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ICT self-efficacy, self-efficacy for teamwork, and collegial collaborations: an exploratory study of elementary school teachers' ICT uses in inquiry-based learning in Japan

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Inquiry-based learning, an educational approach that is gaining international recognition, emphasizes active engagement and deeper understanding. Despite its benefits, integrating information and communication technology (ICT) into inquiry-based learning remains a challenge, often hindered by factors such as teachers' confidence in ICT use and organizational support. This study aimed to explore the relationship between the utilization of ICT in inquiry-based learning and various factors including ICT self-efficacy, lack of ICT resources at school, teachers' collaboration in using ICT, and self-efficacy for teamwork. A web questionnaire was administered to 324 full-time elementary school teachers in Japan, assessing their perceptions of ICT use in inquiry-based learning, ICT self-efficacy, collaboration, teamwork self-efficacy, and school ICT resources. Statistical analyses, including exploratory factor analysis and multiple regression, were employed to examine the relationships between variables. The findings revealed significant positive associations between ICT use in inquiry-based learning and ICT self-efficacy for instructional purposes, teachers' collaboration in using ICT, and self-efficacy for teamwork. However, the relationship with the lack of ICT resources at school was not statistically significant. These results underscore the importance of fostering teachers' self-efficacy and promoting collaborative practices to enhance ICT use in inquiry-based learning. Furthermore, the study highlights the need for ongoing support and resources to facilitate the effective utilization of ICT in educational settings.

KEYWORDS

inquiry-based learning, ICT, ICT self-efficacy, lack of ICT resources, teacher collaboration, teamwork

1 Introduction

Inquiry-based learning in classroom settings is gaining international attention. In Japan, emphasis on inquiry-based learning in classes has been growing, such as the Period for Integrated Studies, since the 2008 revision of curriculum guidelines (Ministry of Education, Culture, Sports, Science and Technology, 2018). Inquiry-based learning has been reported to

enhance motivation in children by deepening their knowledge and enabling active learning (Pedaste et al., 2015; Van Uum et al., 2016).

Previous studies have highlighted the importance of utilizing information and communication technology (ICT) to support inquiry-based learning (Fraillon et al., 2014, 2020), with the expectation of improving learning outcomes for children. In response to the COVID-19 pandemic, Japan has rapidly promoted policies aimed at providing one device per student and establishing a high-speed, high-capacity communication network. For this reason, schools and teachers are required to effectively use ICT and promote educational practices such as inquiry-based learning (Ministry of Education, 2020, 2022; Ministry of Education, Culture, Sports, Science and Technology Central Council for Education, 2021). However, teachers are sometimes reluctant to incorporate ICT into their lessons due to a lack of confidence in its use (Ye et al., 2022). Motivating teachers to incorporate ICT into their educational activities is crucial for promoting ICT use, with belief in the teacher's own ability to succeed (ICT self-efficacy) being a key factor (Hatlevik and Hatlevik, 2018).

Furthermore, educational activities involving ICT are organizational endeavors, and the importance of organizational support within schools to promote teachers' organizational activities has been emphasized (Fraillon et al., 2014, 2020). Previous studies in Japan and overseas have noted that organizational support for such educational activities includes leadership by school principals, organizational climate, and teamwork (Oude Groote Beverborg et al., 2015; Hatlevik and Hatlevik, 2018; Misawa et al., 2020; Tsuyuguchi et al., 2020; Ye et al., 2022). Such organizational activities are not solely accomplished by individual teachers but are often achieved collaboratively within teacher teams (Park et al., 2005; Oude Groote Beverborg et al., 2015). The use of ICT in inquiry-based learning is no exception. It requires team-based organizational efforts and the demonstration of teamwork: collaborative activities aimed at achieving common goals. In this context, teamwork self-efficacy—belief in one's ability to effectively engage in collaborative activities within a team (Tasa et al., 2007)—is also considered relevant.

1.1 Literature review

1.1.1 Inquiry-based learning and ICT utilization

In general, the process of inquiry-based learning is often depicted as a simplified series of phases referred to as the inquiry cycle (Pedaste et al., 2015; Dobber et al., 2017). Pedaste et al. (2015) conducted a systematic review of research on the inquiry cycle, proposing a framework comprising phases such as orientation (preliminary learning), conceptualization (formulating questions and hypotheses), investigation (conducting investigations/experiments and interpreting results), summarizing (summarizing results), and discussion that promotes these preceding phases (exchanging ideas and reflecting). This framework is similar to the inquiry-based learning process observed during the Period for Integrated Studies in Japan (MEXT, 2017), and it is discussed internationally.

