index of economic, social and cultural status (ESCS) in its dataset, which is methodically calculated from a series of variables, such as parents' education levels, occupational status and their household possessions, etc [20]. Therefore, this study directly utilized ESCS in the PISA 2015 dataset as a measure of students' SES.

3) ICT use: PISA 2015 ICT familiarity questionnaire for the first time added four more sub-scales on students' ICT use, namely ICT interest (IC013, six items), perceived ICT competence (IC014, five items), perceived autonomy related to ICT use (IC015, five items) and the degree to which ICT is a part of their social interaction (IC016, five items) [20]. These four sub-scales are composed of statements regarding daily ICT use on a 4-point Likert ("*1*" = strongly disagree and "*4*" = strongly agree) and students are required to respond in terms of the extent to which they agree or disagree with each statement.

C. Data Analysis

The present study first made an attempt to directly integrate the four constructs in the parallel mediation model via structural equation modelling (SEM) but found that there was an excessive proportion of correlated residuals between the four dimensions. Therefore, a second order construct was established out of these four dimensions as a predictor of students' ICT use.

Accordingly, confirmatory factor analysis (CFA) was performed via Amos 24.0 to validate the construct of ICT use after missing values had been removed. Moreover, composite reliability (CR) and average variance extracted (AVE) were calculated to further assess the convergent validity. With that, the SEM mediation model was established using the bootstrapping method to determine the magnitude of the mediating effect of ICT use on the relationship between SES and academic performance. To test the second hypothesis, an interaction term was calculated to examine the moderating effect of ICT use on the relationship between SES and students' academic performance.

IV. RESULTS

A. Validation of ICT Use

The model fit indices of the CFA indicate that the data fit the model well (*GFI* = .966, *AGFI* = .951, *NFI* = .974, *TLI* = .967, *CFI* = .974, *RMSEA* = .053, *SRMR* = .036). Through CFA, items with low factor loadings were removed from their separate sub-constructs and the composite reliability and average variance extracted were calculated (see Table I). All the estimated values indicate that the constructs are acceptable except for the AVE of ICT interest, which is marginally below the threshold of .500.

TABLE I.   FACTOR LOADINGS, CR AND AVES ESTIMATES FOR ALL CONSTRUCTS

Construct	Item	Factor loading	CR	AVE
ICT interest	IC013Q05NA	.685	.798	.499
	IC013Q11NA	.745		
	IC013Q12NA	.596		
	IC013Q13NA	.785		
perceived ICT competence	IC014Q08NA	.904	.885	.793
	IC014Q09NA	.877		
perceived ICT autonomy	IC015Q02NA	.777	.848	.650
	IC015Q03NA	.822		
	IC015Q07NA	.819		
ICT for social interaction	IC016Q01NA	.834	.893	.676
	IC016Q02NA	.828		
	IC016Q05NA	.846		
	IC016Q07NA	.780		
Academic performance	PL_MATH	.919	.950	.864
	PL_READ	.904		
	PL_SCIE	.964		

Table II shows some key descriptive values for all latent variables. The correlations between the four sub-scales of ICT use are moderate, and the estimates of skewness and kurtosis indicate a normal distribution of the sample data. Meanwhile, the reliability of each sub-scale is also quite acceptable.

B. Mediating Effect of ICT Use

To minimize the effect of correlated residuals of the four ICT-related constructs, a second order was established as ICT use to investigate the mediating effect on the relationship between SES and academic performance. The model fit of the mediation model (see Fig. 1) indicates this model is psychometrically acceptable (*GFI* = .959, *AGFI* =

.944, *NFI* = .966, *TLI* = .960, *CFI* = .967, *RMSEA* = .056, *SRMR* = .051) and all the regression weights are significant.

	1	2	3	4	5
1. ICT interest	1.000				
2. perceived ICT competence	.451**	1.000			
3. perceived ICT autonomy	.401**	.605**	1.000		
4. ICT for social interaction	.415**	.525**	.520**	1.000	
5. Academic performance	.129**	.056**	.171**	-.039**	1.000
Mean	11.65	5.29	8.26	10.12	9.73
SD	2.45	1.53	2.17	2.83	3.56
Skewness	-.569	-.319	-.420	-.353	-.169
Kurtosis	1.104	-.177	.268	.025	-.589
Cronbach's Alpha	.789	.884	.847	.893	.947

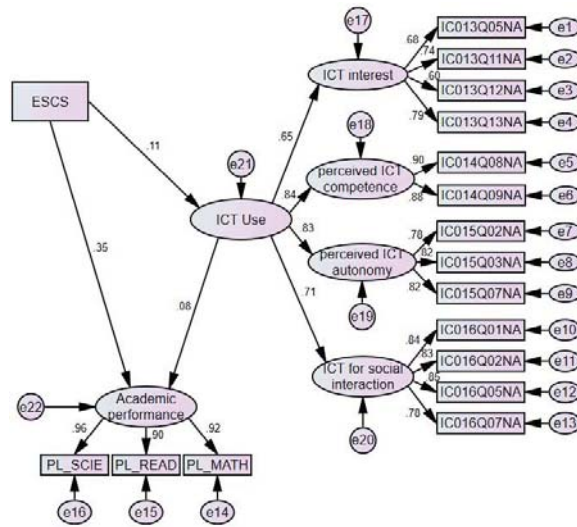**. Correlation is significant at the 0.01 level (2-tailed).

