The Influence of Information and Communication Technology Use on Students' Information Literacy

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Contents

Abstract

In this chapter, the concept of information literacy and research findings on the impact of children's use of ICT (information and communication technology) on information literacy are introduced, with a focus on Japan and including comparisons to other parts of the world. A general explanation of information literacy is first provided; then the concept, history, measurement, and other issues of information literacy are described. The findings of Japanese empirical research on the impact of children's ICT use on information literacy are detailed and aligned with major international research findings and orientations on the issues of impact of ICT use. Major findings are as follows: (a) ICT use can improve information competencies, in particular abilities to collect and evaluate information; and (b) it

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appears that ICT use at school could be more effective than ICT use at home, but even the use at home has effects which cannot be ignored. Findings contribute additional evidence of causality to the current body of literature based primarily on large international studies addressing the issues of the educational impact of ICT use through data gathered across many educational systems but from each subject just one time.

Keywords
Information literacy · ICT use · Quasi-experiment · Panel study · Japanese research

Introduction

This chapter introduces studies on the influence of ICT use on information literacy among elementary, junior high, and senior high school students. Although many references are made to studies from other parts of the world, detailed examples are provided from research studies in Japan.

What Is Information Literacy?

Information literacy has been regarded as being a skill necessary to live well in the information society. According to Virkus (2003), increasing attention to information literacy in recent years is partly due to the result of information overload especially related to the growth of digital information and the new focus on student learning in a lifelong learning context. Although such notice of information literacy has been taken, its concrete concept is not quite clear. In the glossary section of the first edition of the *International Handbook* (Voogt and Knezek 2008), the term information literacy was defined as:

> Computer literacy, digital literacy, e-literacy, e-skills, technological literacy, new literacy – all knowledge and skills that are necessary to participate in an information society; . . . [and] more narrowly defined as skills that are necessary to effectively use technology, e.g., finding and evaluating information on the Internet. (p. 1185)

Based on the explanation provided in the previous paragraph, it is possible to recognize that the term information literacy can have many meanings from narrow to wide definitions. Virkus (2003) described its various concepts and definitions. Some researchers have been engaging in work to overcome such confusing situations. For example, Anderson (2008) presented the term *knowledge-related skills* as inclusive abilities necessary for life in the information society. Knowledge-related skills consist of seven subskills, and Anderson described the subskill *to access*, *assemble*, *and reorganize knowledge*, as being the original information literacy.

Anderson (2008) also discussed relationships between information literacy and its similar concept, that is, ICT literacy. According to Anderson, information literacy

is usually defined based on information functions, while ICT literacy is defined based on information skills. From this perspective, he made and presented a comprehensive model to describe the relationships of the two concepts. Anderson's work can also be regarded as an effort to resolve long-standing confusion related to the meaning of the term information literacy.

One reason the concept of information literacy is ambiguous could be that abilities which are regarded as important have changed depending upon the time period (Martin 2006; Voogt 2008). Actually, it seems that skills to operate ICT tools were important before, while the skills of high-order thinking for ICT are important now. It is conceivable that the concept of information literacy which focuses on important skills particular to each time period has so far been presented, and this time period transition has led to the currently existing variety of information literacy concepts.

Since the important abilities are still continuing to change, concepts are also continuing to be presented. For example, Mioduser et al. (2008) presented a new literacy, which consisted of multimodal information processing, navigating the infospace, communication literacy, visual literacy, hyperacy (the ability to deal with nonlinear knowledge representations), personal information management literacy, and coping with complexity.

Researchers have taken notice of such issues regarding the concept of information literacy, but the issue of whether ICT use can enhance information literacy has also gathered their attention, and consequently some studies have been being conducted. As far as the results of these studies are concerned, it seems that they have produced mixed findings as to effects on information literacy (Scherer et al. 2017), although they have in general indicated positive effects on subject learning (Tamim et al. 2011).

In particular, according to Scherer et al. (2017), a mixture of results have been found for research on ICT use at school, and as for the use of ICT at home, its positive effects are more clear. The use of ICT at home was not previously regarded as effective to obtain information literacy, and so the importance of school education was argued, but there is now a view that the home use could be effective (Rohatgi et al. 2016). This is supported by the fact that home use has now become sophisticated (Biagi and Loi 2012; Steinkuehler and Duncan 2008). As for the effects of ICT use on information literacy, it seems that researchers' attention has recently been focused not only on school technology access but also on home technology access. Home use was much more frequently found than school use (Fraillon et al. 2013a), also making issues related to the impact of home use important to study.