Previous studies have highlighted that teachers' implementation of inquiry-based learning significantly impacts children's learning outcomes (Pedaste et al., 2015; Lazonder and Harmsen, 2016; Van Uum et al., 2016; Dobber et al., 2017). Furthermore, findings from the International Computer and Information Literacy Study (ICILS) 2013 by The International Association for the Evaluation of Educational Achievement (IEA) and the ICILS 2018 international survey (Fraillon et al., 2014, 2020) suggest that ICT is frequently utilized to support inquiry-based learning. Additionally, research on the role of teachers and instructional methods in inquiry-based learning indicates that teachers' use of ICT influences children's inquiry-based learning process (Lazonder and Harmsen, 2016; Dobber et al., 2017). These findings demonstrate that focusing on the utilization of ICT in inquiry-based learning, across each phase of the inquiry cycle, is crucial.

1.1.2 Teachers' ICT self-efficacy

Bandura (1997) describes self-efficacy within specific domains and contexts as a catalyst for individual performance in organizational settings. According to Bandura (1997), self-efficacy pertains to the belief in one's ability to accomplish actions required to produce desired results, specific to particular domains and contexts. In the realm of education, teachers' self-efficacy—the confidence in their ability to deliver instruction conducive to desired learning and developmental outcomes in students—has garnered attention (Tschannen-Moran and Hoy, 2001). Self-efficacy in the domain and context of ICT use in education is a particularly important concept (Fraillon et al., 2014, 2020). Previous studies have indicated a positive correlation between teachers' self-efficacy in ICT (ICT self-efficacy) and their utilization of ICT in educational settings (Hatlevik and Hatlevik, 2018; Ye et al., 2022). Additionally, teachers' ICT self-efficacy encompasses their general confidence in their ICT skills (general ICT self-efficacy) and their belief in utilizing ICT for instructional purposes (ICT self-efficacy for instructional purposes). While related, these concepts are distinct and each is being explored as factors influencing ICT use in education (Hatlevik and Hatlevik, 2018). Based on these findings, both general ICT self-efficacy and ICT self-efficacy for instructional purposes are assumed to play pivotal roles in ICT use within inquiry-based learning.

1.1.3 Organizational support to promote ICT utilization

The incorporation of ICT into educational activities is inherently an organizational activity, warranting acknowledgment of the level of organizational support, especially from their own institutions. Previous studies have cited school ICT resources, teacher collaboration, and facilitation by management as specific examples of organizational support (Fraillon et al., 2014, 2020; Hatlevik and Hatlevik, 2018; Ye et al., 2022). For example, Hatlevik and Hatlevik (2018) report that collaborative engagement with colleagues in utilizing ICT for teaching and learning positively correlates with teachers' utilization of ICT in their educational practices and their ICT self-efficacy for instructional purposes. Consequently, this study will investigate the interplay between the lack of ICT resources in schools, teachers' collaborative efforts in ICT use, and the adoption of ICT within inquiry-based learning as organizational-level factors.

1.1.4 Self-efficacy for teamwork

The implementation of organizational activities to introduce and use ICT in educational activities is not solely accomplished by individual teachers but rather through collaborative efforts within

teacher teams (Vangrieken et al., 2015; Park et al., 2005; Oude Groote Beverborg et al., 2015). A teacher team is a group formed to enable educators to work more collaboratively with their colleagues (Park et al., 2005). Collaborative activities undertaken by team members to achieve team goals are collectively referred to as teamwork (Oude Groote Beverborg et al., 2015). Teamwork is closely related to the execution of educational activities (Park et al., 2005). The implementation of inquiry-based learning and the use of ICT within it are no exception, as they necessitate team-based collaborative efforts. In this context, teamwork self-efficacy, which pertains to one's belief in their ability to smoothly engage in collaborative activities within a team (Tasa et al., 2007), is also considered relevant. In organizational settings, it is important not only to acknowledge the level of support from one's team but also to evaluate one's capacity to engage in teamwork with colleagues from the same team. Therefore, self-efficacy for teamwork is assumed to be a factor influencing the utilization of ICT in inquiry-based learning.

