The Relation between ICT Usage and 15-Year-Old Students' Science Self-efficacy

Yuanyuan Zheng and I-Hua Chen

***Abstract*—Self-efficacy is a perceived competence in performing a particular task, and science self-efficacy can determine the engagement to students' science learning. Based on the theory of learning life approach, this study proposed a conceptual framework to clarify the role of information and communication technology (ICT) on forming science self-efficacy. Furthermore, we compared the difference between boys and girls in the pathways in the proposed framework. 15-year-old secondary school students in China released by Organization for Economic Co-operation and Development (PISA) in 2015 were as the participants. After weighting, there were 790,611 secondary school students involved in this study (415,066 boys and 375,545 girls) to test the model fit with structural equation models and multi-group analysis by using Lisrel 8.80. Results showed that: 1. The correlations between science self-efficacy and ICT self-regulated ability, out-school ICT science learning behavior, and inquiry-based teaching were significantly positive related. Science self-efficacy was significantly negative correlated with out-school ICT leisure activities. 2. The proposed framework not only had ideal model fit on the whole participants but also on boys and girls. 3. The coefficient of boys of positive impact of out-school ICT leisure activities on ICT self-regulated ability, out-school ICT science learning behavior on science self-efficacy, and the positive impact effect of out-school ICT leisure activities on the indirect positive impact of science self-efficacy were all lower than girls. According to our findings, it is suggested that teachers should not only use inquiry-based teaching strategies in science classrooms, but also encourage students to independently apply ICT's scientific learning behaviors out-school, which is particularly important for girls.**

***Index Terms*—Science self-efficacy, ICT, PISA 2015, Structural equation modeling.**

I. Introduction

Self-efficacy refers to the individual competence evaluation on whether one can complete a certain task or not [1]. Educational psychology regards the variable as a learning motivation type which students put into a particular subject [2], and each subject has its own corresponding self-efficacy, such as science, math and English self-efficacy. The emphasis on education across the world in recent years drove many researchers to enter the study on science self-efficacy and gave rise to many findings: science self-efficacy not only determines the students' commitment to learning [3]-[5], but also has a long-term influence on their degrees related to science as well as their career choices [6], [7]. The result of the longitudinal study on the university first-year students in some particular subjects by Larson et al in 2014 showed that the science self-efficacy can obviously forecast the results of obtaining a degree after controlling the initial effect from their high school science academic performance and the scientific aptitude [8]; The result of one longitudinal study on senior high school students who are going to enter into college and choose their majors related to science shows that the extents of science self-efficacy change are closely related to their tendency of occupations related to science, and the students with stable self-efficacy or on the increase are more willing to engage the science related jobs in the future [9].

The future society needs more science and technology talents [6], [10], therefore, the educators should attach more importance to science self-efficacy, so as to improve the probability of choosing science related majors and willing to put efforts into them. The key problem is how to cultivate students' self-efficacy. Although Bandura, the founder of self-efficacy, has provided four influencing factors on self-efficacy: direct success-failure experience, observing others' experience, importance of people's words and psychological states [1]. However, how to implement these four factors into the practical education has been rare discussed. Besides, the latest study found that the factors affected self-efficacy will be changed within different environments [11]. This suggests that it is still necessary to investigate the pathway of the influencing factors on science self-efficacy for Chinese students. Furthermore, when students make the decision on choosing the major in the university, the obvious gender difference is existed: boys prefer engineering majors and girls are tend to the humanities majors, which leads to force girls to engage the low-tech jobs and further deepen the girls' weak position in the labor market [12]. Since science self-efficacy has a great influence on major selecting for students in the future [13], clarifying the difference of the pathway of science self-efficacy between boys and girls will be the ground work to eliminate the imbalance of scientific major between genders.

There are some studies on formation pathway of students' self-efficacy, but many of them are author's experience or the extended views based on Bandura Theory [14], [15]. These arguments still need substantial evidence to be verified the feasibility and the effectiveness. Although some master's theses have carried out science self-efficacy cultivating works from biology, chemistry and physics areas [16]-[18], the empirical research published in academic journals were rare. It is obvious that there's a need to investigate how to promote science self-efficacy for Chinese students.