Information Literacy Study in Japan

In Japan, the term information literacy has a unique and broad definition in the field of primary and secondary education, This chapter first introduces the Japanese concept of information literacy, its characteristics, measurement methods, and the influence of ICT use on information literacy. The outline and characteristics of quasi-experiments and panel studies in media influence research are briefly described. These methods have often been used for Japanese research regarding the influence of

ICT use on information literacy. While many Japanese studies have addressed some aspect of the influence of electronic media tools use (e.g., Sakamoto 2013; Takahira et al. 2012), this chapter focuses on the relationship between ICT use and information literacy and describes the background and trends in this area.

Historical Development of Information Literacy in Japan

In 1986, the Japanese concept of information literacy (jouhou katsuyou nouryoku) was presented by the Japanese government for the first time. Information literacy was defined as the "basic qualities of individuals necessary for independently selecting and using information and information tools" (Ad Hoc Council on Education 1986, p. 101), and the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) established development of these qualities as the goal of information education in primary and secondary schools (MEXT 2010).

MEXT first described and defined information literacy in 1987 (Curriculum Council 1987) and then refined its description in 1998 in terms of the following three components that remain as of 2018: (1) information competencies, (2) the ability to understand information scientifically, and (3) the ability to contribute to a desirable information society (MEXT 2010).

The first component, information competencies (jouhou katsuyou no jissenryoku), is defined as "the ability to independently collect, evaluate, organize, process, and create necessary information, and to send out or communicate information while taking into consideration the state of the recipient, including appropriately using information tools in accordance with issues or objectives" (MEXT 2010, p. 72). Information competencies defined for Japan seem to be similar to *information literacy* as it is widely used in other countries. Collection, evaluation, organization, processing, creation, and communication of information represent a series of activities from acquisition of information to outputting results in problem solving or research, and the abilities required for these activities are defined as shown in Table 1.

Table 1 Six components of information competencies in Japan

1. Ability to collect information (syuusyuu ryoku): the ability to actively collect all information necessary to the objective in an appropriate way
2. Ability to evaluate information (handan ryoku): the ability to select necessary information from among a vast amount and evaluate it in order to draw out appropriate information
3. Ability to organize information (hyougen ryoku): the ability to organize information in an appropriate way with attention to how it should be expressed
4. Ability to process information (syori ryoku): the ability to appropriately process collected information in order to understand key information
5. Ability to create information (souzou ryoku): the ability to formulate and produce based on one's own ideas and opinions
6. Ability to communicate information appropriately (hassin dentatsu ryoku): the ability to send out or communicate information while taking into consideration the recipient's perspective or ability to process information

Table 2 Examples of scientific understanding of information

Understanding of:
A method to effectively, efficiently, and accurately process written character, numerical, and image data
Statistical approaches to correctly collect and analyze experimental, observational, and study data and a method of developing a model necessary to allow such statistical approaches
An effective simulation method to predict future results or to learn how different conditions can lead to different results
Human cognitive characteristics that support effective and accurate communication of information and prevention of incorrect judgment of information
The mechanism of information technology widely used in home appliances
Functional categories and characteristics of typical information tools for communicating, processing, and recording information

The second component, the ability to understand information scientifically (jouhou no kagakuteki rikai), is defined as "the ability to understand the characteristics of information tools, which are the basic building blocks of information use, and the ability to understand the basic theories and methods in order to not only handle information appropriately but also to evaluate and improve one's information skills" (MEXT 2010, p. 72). It could also include knowledge and skills of information science and computer science. Table 2 lists detailed examples of scientific understanding. While information competencies focus on the ability to achieve good results through information processing activities, the ability to understand information scientifically focuses on the basic knowledge and skills that support such achievement.

The third component, the ability to contribute to a desirable information society (jouhou syakai ni sankakusuru taido), could be rephrased as having the knowledge and attitudes of a desirable digital citizen. It is defined as "the ability to understand the roles and influences of information and information technology in society, to consider the necessity of information morals and responsibilities for information, and to demonstrate a willingness to take part in the creation of a desirable information society" (MEXT 2010, p. 72). Note that the Japanese term *information morals* (*jouhou moraru)* covers both information ethics, such as prevention of harming others and spending unnecessary time and money with the use of ICT, and online safety, such as avoiding being harmed by others. In summary, this third component of information literacy focuses on the ability to understand the positive and negative aspects of digitization of society and to pay the necessary attention or give appropriate consideration in order to overcome the negative aspects.

This Japanese version of information literacy seems to have a unique structure and concept. First, the Japanese version emphasizes the independence of information users. This is particularly explicit for information competencies. In Japan, it has been frequently argued that Japanese lack independence and assertiveness, holding them back from playing an important role internationally. Accordingly, in the field of education, the importance of helping children and students develop independence has been frequently emphasized. The focus on independence in information literacy seems to reflect these values.