1.2 Research framework

Based on the aforementioned research interests, the present study aims to examine the relationship between the use of ICT in inquiry-based learning and general ICT self-efficacy, ICT self-efficacy for instructional purposes, the lack of ICT resources in schools, teacher collaboration in using ICT, and self-efficacy for teamwork. Four research questions (RQ) were formulated regarding the relationship between these variables, drawing from the review of previous studies discussed above (Figure 1).

> RQ1: To what degree is teachers' ICT self-efficacy (general ICT self-efficacy, ICT self-efficacy for instructional purposes) related to ICT use in inquiry-based learning?
>
> RQ2: To what degree is the lack of ICT resources in schools related to ICT use in inquiry-based learning?
>
> RQ3: To what degree is teacher collaboration in using ICT related to ICT use in inquiry-based learning?
>
> RQ4: To what degree is self-efficacy for teamwork related to ICT use in inquiry-based learning?

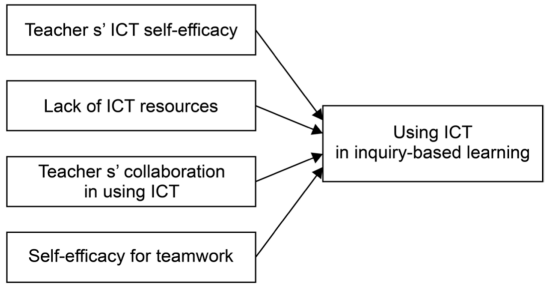

FIGURE 1
Hypothesized model of multiple regression analysis.

2 Materials and methods

2.1 Participants and ethical considerations

In June 2023, a web questionnaire was administered to monitors at INTAGE, Inc. This survey targeted elementary school teachers without any bias regarding gender, age, or prefecture of residence. Among the respondents, 324 individuals who confirmed their current employment as full-time elementary school teachers participated in the survey. Ethical considerations were addressed by obtaining individual participant consent, explaining that the responses would be used for academic research, that the data would be processed statistically, that personal information would not be disclosed, and that they could withdraw from the survey at any time. The survey was approved by the research ethics review committee of the university to which the first author belongs (approval number: HR-ES-001020).

2.2 Survey structure

The survey comprised screening items, basic statistical items, and questions regarding ICT use in inquiry-based learning, teachers' ICT self-efficacy, lack of ICT resources at school, teacher collaboration in using ICT, and self-efficacy for teamwork. Responses were requested for randomly displayed items (Table 1).

Scales for teachers' ICT self-efficacy, lack of ICT resources at school, teacher collaboration in using ICT, and teamwork self-efficacy were adapted from previous studies. Originally developed in English, these scales were translated into Japanese by a bilingual researcher. This bilingual researcher is a specialist in pedagogy and is highly experienced in translating academic papers. The authors ensured the validity of the content and created a Japanese version. Specifically, they discussed whether the translated content remained relevant in the Japanese school education context and whether Japanese teachers would be able to understand the content of scale items and thereby respond. If there were any differences of opinion between the first and second authors, a decision was reached through discussion and mutual agreement. Subsequently, the Japanese version was back-translated into English by another bilingual researcher, confirming the absence of mistranslations.

Screening was conducted to verify that survey participants were full-time elementary school teachers, asking them to answer three questions: "Are you presently working as an elementary school teacher?," "Is your employment status full-time?," and "At what grade level does the Period for Integrated Studies begin in Japanese elementary schools?" Consequently, responses from 324 subjects who confirmed that they presently work as full-time elementary school teachers and indicated that the Period for Integrated Studies starts from the third year in Japanese elementary schools were analyzed. Concerning basic statistics, participants were asked about gender and years of experience as elementary school teachers, yielding the following results: Gender distribution: 195 male (60.2%) and 129 female (39.8%) participants; years of teaching experience: *M* 23.9, *SD* 11.52. Regarding the years of teaching experience for the participants, 62

TABLE 1 Means, standard deviations, skewness, kurtosis, and factor loadings for all items of the administered scales.