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In conclusion, based on the importance of science self-efficacy and the educational purpose of safeguarding the gender equality, we first proposed a conceptual framework which illustrates the pathways from the influencing factors on science self-efficacy. Then, we compared the path differences between girls and boys. Considering the existing research that students are gradually forming the tendency of major selecting from their middle school [10], this study carried out analysis on Chinese students' data at age of 15 in PISA 2015. Students from four provinces in Mainland China participated in this international survey.

II. Hypotheses of the Pathways from Influencing Factors on Science Self-efficacy

From the theory of living learning approach of ICT proposed by Erstad in 2012, this study proposed a conceptual framework. In this model, ICT leisure activities has influence on science self-efficacy. The learning lives approach is aiming at eliminating the barriers between the students' out-school ICT leisure and academic learning at school, so as to give a new explanation for adolescents' learning in the new media environment [19]. The core concept is "life and learning" which means that learning exists in many daily activities and aren't just limited in classroom. In respect of the life events, the individuals are moving among various location, and the integrated learning identity is established with the help of ICT during the process. For example, based on the theory, students can take photos for the contents during the class when they learned a new subject concept; and they can discuss with friends by showing the photo in the phone when they take tutoring classes; and then when they go home, they can send the photos to net friends as a leisure theme or get more information about the subject by using internet and conduct a deeper learning. The multiple location transferred between schools, tutoring class and home reflects the whole unified identity of overall learning.

Although the learning lives approach has proposed a new idea of learning, it is a more abstract one. Erstad mentioned that pathway from ICT leisure on school learning is still needed to be clarified [19]. Aiming on this restrict, in this study, we referred to other studies and logical experience to provide the framework as shown in Fig. 1 to illustrate the pathway from ICT leisure to science self-efficacy.

1) Path H_1: The influence of out-school ICT science learning behavior s on science self-efficacy

This is the Path H_1 that students who use ICT to conduct science learning can improve their own science self-efficacy. There are many abstract scientific concepts which often give the frustrating experience to learners. Thus, more and more studies aim to help students to learn science acknowledge by using the ICT. Webb once induced the positive influence of ICT on learning in 2005 [20], which includes promoting understanding of acknowledge, linking the concept of science and real world, cultivating the self-adaptive learning ability, material collecting and communication ability. According to Webb's conclusion, students can better understand the science acknowledge and put them into practice when they conduct science learning by using ICT which also conform to the principle of mastery experience.

Furthermore, Bandura believes that the most important factor affecting self-efficacy is direct success-failure experience which is related to the task proficiency [1]. Since students conduct science learning by ICT, and they may benefit from the increasing of proficiency and gather more successful learning experience, so as to generate positive effect on science self-efficacy. As for the of empirical studies, Meluso et al. conducted game-based learning for fifth-grade primary school students and found that students can learn knowledge from carrying out the scientific number games as well as applying the knowledge to practice and us them in the virtual world over and over again so that they improve their own science self-efficacy [21]; Chen *et al.* believe that ecosystems multi-user virtual environment allow students to design the science experiments and observe by themselves ,which helps students to learn science better [22]. Therefore, the research group build the ecosystems virtual environment for multi-user and inspect the results of this system for high school students. This research found that the higher participation degree of ecosystems multi-user virtual environment students put in. The higher science self-efficacy students will get.

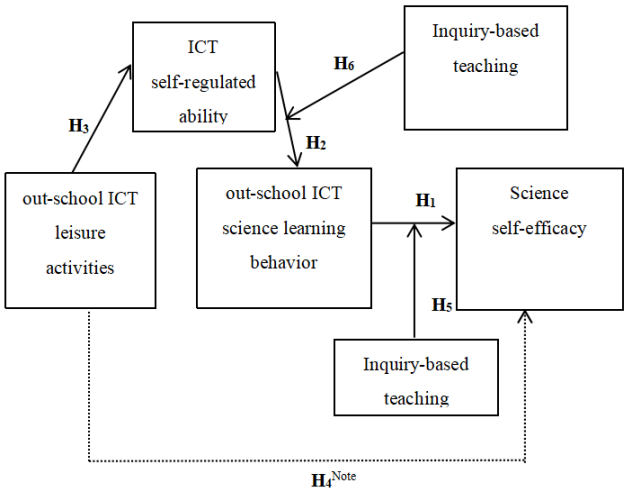

Fig. 1. Pathway of the model from ICT leisure to science self-efficacy. Note: Path H4 for the influence from out-school ICT leisure activities through the mediators, ICT self-regulated ability and outside the ICT science learning behavior on science self-efficacy.