Fig. 1. Mediation model of ICT use

Even though the goodness of fit is quite acceptable, the modelling barely indicates an indirect effect of ICT use on the relationship between SES and academic performance. From Fig. 1 it could be clearly seen that the path from ICT use to academic performance bears a regression weight of .08, albeit significant, which means ICT use could hardly predict students' academic performance. Furthermore, the standardized indirect effect of SES on academic performance is merely .009, and based on the results of bootstrapping, the indirect effect of ICT use could not be tested for significance due to the low effect value. Comparatively, the standardized direct effect of SES on academic performance is .35 with a corresponding significance value of .001, meaning SES could predict students' academic performance to a moderate extent. Therefore, H1 is rejected in the present study, that is, ICT use (i.e. ICT interest, perceived ICT competence, perceived autonomy in related to ICT use and ICT for social interaction) does not mediate between students' SES and their academic performance.

C. Moderating effect of ICT Use

Since there is neither full nor partial indirect effect of ICT use on the relationship between SES and academic performance, the present study continued to make an attempt to explore whether ICT use could moderate between SES and students' academic performance. Consequently, item scores were standardized into z-scores and thus z-scores of the four first-order dimensions were generated and multiplied by the standardized ESCS value respectively. Thus, the interaction term of SES × ICT use was determined and incorporated in the modelling (see Fig. 2). Nonetheless, the result of SEM on the moderation model revealed that the moderating effect of ICT was not adequate. The regression weight of the interaction term to academic performance is only -.02, which could be considered no moderating effect. Hence, H2 is also be rejected, that is, there is no moderating effect between ICT use (i.e. ICT interest, perceived ICT competence, perceived autonomy in related to ICT use and ICT for social interaction) and SES on students' academic performance.
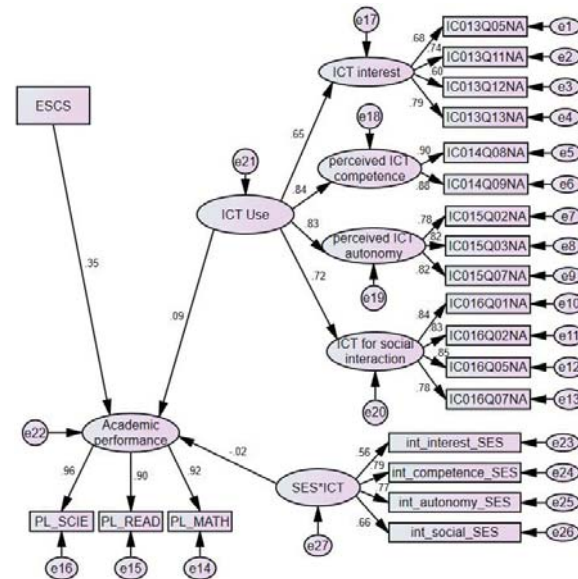

Fig. 2. Moderation model of ICT use

DISCUSSION

Similar to the findings in OECD's report [4], the present study found no mediation of ICT use between students SES and their academic performance. One possible reason that may explain this no-mediating effect can be the relatively strong direct effect of SES on students' academic performance. SES has long been considered a good predictor of students' achievement in school settings; therefore, ICT use may not adequately play a mediating role in between. Another reason may be associated with the top-performing countries or economies selected for the study. Comparatively, these seven regions are all quite developed in economy, and electronic devices such as computers, tablets and other smart devices are ubiquitously accessible, so students may not differ sufficiently to illustrate some different patterns in ICT use, meaning low-SES students in these seven regions may have much in common with their high-SES peers when it comes to using ICT for learning and in life. Therefore, ICT in these developed areas may not amount to a significant mediator between those students' SES and their academic performance. Instead, other SES-related resources for educational purposes that may not be as accessible as ICT for almost all students may mediate in between.

Since no indirect effect of ICT use was detected, the present study explored further to test the moderation effect. But still, no significant moderating effect was found. The possible reasons could be quite similar, but some additional facts may also explain this no-moderating effect. Since PISA involved only 15-year-olds and they are to some extent in a life period of pre-adult, they may not be as mature in self-control when using ICT for academic purposes. ICT devices may be engaging as much as distracting for adolescents who still need to be trained in self-regulated learning. Therefore, using ICT in learning may not influence the strength of the effect that SES has on academic performance. Probably, regardless of their SES, secondary school students could be distracted while using ICT devices for learning. The findings in the present study are somewhat contradictory to what is known as common sense about ICT in education and thus lead us to reconsidering the application of ICT use in secondary education and also how ICT can be better integrated to our curriculum implementation to enhance students' academic performance.

CONCLUSION AND LIMITATIONS

Based on the PISA 2015 dataset of seven top-performing countries or economies in East Asia, we found that, even though SEM indicates a good model fit, yet ICT use in terms of ICT interest, perceived ICT competence, perceived autonomy in related to ICT use and ICT for social interaction does not mediate between students' SES and their academic performance. Moreover, there is no moderating effect between ICT use and SES on students' academic performance, either. This nonsignificant effect (neither mediating nor moderating effect) may be due to a) a relatively strong direct effect of SES on academic performance, b) homogeneous patterns of students' similar ICT use in developed regions regardless of their family SES, and c) easy distraction and lack of training and inexperience in self-regulated learning with ICT.

The nonsignificant result may also have a bearing on the research limitations in the present study. For one, the present study only utilized seven economically developed countries or economies in East Asia to examine the role of ICT use on the relationship between students' SES and academic performance, which form quite a homogeneous sample of students that share similar values and merits in Confucius culture. Representativeness and diversity to some extent are understated in determining the sample. For another, the construct of ICT use was merely derived from the four newly-added subscales of PISA 2015 dataset; we did not test it against operationalized definitions of ICT use, and therefore its construct may not be fully valid. It is advisable that studies in the future use a more well-developed construct to investigate the effect of ICT use on the relationship between students' SES and their academic performance.

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