Second, the Japanese version of information literacy gives particular weight to the ability to contribute to a desirable information society or demonstration of knowledge and attitudes of a digital citizen. As mentioned earlier, this ability is one of the three components of information literacy. By way of comparison, in the new 2016 National Education Technology Standards for Students by the International Society for Technology in Education (ISTE) (2016), *digital citizenship* is one of seven standards. Japanese school education places importance on teaching students how to avoid problems caused by ICT use, and this is reflected in the weight given to the ability to contribute to a desirable information society.

Third, the Japanese version of information literacy also gives weight to the ability to understand information scientifically or to the acquisition of knowledge and skills of computer science and information science. Similarly, in the 2007 ISTE National Education Technology Standards for Students, one of the six standards called *technology operations and concepts* corresponds to the ability to understand information scientifically. However the 2016 ISTE standards no longer include this technology standard. It appears that recent situations where technological operations and concepts have been deemphasized have often also led to the use of the concept of computer and information literacy (CIL). This is defined as "an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society" (Fraillon et al. 2013b, p. 17) and is often used in research and discussion on educational ICT use. It seems that this discussion of terminology has become necessary because researchers often want to deal with the issues of abilities including technical operations and concepts. The Japanese version of information literacy gives relatively greater weight to technical issues, and therefore it might be that Japanese information literacy and CIL can be regarded as being reasonably overlapping concepts but they are not exactly the same.

Recently, UNESCO (2017) presented an ICT Competency Framework which was jointly developed by many nations of the world. The framework addresses three different areas of competencies. The first is technology literacy, enabling students to use ICT in order to learn more efficiently. The second is knowledge deepening, enabling students to acquire in-depth knowledge of their school subjects and apply it to complex, real-world problems. The third is knowledge creation, enabling students, citizens, and the workforce they become to create the new knowledge required for more harmonious, fulfilling, and prosperous societies. Although this framework is based on viewpoints different from those of the Japanese version of information literacy, it seems that topics covered by each overlap to some extent. However, knowledge creation is one of three categories in UNESCO's framework, which is not emphasized in the Japanese version of information literacy. The ability to contribute to a desirable information society in the Japanese version of information literacy includes some parts of this in knowledge creation, but the other two components (information competencies and the ability to understand information scientifically) do not include knowledge creation to a significant degree. The Japanese version of information literacy has concepts in common with the UNESCO framework but is not exactly the same.

Measurement and Structure of Information Literacy in Japan

Abilities can be measured through tests, observations, and self-evaluation (Christensen and Knezek 2008; Schulz-Zander et al. 2008). Measurement by tests and observations has strength in that it guarantees objectivity, but it seems that self-evaluation can also be useful for measurement of Japanese information literacy. Information competencies focus not only on the abilities to produce good results using information but also on independent information use, the latter of which can often be represented by attitudes. The ability to contribute to a desirable information society is also related to attitudes. Generally speaking, the importance of self-evaluation is high in attitude measurements (Christensen and Knezek 2008), and therefore, self-evaluation can be a useful option when researchers wish to measure a construct which has both aspects of skills and attitudes, like Japanese information literacy.

Scales for self-evaluating components of information literacy have been studied and developed. For example, Takahira et al. (2001) developed a 56-item information competency self-reporting scale. This scale covered all six components of information competencies, which include the abilities to collect, evaluate, organize, process, and create information as well as the ability to communicate information appropriately. The researchers administered the survey to 1649 junior and senior high school students and confirmed that the scale had sufficient reliability and validity. Table 3 shows example questionnaire items.

Table 3 Example statements in the scale measuring information competencies

Ability to collect information: ten items
I ask my friends for information materials when I need them more often than collecting the materials by myself [R]
I make myself use dictionaries when I encounter information that I do not understand
Ability to evaluate information: eight items
When there are opposing opinions, I always listen to both sides to understand pros and cons of each opinion
I am not very good at finding necessary information from a large volume of materials [R]
Ability to organize information: eight items
After I have collected a lot of information, I make myself categorize it by content
When I read sentences, I never underline important points [R]
Ability to process information: eight items
When I solve problems, I tend to draw a conclusion more instinctively than logically [R]
I am good at identifying a common feature or a rule in information organized in charts and tables
Ability to create information: ten items
I am not good at coming up with opinions different from others [R]
Once I solve a problem using a particular method, I will not try to find a better method
Ability to communicate information appropriately: ten items
When I have a message for someone, I try to make the message eye-catching by, for example, underlining important points
When I talk with someone, I usually do not wonder what the other person wants to know [R]