2) Path H_2: The influence of ICT self-regulated ability on out-school ICT science learning behavior

ICT self-regulated ability refers to the media mastery degree which the individual believes he can master by ICT planning and executing specific behaviors when he needs resolve problem by using ICT [23]. According to the idea of Friedman and Nissenbaum in 1997, the ICT self-regulated ability will affect the individual's intention to use ICT to conduct specific behaviors [24]. The individual will believe this media with highly operating complexity when the ICT self-regulated ability is low, thus the using is decreasing. Moreover, the result of Technology Acceptance Model research showed that the individual with higher perceived ease of use, will have strong intention to use technology [25]. Since the easier operating degree represents the higher media independence ability, and based on the result of Technology Acceptance Model, can be speculated that there's an obvious relationship between ICT self-regulated ability and ICT

behaviors. In short, the students' independence ability should be the key factor to use ICT in science learning behavior; and for the students lack of independence ability, it's hard to use ICT into their science learning activities.

From this we proposed the H_2 path represent that there's a significant correlation between students' independence ability and ICT science learning behaviors; the higher ICT self-regulated ability students have, the more likely they are to use ICT science leaning behaviors.

3) Path H_3 and H_4: The influence of out-school ICT leisure and ICT self-regulated ability on science self-efficacy

The path H_3 is that, in the respect of logical empirical corollary, the ICT self-regulated ability will be increased nature when individual often carry out ICT related behaviors, then the correlation of two variables are quite evident and the variables are research supported by the former empirical [26]. Besides, this research supposed that the out-school ICT leisure activities can be correlate with science self-efficacy by the serial mediation of ICT self-regulated ability and out-school ICT science learning behavior, which combining is set as H_4. H_4 serial mediation path is the supposed tentative formation path after supposing the variables mentioned above such as the out-school ICT leisure activities, ICT self-regulated ability and out-school ICT science learning behavior , which is used for making up the shortage of Erstad's theory of learning lives approach proposed [19].

4) Path H_5 and H_6: The moderating effect of inquiry-based teaching

Inquiry-based teaching is an effective teaching method in science sector. Inquiry-based teaching has various definitions, and according to the National Science Education Standard of the US, teachers should guide the students to conduct the following activities: scientific problem guidance, gathering evidence by scientific experiment, answering and explaining the problem on the basis of evidence, assessing their own explanations and displaying their own findings. The process of the inquiry science teaching conform to the nature of science knowledge discovery as well as the abstract principles of science. Thus this teaching method is beneficial improving the science self-efficacy and are supported by many empirical researches [27]-[29].

Differing from the over emphases on the direct influence of inquiry science teaching on science self-efficacy in the past, this research verify the regulation effect of variables on the H_1 and H_2, that is the out-school ICT science learning behavior can improve students' science self-efficacy, if this path is workable, then add the inquiry science in the class can help students to improve the effect on increasing self-efficacy [27]-[29], since the after-school and campus activities both helps cultivate the students' self-efficacy, might thus to produce interactive positive effect on the science self-efficacy. Moreover, the regulation assumption of inquiry science teaching - H_6 in the path H_2, that is the ICT self-regulated ability has the positive effect on the out-school science learning behavior, we speculated that the premise of this path to be workable is the students should have the higher self-regulated learning ability, that means ICT self-regulated learning and science self-regulated ability are required to carry out out-school ICT science learning behavior s, in this case the students are more confident to and prefer to apply ICT while they learn. Considering the former studies has indicated that inquiry science learning promotes the self-regulated learning [30],[31], thus we can properly assume that the class teaching method such as inquiry science can catalyze the positive effects of ICT self-regulated learning on out-school ICT science learning behavior, so that is improves the positive effect greatly.