	M	*SD*	Skewness	Kurtosis	Factors loading
Using ICT in inquiry-based learning					
Orientation	2.27	0.59	−0.15	−0.53	0.56
Students conceptualization	1.95	0.62	0.03	−0.35	0.76
Students questioning	1.98	0.63	0.01	−0.44	0.70
Students hypotheses generation	1.89	0.62	0.07	−0.41	0.75
Students investigation and experimentation	2.25	0.58	−0.08	−0.44	0.68
Students analysis of data obtained from investigations and experiments	2.14	0.60	−0.07	−0.33	0.72
Students conclusion	2.11	0.59	−0.03	−0.18	0.75
Students discussion	2.06	0.59	−0.02	−0.16	0.77
Students communication	2.22	0.60	−0.13	−0.47	0.73
Students reflection	2.29	0.59	−0.17	−0.57	0.68
General ICT self-efficacy					
Producing a letter using a word processing program	2.59	0.63	−1.26	0.46	0.50
Emailing a file as an attachment	2.72	0.54	−1.83	2.43	0.80
Storing your digital photos on a computer	2.72	0.51	−1.60	1.68	0.85
Filing digital documents in folders and subfolders	2.48	0.64	−0.84	−0.34	0.52
Using the Internet for online purchases and payments	2.58	0.67	−1.31	0.40	0.71
Finding useful teaching resources on the Internet	2.49	0.61	−0.79	−0.36	0.61
Installing software	2.51	0.67	−1.03	−0.15	0.62
ICT self-efficacy for instructional purposes					
Monitoring students' progress	2.38	0.64	−0.55	−0.64	0.61
Using a spreadsheet program for keeping records or analyzing data	2.20	0.77	−0.36	−1.24	0.77
Contributing to a discussion forum/user group on the Internet	2.10	0.74	−0.16	−1.17	0.59
Producing presentations, with simple animation functions	2.51	0.66	−1.01	−0.15	0.48
Assessing student learning	2.43	0.61	−0.58	−0.58	0.55
Collaborating with others using shared resources such as a word processing program	2.25	0.70	−0.40	−0.92	0.83
Lack of ICT resources at school					
My school does not have sufficient ICT equipment	2.14	0.75	0.44	0.11	0.80
My school does not have access to digital learning resources	2.05	0.79	0.44	−0.20	0.74
My school has limited connectivity to the Internet	2.43	0.87	0.10	−0.65	0.71
The computer equipment in our school is out of date	2.26	0.71	0.43	0.24	0.65
There is not sufficient provision for me to develop expertise in ICT	2.55	0.78	−0.06	−0.40	0.67
There is not sufficient technical support to maintain ICT resources	2.44	0.73	0.28	−0.20	0.76
Teachers' collaboration in using ICT					
I work together with other teachers on improving the use of ICT in classroom teaching	2.83	0.60	−0.52	0.96	0.80
There is a common set of rules in the school about how ICT should be used in classrooms	2.94	0.64	−0.51	0.98	0.59
I systematically collaborate with colleagues to develop ICT-based lessons based on the curriculum	2.71	0.66	−0.21	0.04	0.66
I observe how other teachers use ICT in teaching	2.93	0.59	−0.62	1.73	0.70
There is a common set of expectations in the school about what students will learn about ICT	2.93	0.62	−0.60	1.44	0.76
Self-efficacy for teamwork					
Set time deadlines for achieving tasks	5.02	1.04	−0.07	−0.24	0.76
Take steps to ensure everyone participates in group discussions	4.83	1.00	−0.11	0.12	0.83

(Continued)

TABLE 1 (Continued)

	M	*SD*	Skewness	Kurtosis	Factors loading
Take the group's ideas and develop specific plans of action	4.83	0.94	−0.24	0.01	0.87
Make correct judgments about connections in complex situations	4.67	1.03	−0.05	0.10	0.81
Participate in developing strategies to achieve team goals	4.81	1.02	−0.11	0.27	0.82
Remind other team members of the team's goal	4.75	1.01	−0.13	0.19	0.83
Draw team members into discussions that are relevant to achieving the goal	4.67	1.05	−0.18	−0.09	0.78
Ignore or discourage off-topic conversations	4.48	1.13	−0.10	0.18	0.55
Steer team members towards on-topic conversations	4.84	1.01	−0.40	0.62	0.84
Address conflict immediately by raising it for discussion with other team members	4.62	1.07	−0.13	−0.05	0.79
Try to calm down team members who are in conflict	4.64	1.05	−0.18	0.08	0.79
Assume leadership	4.66	1.10	−0.15	0.09	0.79

participants had less than 10 years of teaching experience, 69 had 11–20, 77 had 21–30, and 116 had over 30 years of teaching experience.