Note: Statements marked with [R] are reverse scoring items

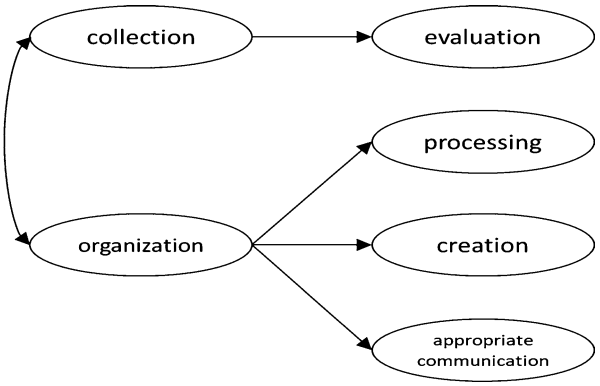

Fig. 1 The structure of the information competencies

Using the scale developed by Takahira et al. (2001), Ichihara et al. (2008) examined the structure of information competencies. Ichihara et al. (2008) administered the survey to 714 junior high school students and performed confirmatory factor analysis using the obtained data. As a result, the model shown in Fig. 1 was selected due to its goodness of fit. Based on the results of this study along with others, the researchers argued that it was possible to assume two effective learning activities: (1) acquisition of the ability to collect information followed by acquisition of the ability to evaluate information and (2) acquisition of the ability to organize information followed by acquisition of the ability to process and create information as well to communicate information appropriately. They also emphasized the importance of the former activity for younger students and the latter activity for older students. Note that information competency scales have also been developed by other researchers in Japan (e.g., Okugi and Furuta 2005).

Kobayashi et al. (2000) created a 50-item scale to measure the ability to contribute to a desirable information society. This scale covered all components of the ability to contribute to a desirable information society. These researchers administered the survey to 1639 junior high, senior high, and university students and concluded that the scale had sufficient reliability and validity. They performed confirmatory factor analysis on the obtained data. Figure 2 displays the structure of the ability to contribute to a desirable information society. Table 4 lists example questionnaire items. Note that other researchers have also developed scales to measure this ability (Miyagawa and Moriyama 2011; Miyake 2005).

A wide variety of studies have been conducted using the scales previously described. For example, Mori et al. (2004) used these scales to examine the correlation between individuals' self-teaching ability, information competencies, and the ability to contribute to a desirable information society, finding high correlations. Also, Omi et al. (2004) conducted a survey of elementary school students to examine the correlation between their information competencies and intelligence. The study showed that the magnitude of correlation between information competencies and numerical intelligence was approximately $r = 0.30$, moderate in magnitude according to guidelines provided by Cohen (1988). Finally, Ando and Ikeda

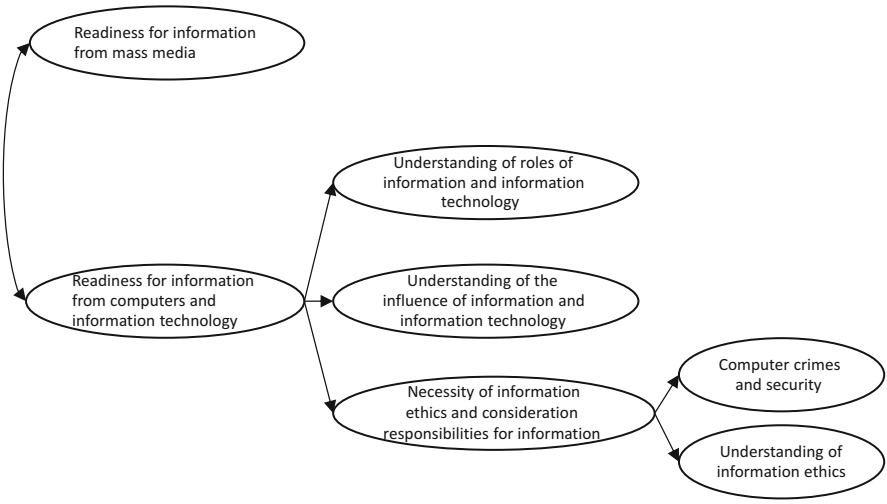

Fig. 2 The structure of the ability to contribute to a desirable information society

(2012) found that high information competencies predicted higher critical thinking skills in follow-up assessments 5 months later.

Empirical Research on the Influence of ICT Use on Information Literacy in Japan

Japanese junior high schools have a technology and home economics class, which includes an information education module. Japanese senior high schools have a class dedicated to information education. These classes are designed to develop students' ability to understand information scientifically, which is a component of information literacy. Meanwhile, students cannot acquire the other two components of information literacy, which are information competencies and the ability to contribute to a desirable information society, through these classes alone; they need hands-on experience with ICT while studying a wide variety of school subjects and engaging in school activities. MEXT has provided detailed examples of activities using ICT, which should be provided in each school subject in order to improve students' information literacy (MEXT 2002). Table 5 shows examples of activities for a science class.

As previously described, the use of ICT is considered important for the development of information literacy. The Japanese government therefore has promoted the introduction and use of ICT in schools, and whether or not ICT use actually improves students' information literacy, information competencies, and the ability to contribute to a desirable information society in particular has become an important research area. The following sections introduce quasi-experiments and panel studies conducted on this theme.