III. Research Method

This research adopted the secondary date analysis which makes the secondary analysis by using the original data revealed by PISA 2015. The corresponding measurement, Subject background, the corresponding measurement of data, and data analysis are described as follows:

1) Subject Background

This research analyzed Chinese students' data of PISA 2015 which is a cross-border high school student quality assessment programme on the students at the age of 15, high school students from Beijing, Shanghai, Guangdong and Jiangsu have participated the programme. Excluded the unanswered or incomplete samples, there are 5,465 samples are included in the analysis,2773 are boys and 2692 are girls. 34,4% of them come from cities, 54.4% of them are from towns and 11.2% are from the rural area. According to PISA technical manual the W_FSTUWT will require during statistics estimation of the PISA data [32]. The total number of samples is 790,611 after data weighting, of which there are 415,066 boys and 375,545 girls.

2) The Corresponding Measurement of Used Data

The PISA 2015 data used in this research consists of variable measurement index and the corresponding original items. The variable measurement index is the external measurement variables represent the model of this research, and these indexes are estimated by the corresponding original theme. The variable measurement indexes in this research came through the processing of the item response theory by PISA project group except the scores of out-school ICT science learning behavior s which are calculated in this research and are also named as derived variables [32], and these variables and original themes are available for download in the website of PISA.

3) Science Self-efficacy

In the measurement themes of PISA 2015, the science self-efficacy refers to the students' competence feeling to some natural science tasks for example explaining why the earthquake frequently occurs in some areas and proposing the potential scientific problems for the health issues reported in the newspaper. And it was named as "SCIEEFF" in data of PISA 2015, and it represents a higher science self-efficacy degree when the value of the "SCIEEFF" is higher. The Cronbachs'α of Chinese students is 0.877 which is calculated by this study.

4) Out-School ICT Leisure Activities

According to the measurement contents of PISA 2015, the out-school ICT leisure activities which have nothing to do with school subject learning such as social communication, playing games and downloading files. The out-school ICT leisure activities were named as "ENTUSE". The higher value it is, the more frequent out-school ICT leisure activities

will represent. The Cronbachs'α of Chinese students of out-school ICT leisure activities original items is 0.878.

1) ICT Self-regulated Ability

According to PISA 2015, ICT self-regulated ability refers to the self-mastery degree when the students need to use ICT.

TABLE I: MEASUREMENT INDEX FOR THE MODEL VARIABLES

Variables name in the model		Data of PISA 2015	
		Variable Measurement Index	**Original Items**
Dependent Variables	Science self-efficacy	SCIEEFF	ST129Q01-ST129Q08
Independent Variables	out- school ICT leisure activities	ENTUSE	IC008Q01-IC008Q13
	ICT self-regulated ability	AUTICT	ICQ15 Q02 ICQ15 Q03 ICQ15 Q05 ICQ15 Q07 ICQ15 Q09
	out-school ICT science learning behavior	Adopted the average value of original theme listed on the right column	ST146 Q01TA ST146 Q03TA ST146 Q06TA ST146 Q07TA ST146 Q08TA ST146 Q09TA
	Inquiry-based teaching	IBTEACH	ST098Q01 - ST098Q010
Control Variables	ICT equipment resource in school	ICTSCH	IC01Q01 - IC01Q11
	ICT equipment resource at home	ICTHOME	IC02Q01 - IC02Q07
	Family's social economic status	ESCS	Weight approach by using HOMEPOS, HISEI and PARED

Note: this table is collected from the PISA 2015 manual by this study [32]

It includes relevant measurement themes such as " I can install a special software when I need to use it; I can resolve the problems during the operation of digital instrument". ICT self-regulated ability was named as " AUTICT" in the file. A higher value represents a higher self-regulated ability to use ICT. The Cronbachs'α of Chinese students' ICT self-regulated ability is 0.873.

2) Out-School ICT Science Learning Activities

PISA 2015 defined out-school ICT science learning behaviors as behaviors which students used ICT in science learning, such as TV, Internet, virtual science laboratory and blog, and the corresponding themes like "watching TV program about science and viewing the science related websites". Since PISA haven't calculated out-school ICT science learning behavior's variables, we take the average value of the six original items as the measurement indexes of the variables, and the higher value it is, the more frequent ICT science learning behavior is represented. The Cronbachs'α of Chinese students out-school ICT science learning behaviors is 0.865.