2.2.1 Using ICT in inquiry-based learning

A model was created by referencing the inquiry-based learning process models outlined by Pedaste et al. (2015) and Ministry of Education, Culture, Sports, Science and Technology (2018). The content was validated by the first and second authors, as well as by a researcher specializing in the Period for Integrated Studies. The model comprises 11 items, including "Orientation," "Students conceptualization," "Students investigation and experimentation," "Students conclusion," and "Students discussion." Drawing on the works of Fraillon et al. (2014) and Hatlevik and Hatlevik (2018), survey participants were instructed to rate their responses on a three-point scale ranging from "1. Never" to "3. Frequently."

2.2.2 Teachers' ICT self-efficacy

A total of 14 items concerning teachers' ICT self-efficacy from Fraillon et al. (2014) were translated and utilized. These items were employed in the IEA's ICILS 2013 and ICILS 2018, and two factors—general ICT self-efficacy and ICT self-efficacy for instructional purposes—were derived in a study by Hatlevik and Hatlevik (2018) using some of the same items. Survey participants were instructed to respond using a three-point scale ranging from "1. I do not think I can do this" to "3. I know how to do this."

2.2.3 Lack of ICT resources at school

Six items concerning teachers' perception of resource availability from Fraillon et al. (2014) were translated and utilized. Participants were asked to rate their responses using a three-point scale ranging from "1. Completely disagree" to "4. Strongly agree." A lower score on this item suggests a perception of substantial ICT-related resources.

2.2.4 Teacher collaboration in using ICT

Five items concerning teachers' collaboration in using ICT from Fraillon et al. (2014) were translated and utilized. Survey participants were asked to respond using a three-point scale ranging from "1. Strongly disagree" to "4. Strongly agree."

2.2.5 Self-efficacy for teamwork

A total of 12 items concerning self-efficacy for teamwork from Tasa et al. (2007) were translated and utilized. These items represent a generalized scale deemed suitable for measuring self-efficacy for teamwork in the teaching profession. Survey participants were asked to rate their responses using a seven-point scale ranging from "1. Not at All" to "7. Very Much So."

3 Results

3.1 Basic statistics, convergent validity, and internal consistency of each scale

Table 1 presents the mean, standard deviation (SD), skewness, and kurtosis values of the five components outlined in the present study's framework. Similar to Hatlevik and Hatlevik (2018) and Ye et al. (2022), the average values for all items were observed to be relatively high, prompting careful consideration of data normality during analysis. To confirm the convergent validity of each scale, exploratory factor analysis (using the principal factor method with Promax rotation) was performed. The results confirmed the convergent validity of each scale, as indicated by factor loadings ranging from 0.48 to 0.87 for all items (Table 1). Given that scales other than those concerning ICT self-efficacy exhibited a single-factor structure, each factor was defined as follows: ICT use in inquiry-based learning, ICT resources at school, teacher collaboration in using ICT, and self-efficacy for teamwork. In contrast, scales concerning ICT self-efficacy demonstrated a two-factor structure, with each factor identified as general ICT self-efficacy and ICT self-efficacy for instructional purposes, in line with the findings of Hatlevik and Hatlevik (2018). Furthermore, during the analysis, one item with a factor loading of 0.40 or higher for both factors was excluded. Additionally, Cronbach's alpha coefficient ranged from 0.83 to 0.95, confirming the internal consistency of each scale (Table 2). Exploratory factor analysis was performed for the scale concerning ICT use in inquiry-based learning because the scale in this study was created based on previous studies. Consequently, this scale exhibited a single-factor structure, so it is possible that participants' awareness at each stage of inquiry-based learning has not been captured in detail. This point should be noted when proceeding with subsequent analysis.

TABLE 2 Descriptive Statistics for Each Variable and Correlation Matrix Between Variables.

	1	2	3	4	5	6	*M*	*SD*	αCoefficient
1. Using ICT in inquiry-based learning	–	0.15**	0.29***	−0.12*	0.33***	0.29***	2.19	0.43	0.91
2. General ICT self-efficacy		–	0.72***	−0.12*	0.21***	0.27***	2.58	0.47	0.88
3. ICT self-efficacy for instructional purposes			–	−0.15**	0.31***	0.30***	2.31	0.52	0.85
4. Lack of ICT resources at school				–	−0.12*	0.10*	2.31	0.57	0.84
5. Teachers' collaboration in using ICT					–	0.45***	2.87	0.48	0.83
6. Self-efficacy for teamwork						–	4.74	0.83	0.95

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 3 Results of multiple regression analysis.