Table 4 Example statements in the scale measuring the ability to contribute to a desirable information society

1. Understanding of roles of information and information technology
I am not interested in studying computer programming [R]
I want to actively use computers to make my daily living more convenient
2. Understanding of the influence of information and information technology
(a) Issues regarding a computer-dependent society
I want to understand issues regarding a computer-dependent society
I am not interested in the influence of computers on the human body [R]
(b) Influence of mass media on society
I try not to let commercials influence my purchasing decisions
I am easily influenced by opinions introduced on TV, in newspapers, and in magazines [R]
3. Necessity of information ethics and consideration of responsibilities for information
(a) Understanding of information ethics
1. Information ethics and manners
I often give information to others even though I am not sure of its correctness [R]
I do not want to post information on the internet that may make viewers uncomfortable
2. Privacy
I disclose my friends' street addresses and phone numbers without their permission [R]
I do not want to view websites containing content that violates someone's privacy
3. Copyrights
If I can copy game software such as video games, I will do so without hesitation [R]
I want to understand the Copyright Act properly
(b) Computer crimes and security
I hope technology that allows safe online information exchanges will develop further
I admire hackers (people who infiltrate others' computers via networks) [R]

Note: Statements marked with [R] are reverse scoring items

Table 5 Examples of science class activities that improve students' information literacy

Tabulation, processing, and drawing graphs of observational or experimental data using a computer and discovering a new rule in the processed data
Quantification of natural events and changes and performance of experiments, including measurement and control, using a computer
Consideration of a causal relationship within an event through simulation
Searching for information on natural events and objects using a computer or the internet
Exchanging information on nature or the environment via the internet

Quasi-experiments

A randomized experiment is a powerful method to determine a causal relationship between independent and dependent variables by controlling extraneous variables. It is however not realistic to implement a randomized experiment to examine the educational effect of ICT use on Japanese primary and secondary school students. In a randomized experiment, participating students are first divided into groups, and

each group is subject to a different educational intervention. Should a randomized experiment be conducted, it usually involves a short-term intervention or a small number of participants. It has been pointed out that many studies on the effect of ICT use face this experimental limitation (Pérez-Sanagustín et al. 2016).

A quasi-experiment is an experimental method that overcomes the issues of randomized experiments by sacrificing some control of extraneous variables. Studies on the influence of ICT use on information literacy should examine long-term effects, and their results need to be generalizable to a wide range of student categories. These criteria provide a strong rationale for selecting a quasi-experimental approach. Extraneous variables are not fully controlled in a quasi-experiment, and it is therefore important to discuss and nullify an alternative interpretation that interferes with the determination of a causal relationship between independent and dependent variables.

For example, a quasi-experiment to examine the influence of a use is viable when (a) changes in participants between before and after the diffusion of the subject media tool in one area (treatment condition) are compared to (b) changes in participants in areas where the same media tool has already been or does not take place (control condition) within the same period of time. One of the well-known quasi-experiments is by Harrison and Williams (1986) where researchers measured creative thinking skills, spatial perception skills, and the vocabulary size of children at two different time points in a town with no television (Notel condition), a town with only a single TV channel available (Unitel condition), and a town where all TV channels were available (Multitel condition). TV was introduced to the Notel town between the first and second measurements. Analysis of the obtained data indicated that, although children in the Notel condition had higher creative thinking skills than their counterparts at the first measurement, such skill difference was no longer observed at the second measurement. The study suggested that TV viewing may have been responsible for the decline of creative thinking skills.

In the field of information literacy, Naito et al. (2003) conducted a quasi-experiment to examine whether or not the use of high-speed internet improved students' information competencies. In one region of Japan, high-speed internet was introduced to three schools (treatment condition) and was not introduced to two schools (control condition). These five schools existed in very similar environments, and Naito et al. (2003) compared the changes in students' information competencies between treatment and control schools. The pre-post change score was computed by subtracting the students' information competency score measured before the high-speed internet was introduced from the score after it was introduced. The interval between measurements was 6 months. The data analysis indicated that the change score was significantly more positive for the treatment schools than for the control schools. This result suggests that internet use at school may contribute to improvement of information competency. The result also supports the study by Underwood et al. (2005) on the effectiveness of high-speed internet.

Naito et al. (2003) also compared the six components of information competencies – the ability to collect, evaluate, organize, process, and create information as well as the ability to communicate information appropriately – between schools with

and without high-speed internet. Except for the ability to create information, the scores of pre-post change were more positive at the schools with the high-speed internet than those without it.

In a quasi-experiment by Naito et al. (2003), students' information competencies were measured twice, before the high-speed internet was introduced and once after the introduction. The interval between the two pre-introduction measurements was 6 months. These two measurements allowed controlling for the baseline changes between the two conditions (Shadish et al. 2002). As a result of analysis, the information competency score between the two conditions showed no changes in the two pre-introduction measurements. The difference score changed rapidly after the introduction, however, and this difference could not be explained by any changes observed prior to the introduction of high-speed internet. Such nullification of alternative explanations strengthens the argument that the introduction of high-speed internet influenced information competencies in students.