3) Inquiry-Based Teaching

Inquiry-based teaching refers to the frequency of inquiry-based teaching used by teachers during the process of class learning. The relevant tasks in PISA 2015 include: "whether the students have the chance to explain their own ideas; students should make conclusions through the experiments by themselves".

class. The Cronbachs'α of Chinese students is 0.875 after the calculation by researcher.

4) Data Analysis

PISA selects the school first and then students who are selected to take the tests, which will lead to the dependence on the samples. Considering the non-dependent sample's deviation, researchers first calculated the Intraclass Correlation Coefficient (ICC) so as to confirm the severity of the problem. The result shows that ICC is 0.002 and it is generally acknowledged that the value higher than 0.059 needs to apply the standard of hierarchical linear modeling. Therefore, we can use the traditional linear modeling analysis.

We first verify the fitting degree between self-efficacy forming path model and empirical data by using structural equation model. All the measurement index can use the derived variables except measurement index of the out-school ICT science learning behaviors which is adopted the average value of the original items. According to the PISA technique manual, the derived variables are defined as latent variables, thus we have not set the corresponding external measurement errors. Besides, in order to obtain an accurate path coefficient, we add the school and family's ICT equipment resource and family's social economy status in the model as control variables. Moreover, after verification of fitting degree among the whole samples, we further examine formation path coefficient of science self-efficacy and investigate the difference between boys and girls. All the fitting degree verification, path coefficient verification and multiple group analysis adopted Lisrel 8.0 to conduct analysis except the serial mediation effect of path H_4 which can not use Lisrel's Sobel Test. The "process macro" of Hayes is adopted for the serial mediation testing of H_4 which uses SPSS 22.0 [33].

IV. RESULTS

1) Descriptive Statistical Results

Table II is the descriptive statistical result, the average value of variables, standard deviation and the relevant coefficient are offered. Firstly, we start from the average value of variables and standard deviation, except the variables of out-school ICT science learning behaviors calculated by us are positive value, the rest derived variables are negative. According to the PISA 2015 manual, the variables are lower than OECD students when the value is negative, therefore (OECD, 2016), it Shows that the Chinese students' variables such as science self-efficacy, ICT leisure activities out-school, ICT self-regulated ability and inquiry science teaching are lower than students of OECD. Moreover, the result of Zero-order Correlations shows that except for

the correlations between out-school ICT leisure activities and science self-efficacy, the correlations of science self-efficacy and other variables are showing significant positive.

TABLE II: DESCRIPTIVE STATISTICS

Variables	Descriptive Statistics		Correlation Coefficients Among Variables			
	Average Value	Standard Deviation	Out-School ICT leisure Activities	ICT self-regulated ability	Out-School Science Learning Behavior	Inquiry-based teaching
Dependent Variables						
Science Self-Efficacy	-0.109	1.064	-0.047*	0.171*	0.336*	0.212*
Independent Variables						
out-school ICT leisure activities	-0.555	1.025	1.000			
ICT self-regulated ability	-0.038	0.860	0.317*	1.000		
out-school ICT science learning behavior	1.765	0.583	0.110*	0.149*	1.000	
Inquiry-based teaching	-0.387	1.014	0.020*	0.047*	0.295*	1.000

Note: *p < 0.05

TABLE III: FITTING INDICES OF THE CONCEPTUAL FRAMEWORK

	Chi-square Test			Fitting Index					
	X^2	df	Chi-Square/df	NFI	IFI	GFI	CFI	RMSEA	SRMR
The Whole Samples									
Result	36114.60	8	4.514.325	0.963	0.963	0.991	0.964	0.076	0.023
Decision			Unsupported	Supported	Supported	Supported	Supported	Supported	Supported
Boys									
Result	20979.33	8	2.622.416	0.964	0.962	0.991	0.965	0.079	0.024
Decision			Unsupported	Supported	Supported	Supported	Supported	Supported	Supported
girls									
Result	22625.80	8	2.828.225	0.966	0.965	0.992	0.962	0.086	0.029
Decision			Unsupported	Supported	Supported	Supported	Supported	Unsupported	Supported

Note1: the ICT equipment resources at home and school has been taken into consideration in this model.
Note2: the model fitting indexes include NFI, IFI and GFI, the surrogate indexes include CFI, RMSEA and SRMR.