	β	95% CI	*p*	*VIF*
General ICT self-efficacy	−0.12	[−0.25, 0.02]	0.09	2.08
ICT self-efficacy for instructional purposes	0.27	[0.10, 0.34]	<0.001	2.21
Lack of ICT resources at school	−0.05	[−0.11, 0.04]	0.31	1.03
Teachers' collaboration in using ICT	0.20	[0.08, 0.28]	<0.001	1.31
Self-efficacy for teamwork	0.15	[0.02, 0.13]	<0.05	1.31
R^2	0.17			
adj R^2	0.16			

3.2 Relationship between ICT use in inquiry-based learning and each variable

Correlation coefficients between variables were calculated using Pearson's product–moment correlation coefficient (Table 2). Upon examining the correlation matrix table, which presents correlation coefficients between variables, no variables were found with $|r| > 0.80$. Subsequently, multiple regression analysis was conducted using the forced entry method, with ICT use in inquiry-based learning as the objective variable and general ICT self-efficacy, ICT self-efficacy for instructional purposes, and self-efficacy for teamwork as explanatory variables (Table 3).

Based on the results, the analysis of variance was significant ($p < 0.001$), with an adjusted R^2 of 0.13, a Durbin–Watson ratio of 1.63, and all variance inflation factors (VIF) less than 3.0. Examination of the standard partial regression coefficients revealed a significant positive relationship between ICT self-efficacy for instructional purposes ($\beta = 0.27$, $p < 0.001$), teacher collaboration in using ICT ($\beta = 0.20$, $p < 0.001$), and self-efficacy for teamwork ($\beta = 0.15$, $p < 0.05$) with ICT use in inquiry-based learning. However, the relationship between general ICT self-efficacy ($\beta = -0.12$, *n.s.*) and lack of ICT resources at school ($\beta = -0.05$, *n.s.*) was not statistically significant.

4 Discussion

This study has a single-point, cross-sectional survey design. Therefore, it should be noted that the study does not identify detailed causal relationships between variables, and as presented in Table 3, the adjusted coefficient of determination is low.

The multiple regression analysis results clearly demonstrate that the more teachers recognize self-efficacy for instructional purposes, the more ICT is utilized in inquiry-based learning practices. The results support Bandura's (1997) self-efficacy theory and previous research findings that ICT self-efficacy is positively correlated with ICT use in educational practice and that teachers' ICT self-efficacy predicts ICT use in teaching practice (Hatlevik and Hatlevik, 2018; Ye et al., 2022).

While previous studies (Lazonder and Harmsen, 2016; Dobber et al., 2017) have indicated the effectiveness of ICT in teacher instruction and children's learning outcomes in inquiry-based learning, the present study suggests that ICT self-efficacy, especially ICT self-efficacy for instructional purposes, serves as a direct catalyst for promoting ICT use in inquiry-based learning. Additionally, Hatlevik and Hatlevik (2018) note that although general ICT self-efficacy and ICT self-efficacy for instructional purposes are mutually related, confidence solely in one's general ICT skills is insufficient. Rather, teachers must possess confidence specifically in utilizing ICT for instructional purposes. Consistent with this assertion, the present study identified a significant correlation between general ICT self-efficacy and ICT self-efficacy for instructional purposes ($r = 0.72$), yet only ICT self-efficacy for instructional purposes was significantly related to ICT use in inquiry-based learning. Consequently, it is evident that utilizing ICT for instructional purposes in inquiry-based learning requires support to cultivate the skills, knowledge, and abilities necessary for its effective use. One study suggested that self-efficacy for using ICT is related to the number of years of using ICT in learning and teaching (Šabić et al., 2022); this aspect, too, warrants examination.

Furthermore, it is evident that the more teachers recognize collaboration with colleagues in using ICT, the more they acknowledge ICT utilization in inquiry-based learning. These results support previous studies indicating that organizational support, such as interpersonal support and cooperation with colleagues, promotes ICT use in educational activities and improves student outcomes (Hatlevik and Hatlevik, 2018; Ye et al., 2022). Collaboration with colleagues is

considered an important factor in enhancing teachers' utilization of ICT in actual inquiry-based learning practices and improving student outcomes.