Kashibuchi et al. (2003) conducted a quasi-experiment on the ability to contribute to a desirable information society, one component of information literacy. Similar to the study by Naito et al. (2003), Kashibuchi et al. (2003) measured students' ability to contribute to a desirable information society. These students were from junior high schools with or without high-speed internet. Changes in the ability score difference between the two conditions were compared before and after the introduction of high-speed internet. The result of the analyses indicated no differences between the two groups in their changes over time. Therefore, high-speed internet use was deemed unlikely to have influenced students' ability to contribute to a desirable information society in the Kashibuchi et al. (2003) study.

Panel Studies

In addition to quasi-experiments, panel studies have been used to examine the influence of ICT use on information competencies and the ability to contribute to a desirable information society. A panel study is a type of longitudinal study in which the same set of participants is measured in the same way multiple times with a certain time interval. For example, to examine the influence of media tool use, participants are measured multiple times for their exposure to the subject media tool and the outcome variables, such as cognitive skills or aggressiveness, which may be influenced by the use of the media tool. As with quasi-experiments, panel studies allow estimation of a causal relationship to some degree (Markus 1979; Finkel 1995).

Markus (1979) popularized panel studies by using the technique to address questions such as whether political party membership in the USA tends to influence positions on issues or whether positions on issues tend to influence party membership. As for the research of media impact, the application of similar methodology has been found in earlier periods in research such as the Sesame Street evaluation study which confirmed a positive impact of viewing this young children's television program on school readiness skills (Bogatz and Ball 1971; Searcy and Chapman

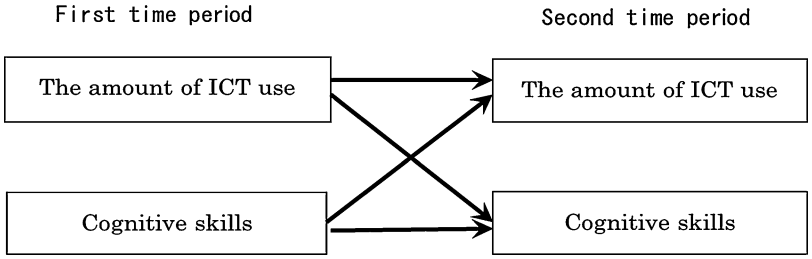

Fig. 3 The cross-lagged effects model of ICT use and cognitive skills

1972). Christensen (2002) gathered and analyzed panel study data to show that needs-based professional development for technology integration in teachers fosters more positive attitudes toward computers in their students. One major advantage of the panel study method is that it allows causal inference without a laboratory-type experimental design. In the field of educational science concerning ICT use, it seems so far that there have been only a small number of studies that examined causal relationships using panel study data.

Figure 3 shows a typical analysis model created for examining the causal relationships between the amount of ICT use and cognitive skills at two different time points. This model is called a cross-lagged effects model. If analysis using this model indicates that the path from the amount of ICT use measured at the first time point to cognitive skills measured at the second time point is significant, a causal relationship of ICT use influencing the cognitive skills is regarded as being supported. Unlike panel studies, on the other hand, cross-sectional correlation studies that require only a single measurement cannot fundamentally determine causal relationships (Prot and Anderson 2013).

Some Japanese panel studies examined the influence of ICT use on information literacy. For example, Takahira et al. (2007) examined the influence of ICT use on information competencies. They measured the amount of daily internet use at school and home and information competencies of 702 students from eight elementary schools. Measurement was performed twice with a 2-month interval, and the two sets of data obtained at different time points were analyzed using the cross-lagged effects model. The result indicated that internet use had a significant effect on improving information competencies of elementary school students, and among the components of information competencies, the ability to collect information improved the most. Internet use also had a positive effect, although weak, on the abilities to evaluate and organize information. The study further indicated that information competencies as a whole and the ability to collect information promoted internet use. The researchers developed and used a scale appropriate for elementary school students based on the scale developed by Takahira et al. (2001) for use by junior and senior high school students.

Another example is a panel study by Takahira et al. (2003) of 675 students from nine junior high schools. This was a two-wave study with a 5-month interval, and researchers measured the amount of internet use at home. Analysis of data indicated

that home internet use had a significant effect on improving the ability to collect information but no other information competency components. In addition, as with the case of elementary school students, the researchers found that the ability to process information promoted internet use and the ability to communicate information appropriately promoted email use. Takahira et al. (2002) also conducted another study of 201 senior high school students. Again, they measured the amount of internet use at home. The result of data analysis indicated that home internet use only had a significant effect on improving the ability to evaluate information while it weakened the ability to create information. No significant effect was observed regarding the ability to collect information.