2) The model fit of the pathway from influencing factors on science self-efficacy

Table III is fitting situation of formation path model of science self-efficacy affected by the control variables ICT equipment resource at home, at school and the family social economic status, and the results are divided into whole testing, boys testing and girls testing. According to Table III, after the weighting, the sample quantity exceeded ten million, which resulted in the enlargement of Chi-square value, as a result, three models do not conform to the standard. For the model fitting indexes and surrogate indexes, the models of whole sample testing, boy testing and girl testing have the relatively good fitting results, which indicates that the formation path of science self-efficacy has supported by empirical evidence.

3) The coefficients in the pathway for science self-efficacy and the differences between gender

After confirming the good fitting results, we further analyze formation path coefficient in details and compare the difference between boys and girls, please see the relevant result in Fig. 2. Fig. 2 is the result in the various path coefficient after taking the control variables. We can see that the science self-efficacy formation path we proposed is supported in the whole sample part: the result of path H_1 shows that the more frequent ICT learning behavior is, the more effectiveness of students' science self-efficacy is (β=0.285, t=261.731, p<0.05); for path H_2, the higher ICT self-regulated ability is, the student are more likely to engage in ICT science learning behavior (β=0.119, t=108.417, p<0.05); for path H_3, out-school ICT leisure activities help students to improve their ICT self-regulated ability (β=0.275, t=254.860, p<0.05); for path $H_4$①, the influence of out-school ICT leisure activities on science self-efficacy through the intermediary of ICT self-regulated ability and ICT science learning behavior orderly, and the value of indirect effect is 0.010 (SE = 0.002, 95% with a confidence interval from 0.007 to 0.013) which meet the statistically significant level.

For path H_5 and H_6, inquiry-based teaching has moderating effect in class, the variable β (inquiry science teaching x out-school ICT science learning behavior) = 0.004, t=3.981, p < 0.05, the variable β (inquiry science teaching x ICT self-regulated ability) = 0.017, t=16.386, p<0.05, the two variables both meet the statistically significant level and require further comparison. By calculation of slope verification, we divided the inquiry-based teaching into high degree and low degree inquiry-based teaching, the positive effect of ICT science learning behavior on science self-efficacy of high degree inquiry-based teaching group are higher than the low degree inquiry-based teaching group (the coefficient of high degree inquiry-based teaching group is 0.549, t=225.188, p<0.05; the coefficient of lower degree inquiry-based teaching group is 0.083, t = 9.017, p<0.05).

The Chi-square test is not suitable for the difference between boys and girls in the formation path coefficient of science self-efficacy due to the great number of samples, then we adopted ΔCFI proposed by Cheung and Rensvold in 2002

as the judgment standard [34]. Regarding the original model and limited model of ΔCFI which exceeds 0.01 as the standard, we found that the main difference between boys and girls in formation path of science self-efficacy as follows: path H_1—the influence of ICT science learning behavior on science self-efficacy (ΔCFI is 0.032) and path H_3—the impact of out-school ICT leisure activities on the ICT self-regulated ability (ΔCFI is 0.022). The coefficient of girls both in path H_1 and H_2 are higher than that of boys.

Moreover, for the path H_4—the serial meditation influence of out-school ICT leisure activities on science the indirect effect of girls in path H_4 is 0.012 (SE=0.003, 95% confidence interval from 0.007 to 0.018, and meet the statistically significant level); and the indirect effect of boys in path H_4 is 0.005 (SE=0.002, 95% confidence interval from 0.002 to 0.009, which meet the statistically significant level); according to the figures, we can see the coefficient of girls in this path is higher than that of boys.