However, the relationship with the lack of ICT resources at school, another aspect of organizational support, was not statistically significant. Previous studies have highlighted the significance of ICT resources at school in facilitating ICT use in educational practice (Fraillon et al., 2014, 2020). However, the present study's results differ from those of previous studies. In response to the COVID-19 pandemic, Japanese schools promoted several policies, including offering one device per student and establishing a high-speed, high-capacity communication network (Ministry of Education, Culture, Sports, Science and Technology Central Council for Education, 2021). Furthermore, the "Survey on the Actual Condition of the ICT Utilization for Education" (Ministry of Education, 2020, 2022) conducted by the national agency of the Ministry of Education reported that these tasks had been completed. This may have led research participants to recognize that interpersonal support for integrating ICT into inquiry-based learning holds greater importance than enhancing physical resources. However, this study did not collect follow-up data to support the correlation between inquiry-based learning utilizing ICT and the lack of ICT resources at school, so further verification is needed.

Additionally, it is evident that the more teachers recognize self-efficacy for teamwork, the more ICT is utilized in inquiry-based learning. Bandura (1997) and Tasa et al. (2007) emphasize the social aspect of collaborative self-efficacy, indicating that collaborative self-efficacy develops and is influenced by individual contexts. Furthermore, past studies have indicated that teachers demonstrating teamwork improve performance at both the organizational and individual levels (Park et al., 2005; Oude Groote Beverborg et al., 2015). The recognition of teamwork self-efficacy, which refers to the extent to which one can engage in teamwork with colleagues in their respective teams, is considered important for the use of ICT in inquiry-based learning. Based on the results related to organizational support discussed above, the interaction between individuals and organizations is also deemed important in facilitating the use of ICT in inquiry-based learning; this is a novel finding derived from the present study.

Although the present study reveals important findings, it has several limitations. First, because this study had a single-point, cross-sectional survey design, it was not possible to identify detailed relationships between variables, including causal relationships. Therefore, there is a need for a longitudinal survey conducted at multiple points in time to examine the relationships between variables from multiple perspectives. Second, the scale concerning ICT use in inquiry-based learning used in the present study, based on the results of exploratory factor analysis, exhibited a single-factor structure, thus oversimplifying the measurement of ICT use in inquiry-based learning. Therefore, it is challenging to thoroughly examine how teachers themselves perceive each phase in inquiry-based learning and how these perceptions relate to other factors. A potential solution to this problem could be conducting a pilot study among elementary school teachers in Japan during the final amendment of the items, to obtain feedback and thereby increase the validity of the tested items. Third, many of the participants in this study had more than 30 years of teaching experience, and no information was collected contextualizing the schools to which participants belonged (e.g., urban vs. rural location, school size, prior access to ICT, etc.). Diverse demographic data needs to be collected and analyzed, allowing the relationship between environmental characteristics and ICT utilization in inquiry-based learning to be more thoroughly verified. Furthermore, follow-up surveys comparing interpersonal support for ICT utilization and physical resources in schools should be conducted for further verification.

5 Conclusion

The present study elucidates that the utilization of ICT in inquiry-based learning, an educational approach gaining international attention, exhibits a positive correlation with ICT self-efficacy for instructional purposes, teacher collaboration in using ICT, and self-efficacy for teamwork in Japan. Although this study raises the issues indicated above, it supports the idea of a relationship between ICT utilization in inquiry-based learning and interpersonal support, as found in previous international studies (Fraillon et al., 2014, 2020; Hatlevik and Hatlevik, 2018), which suggests that enhanced interpersonal support for ICT may further improve inquiry-based learning despite regional and international differences. Furthermore, Japan has focused on developing policies (Ministry of Education, 2020, 2022) to improve physical resources, so the next step may be developing policies (Fraillon et al., 2014, 2020; Hatlevik and Hatlevik, 2018) to promote such interpersonal support. These findings are deemed fundamental for exploring how ICT can be effectively incorporated into inquiry-based learning. However, this study revealed only some aspects of the relationship of individual and organizational factors with the use of ICT in inquiry-based learning. In the future, it will be important to examine the relationship between teachers' Technological Pedagogical Content Knowledge (TPACK) (Mishra and Koehler, 2006), which has recently garnered attention as a personal factor, and the promotion of ICT use in inquiry-based learning. Furthermore, regarding organizational support factors, further examination is necessary to understand the relationship among leadership, organizational climates, teamwork, and ICT utilization in inquiry-based learning.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Research Ethics Review Board at Graduate School of Humanities and Social Sciences in Hiroshima University. The studies were conducted in accordance with the local legislation and institutional requirements.

The participants provided their written informed consent to participate in this study.

Author contributions

TY: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization. YN: Writing – review & editing, Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Validation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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