Mouri et al. (2002) conducted a panel study to examine the effect of computer use at school. From 34 senior high schools, 2304 students participated in the study. Measurements were performed with a 6-month interval. The study showed that, while computer use influenced the ability to operate a computer, it had almost no effect on information competencies. The researchers then conducted a survey of teachers of the participating schools. They examined the level of effort that each school put into information education and reanalyzed measurement data for the schools that actively implemented information education and for those that did not. As a result, the students of the schools that actively implemented information education showed the effect of computer use as improving their ability to operate a computer and also the ability to evaluate information.

In the paper reporting the influence of internet use on information competencies of junior high school students described above, Takahira et al. (2003) also reported the influence of internet use on the ability to contribute to a desirable information society. The result indicated almost no significant effect due to internet use. It even had a significant negative effect on readiness for information from mass media. In the study of senior high school students by Takahira et al. (2002) described above,, internet use also showed almost no significant effect on their ability to contribute to a desirable information society.

The Causal Relationship Between ICT Use and Information Literacy

Only a few extensive evaluation studies have recently been conducted to analyze the causal relationship between ICT use and information literacy. This maintains the relevance of earlier evaluation studies. There are some possible reasons for the decline in the number of evaluation studies. First, current educational science thinking places importance on practicability of studies. This may deter researchers from conducting scientific evaluation studies. Second, it has become difficult to obtain the permission of schools to conduct evaluation studies with students due to human rights concerns. However, some studies in other regions of the world have produced findings with causal inference, and at least one large-scale study has been conducted across nations that tends to provide correlational evidence relevant to findings with causal inferences previously reported. For example, the European

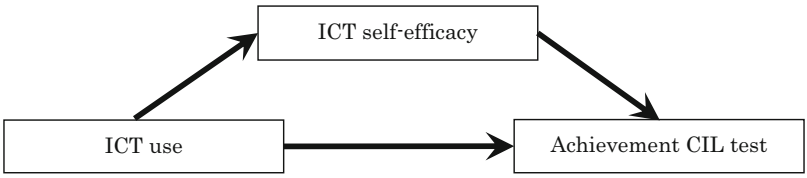

Fig. 4 Indirect effect of ICT use on computer and information literacy (CIL) achievement via ICT self-efficacy (Source: Adapted from Rohatgi et al. 2016, p. 107)

Commission's ET2020 strategy framework identified the innovative use of ICT as a priority and catalyst for achieving transformation in education (Brecko et al. 2014).

In another large-scale analysis, Rohatgi et al. (2016) analyzed Norwegian data obtained from the International Computer and Information Literacy Study (ICILS) in 2013 ($N = 2410$ students in grade level 9) and found through structural equation modeling that there is an indirect effect of ICT use on computer and information literacy (CIL) achievement via ICT self-efficacy (Fig. 4). The indirect effect was significant and positive for students' ICT use for task learning via basic ICT self-efficacy (beta $= 0.03$, $p < 0.001$), with similar but stronger effects for recreational uses of ICT and basic ICT self-efficacy (beta $= 0.07$). For students' ICT use for study purposes, the indirect effects were not significant. By way of contrast, none of the direct effects of ICT use on CIL achievement were significant at the $p < 0.05$ level. Rohatgi et al. (2016) viewed these findings as strong support for the indirect effect of ICT use on computer and information literacy achievement, via ICT self-efficacy.

Brecko et al. (2014) polled 149 educational stakeholders to evaluate a set of 60 policy recommendations developed during the "Up-Scaling Creative Classrooms in Europe" (SCALE CCR) project of the European Commission, in order to produce seven clusters of recommendations and a top ten list. Under the infrastructure cluster was the third recommendation, to "ensure that all learners have equal and ubiquitous ICT access, in and out of school" (p. 5). These recommendations by EC educational stakeholders reinforce the implications of the research by Rohatgi et al. (2016) that access to information technology outside of school appears to be critical for fostering high computer and information literacy in many parts of the world.

Summary of Insights Regarding ICT Use and Information Literacy

The results of quasi-experiments and panel studies introduced in this chapter, in the context of relational studies or expert opinion compendiums from other regions of the world, lead to the following insights.

First, both quasi-experiments and panel studies indicate that ICT use can improve information competencies. In particular, the abilities to collect and evaluate information can be improved by even daily internet use, as suggested by the panel study results. To heighten information competencies, therefore, promotion of ICT use should be effective. This could support such recent international frameworks and

orientations on information education and recent findings of major research on educational ICT use as previously mentioned. This can also be regarded as providing evidence of causality underlying those frameworks and orientations.