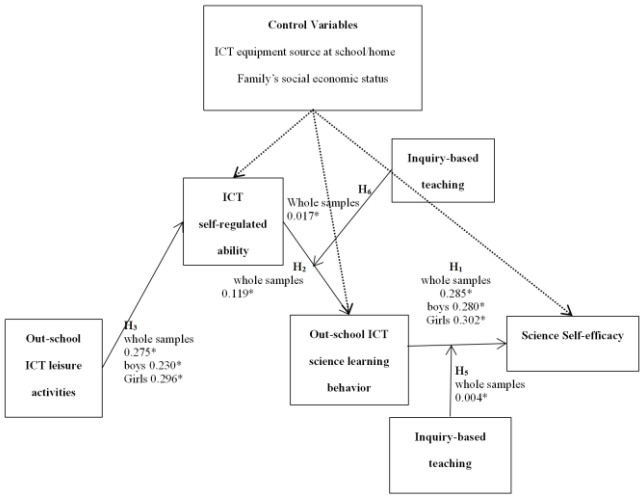

Fig. 2. Model path coefficient results.

Note:1) $*p < 0.05$

Note:2) Solid line indicate the paths we discussed in this research; dotted line indicate control effects on all variable, the coefficient of dotted line has not noted since it is not our focus.

Note:3) In order to present the result concisely of moderators, the representation is different with the actual data analysis. In the actual data analysis, the interaction variable of inquiry science teaching and the ICT science learning behavior is added in the model, and verified the coefficient of influence of inquiry science teaching, ICT science learning behavior and the interaction variable on the dependent variables. The moderating effect is supported when the coefficient of the interaction meet the statistically significant.

Note:4) if the results of the whole sample, boys and girls were all provided, it represents that there is a significant difference between gender in this path; if only the result of the whole sample is showed, it represents that boys and girls has not meet the statistically significant in the path.

V. Discussion

On the basis of the theoretical perspective of living and learning approach proposed by Ersrad in 2012 [19], this research established the formation path model of science self-efficacy for students at the age of 15. This model is fitting with the empirical data of PISA 2015, and the result of this model shows that relevant variables related to ICT play a key role in the direct science learning behaviors and in the indirect ICT leisure activities. At the same time, we also make investigation to the inquiry-based teaching strategy adopted in class by teachers and found that it has positive effect for students on enhancing the application of ICT. Differing from the former research which discuss one of the variables alone, the result of the formation path of science self-efficacy is the overall analysis by combing students' ICT application and inquiry-based teaching [21], [22], [27]-[29].

With a more comprehensive consideration, this research offers the reference to cultivate students' self-efficacy. Firstly, the educators should advocate the out-school ICT science learning behavior while continuing to conduct inquiry-based teaching, since the more ICT science learning behavior the student has made, the more self-efficacy the students will get, and the positive effect of these behaviors are close to the medium effect proposed by Cohen in 1988 [35]. The combination between teacher's teaching and student's out-school learning is the most important, since the combination of two variables will have positive effect on science self-efficacy so that the effectiveness will double owning to the two variables. For the inquiry-based teaching helps students to increase the self-regulated ability [30], [31], we can speculate that the appearance of inquiry-based teaching will catalyze more independent ICT science learning behaviors. Moreover, more out-school independent ICT science learning behaviors can deepen the influence of inquiry-based teaching on the science self-efficacy. Secondly, the paths of model show that ICT self-regulated ability is the key factor for engaging ICT science learning which indicates that the ICT quality should be taken into consideration in the promoting the science education. There's a close correlation between ICT and STEM, since the two key factors of STEM are self-regulated minded and enjoyable learning [36], which can be better realized by ICT, and this argument happens to hold the same view with this research. Finally, according to the result of this research, educators should not prohibit students from taking part in ICT leisure activities. To the contrary, they can courage students to participate these activities properly, since the activities can improve their ICT self-regulated ability as well as have indirect positive effect on science self-efficacy. According to the living and learning approach proposed by Erstad in 2012 [19], all the leisure activities and subject learning outside the classroom are the parts of life, and the two parts can't be completely separated. Leisure and learning can be better linked by ICT, and this research has corroborated that.