Second, unlike for information competencies, ICT use was not found to improve the ability to contribute to a desirable information society. More frequent ICT use of course tends to cause more information ethics issues and online safety problems. As far as the study results are concerned, however, it is quite unlikely that individuals can naturally acquire high-level information ethics and online safety just because they use ICT. This means that students who start or increase the use of ICT must be provided with education designed to improve their ability to contribute to a desirable information society, with a special emphasis on information ethics and online safety.

Third, quasi-experiments and panel studies produce different results. While the quasi-experiments indicated that ICT use could promote the majority of components of information competencies, the panel studies suggested that ICT had a limited effect. This may be explained by the fact that ICT use measured in the quasi-experiments was a part of class or school activities with an educational purpose. In fact, it has been suggested that giving educational meaning to ICT use is important to heighten its effect (Condie and Munro 2006). On the other hand, positive effects detected by the panel studies existed, even if they were limited. As mentioned in the first section of this chapter, it seems that researchers have documented the positive effects of ICT use not only at school but also at home (Scherer et al. 2017). Actually, the sophistication of ICT use at home has been observed (Biagi and Loi 2012; Steinkuehler and Duncan 2008), and additionally some research results which suggest the importance of home use have been presented (Brecko et al. 2014; Rohatgi et al. 2016). It therefore seems that the results of panel studies do not contradict international expectations and findings on ICT home use. Fraillon et al. (2013b) showed that (a) ICT use was much more frequent at home than any other place, (b) the amount of ICT use at home was positively correlated with CIL, and (c) the amount of ICT use at school was also correlated with CIL. This suggests that if children learn the appropriate use of ICT at school, it could lead to the appropriate use at home, and consequently CIL would be improved. Future studies should examine the types of usage of ICT at home that have positive educational effects and how the effects of home use can be enhanced through school education,

Fourth, according to the results of the panel studies presented in this chapter, the effect of ICT use on information competencies may vary with user age. More specifically, it seems to be the most effective on elementary school students and the least effective on senior high school students. The effect on junior high school students is in the middle. These study results match the traditional argument that the effect of ICT use is strong on elementary school students and weak on secondary school students (Balanskat et al. 2006). Components of information literacy that are influenced by ICT use may also vary with user age. In the panel studies of elementary and junior high school students, ICT use improved their ability to collect information. In similar studies of senior high school students, on the other hand, ICT use improved their ability to evaluate rather than collect information. Generally

speaking, if individuals are unable to collect much information, they will have only limited opportunities to evaluate the quality of information, and this may prohibit improvement of the ability to evaluate information. The elementary and junior high school students participating in the panel studies may have shown the effect of ICT use on only the ability to collect information because they had little experience with ICT at the time of study, while the senior high school students may no longer have shown the effect on the ability to collect information but, instead, the ability to evaluate information, which is supported by the ability to collect information, because they already had it established through their earlier experiences.

Fifth, among information competencies, the ability to create information was found unlikely to improve through ICT use. Both the quasi-experiments and panel studies failed to show any improvement. Different studies that measured the ability to create information through tests also failed to find any effect of ICT use (Sakamoto and Sakamoto 1993; Sakamoto et al. 1998). Whether or not ICT use improves the creativity of users has been discussed for a very long time. While optimistic opinions have been presented frequently (Clements 1995; Loveless 2002), some still argue that sufficient testing is necessary (Scherer 2016). As far as the Japanese study results are concerned, it seems to be difficult to have an optimistic view toward the effect of ICT use on creativity. Given that it is not easy to improve creativity, it would seem particularly important to consider educational approaches to improving it.

Finally, the panel studies often indicated a reverse causal relationship in which information competencies promoted ICT use. Students' attitudes toward using ICT and their ICT skills have been found to be important in promotion of ICT use (Knezek and Christensen 2008). The result of Japanese studies suggests that like attitudes toward ICT skills and ICT skills themselves, information competencies could be included in the set of student variables that promote ICT use.

Conclusion

Researchers' interest in the educational impact of ICT use has a long history, and this issue has been studied in Japan as well as other countries. Quasi-experiments and panel studies have often been used in Japan, and these methodologies have strength in the identification of causality. This chapter reported the findings of Japanese research on the impact of ICT use on children's information literacy, while aligning the concept of information literacy in Japan with its major concepts in other countries. Japanese researchers have presented many research results which indicate positive effects of ICT use on information literacy. In particular, positive effects on the ability to collect information from a lot of resources and to appropriately evaluate the authenticity and value of each piece of information have often been identified. Japanese research has also indicated that not only ICT use at school but also the use at home could have positive effects, and therefore home use cannot be ignored. These findings are consistent with current international orientations on the issue of the educational impact of ICT use and also provide strengthened evidence of

causality. It seems that research on the impact of home use becomes necessary to be continued worldwide. If so, quasi-experiments and panel studies would be options for the research, and Japanese research studies could also be referred to as a sample of these methodologies.

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