VI. Teachers Role's Transition As the Evolution of ICT and Intervention Strategy for Boys and Girls

The formation path model of science self-efficacy revealed in this research mainly focuses on the positive influence of ICT application on science self-efficacy. However, the teaching strategy in class is just the "catalytic" for regulation main path. From the perspective of metaphor, "catalytic" can accelerate the chemical reaction and it doesn't involve the body of chemical reaction. Therefore, the teaching strategy is only works as an assistant, and the key point is still the students' initiative for the after-school science learning by using ICT. Classroom teaching is regarded as an assistant and the key element is student's after school learning behaviors

which conforms to the reform trend brought by evolution of information and communication technology in recent years which proposed by Zhou *et al*. in 2014 [37]. By comparing the education informationization policies at home and abroad, the research found all the new measures about education are about the concept of "priority given to learning" instead of "priority given to teaching". Furthermore, Pardo argues that as the development of the ICT, the learning methods are not limited in instructor teaching any more. Students can carry on individual learning from the internet [38]. This also indicated that the students are endowed with more responsibilities on learning, for example, students can learn independently by ICT's assistance. Relatively, as promoters, teachers' responsibility is to stimulate the learning motivation of science in the class. On this matter, some scholars also agree with this idea. Wang and Tang hold that the key point to integrate the modern information technology and teaching is that the teacher should stimulate the internal motivation of interest of learning [39]; Li et al. regards teachers in the information technology environment as conductors of bands, and they can cultivate students' interests by their understanding of textbooks [40].

Moreover, although the result of this research shows that the inquiry-based teaching has positive regulation effect both on boys and girls, and there's no big difference between genders. However, the influence of out-school ICT application exists obvious difference between gender. In fact, the difference between boys and girls in science learning is always a hot topic. In earlier time, scholars analyzed from various dimensions such as visual ability in space, strategy and motivation used in learning, genders stereo type and social experience outside school, and brought out the reason of the difference between genders by discussing the mean difference of the variables between boys and girls [10], [41], [42]. However, in recent years, some researches have switched to compare the formation path between boys and girls due to the inconsistent conclusions of the former researches, and it is found that the difference in formation path of science learning motivation do exist [5], [7]. Corresponding to the trend of overseas research, this research also adopted this analysis tendency, and proposes the following intervention strategies for students' science learning.

1) Instruct girls to conduct science learning behavior systematically

This research found that the positive influence of ICT science learning behavior on girls is higher than boys, which indicated that instructing the girls to conduct science learning behavior systematically is a practicable intervention strategy to improve girls' science self-efficacy. For example, first teachers can provide various Internet virtual laboratory sources, then they assign tasks, and allow girls to complete their tasks by using the given sources and finish the assignments, which is also the most common overseas teaching type [22].

2) Notice the assistance of ICT leisure activities for girls

Nowadays, students' learning can not get rid of ICT products. Instead of prohibiting them, we should the function of them. We found in this research that such activities can improve students' science self-efficacy by increasing their ability of ICT self-regulated application. According to the investigation made by Chen and Du in 2010, the proportion of ICT leisure activities engagement for girls are lower than boys, which indicated that there's a space for girls in ICT leisure activities [43]. We suggest the teachers should communicate with parents. Let parents understand the assistance of ICT leisure activities, and leave their children space for ICT leisure activities.

VII. Research Limitations

Although the conceptual framework of science self-efficacy established in the study is fitting well with the empirical data, and all the path coefficients reach the statistically significant level and the results supported the assumption we proposed. However, the positive effect out-school ICT leisure activities on self-efficacy, the influence coefficient of ICT self-regulated learning ability on ICT science learning behavior and the positive interaction effect of inquiry-based teaching are relative low which indicated that there are other key variables which are not taken into consideration. Therefore, we should be careful as making explanation on this model. We can use the data of PISA 2015 in the future research to investigate whether there are other variables which can be added in this model and then amplify this model for future usage, whose purpose is to enhance the overall explanation of science self-efficacy, and to understand the connotation of living and learning approach theory proposed by Erstad [19].

Annotation

The results of path H4 can not be seen in the figure, and relevant results are from "process macro" of Hayes.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

I.-H.C. conducted the research, analyzed the data; Y.Y.Z. wrote, reviewed and edited the paper, I.-H.C. implemented project management and funding acquisition. All authors had approved the final version.

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